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BalaJi

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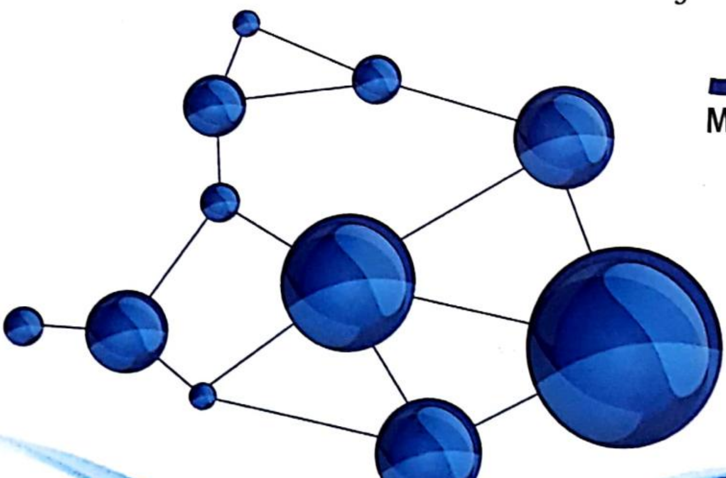
Problems in
Inorganic Chemistry
for JEE
Main & Advanced



9th
edition

Contents

1

PERIODIC PROPERTIES

Level 1

Periodic Table

1. Which is not similar characteristic(s) about the electronic configuration of Be, Mg, Ca?
(a) All the atoms have a pair of *s*-electrons in their outermost energy level
(b) All the atoms contain a pair of *p*-electrons in their outermost energy level
(c) All are alkaline earth metals
(d) All are of second group of the periodic table

2. The elements with atomic number 117 and 120 are yet to be discovered. In which group would you place these elements when discovered ?
(a) 17 , 2 (b) 16 , 4 (c) 15 , 3 (d) 18 , 2

3. The most electropositive element possesses the electronic configuration :
(a) $[He]2s^1$ (b) $[Ne]3s^2$ (c) $[Xe]6s^1$ (d) $[Xe]6s^2$

4. Which one of the following elements shows both positive and negative oxidation states?
(a) Cesium (b) Fluorine (c) Iodine (d) Xenon

5. The number of elements present in fifth period is :
(a) 18 (b) 32 (c) 8 (d) 24

6. Which of the following arrangements shows the correct order of decreasing paramagnetism?
(a) N > Al > O > Ca (b) N > O > Al > Ca
(c) O > N > Al > Ca (d) O > N > Ca > Al

7. The outer electronic structure of lawrencium (atomic number 103) is :
(a) $\text{Rn}\ 5f^{13}7s^27p^2$ (b) $\text{Rn}\ 5f^{13}6d^17s^17p^2$
(c) $\text{Rn}\ 5f^{14}7s^17p^2$ (d) $\text{Rn}\ 5f^{14}6d^17s^2$

8. The elements with the lowest atomic number that has a ground state electronic configuration of $(n-1)\,d^6ns^2$ is located in the :
(a) fifth period (b) sixth period (c) fourth period (d) third period

9. Which of the following sets of atomic numbers corresponds to elements of group 16 ?
(a) 8, 16, 32, 54
(b) 16, 34, 54, 86
(c) 8, 16, 34, 52
(d) 10, 16, 32, 50

10. The atomic numbers of the metallic and non-metallic elements which are liquid at room temperature respectively are :
(a) 55, 87
(b) 33, 87
(c) 35, 80
(d) 80, 35

11. In the periodic table, metallic character of the elements shows one of the following trend :
(a) Decreases down the group and increases across the period
(b) Increases down the group and decreases across the period
(c) Increases across the period and also down the group
(d) Decreases across the period and also down the group

12. Nucleus of an element contains 9 protons. It's valency would be :
(a) 1
(b) 2
(c) 3
(d) 5

13. Transition metals are not characterized by :
(a) fixed valency
(b) coloured compound
(c) high melting and boiling points
(d) tendency to form complexes

14. Sodium generally does not shown oxidation state of +2, because of its :
(a) High first ionisation potential
(b) High second ionization potential
(c) Large ionic radius
(d) High electronegativity

15. Which of the following pairs of molecules have the almost identical bond dissociation energy?
(a) F_2 and H_2
(b) N_2 and CO
(c) F_2 and I_2
(d) HF and O_2

16. According to modern periodic law the properties of elements repeat at regular intervals when the elements are arranged in order of :
(a) decreasing atomic number
(b) increasing atomic weight
(c) increasing atomic number
(d) decreasing atomic weights

17. Give the symbol of the elements of lowest atomic number that has three 2*p* electrons :
(a) Mg
(b) P
(c) N
(d) Si

18. In the fourth period of the periodic table, how many elements have one or more 4*d* electrons?
(a) 2
(b) 18
(c) 0
(d) 6

19. Assuming that elements are formed to complete the seventh period, what would be the atomic number of the alkaline earth metal of the eighth period?
(a) 113
(b) 120
(c) 119
(d) 106

20. Which of the following represents an excited state of an atom?
(a) $[Ne]3s^2 3p^6 4s^2 3d^8$
(b) $[Ne]3s^2 3p^6 4s^1 3d^5$
(c) $[Ne]3s^2 3p^6 4s^2 3d^1$
(d) $1s^2 2s^2 2p^5 3s^1$

21. Choose the correct statement regarding transition elements?
(a) Transition elements has low melting points
(b) Transition elements do not have catalytic activity
(c) Transition elements exhibit variable oxidation states
(d) Transition elements exhibit inert pair effect

22. Which one of the following is a different pair?
(a) Li, Na
(b) Be, Ba
(c) N, As
(d) O, At

23. The element having electronic configuration $[Kr]4d^{10}4f^{14},5s^2 5p^6,6s^2$ belongs to :
(a) *s*-block (b) *p*-block (c) *d*-block (d) *f*-block

24. Which element is named after the name of a planet is ?
(a) Hg (b) Po (c) Pu (d) Ra

25. Zn and Cd metals do not show variable valency because :
(a) They have only two electrons in the outermost subshells
(b) Their *d*-subshells are completely filled
(c) Their *d*-subshells are partially filled
(d) They are relatively soft metals

26. An element whose IUPAC name is ununtrium (Uut) belongs to :
(a) *s*-block element (b) *p*-block element
(c) *d*-block element (d) Transition element

27. Which of the following is not representative element ?
(a) Tellurium (b) Tantalum
(c) Thallium (d) Astatine

28. The period number and group number of "Tantalum" ($Z = 73$) are respectively :
(a) 5, 7 (b) 6, 13 (c) 6, 5 (d) None of these

29. Which of the following pair of elements belong to the same period?
(a) Mg and Sb (b) Ca and Zn
(c) Na and Ca (d) Ca and Cl

30. Consider the following electronic configuration of an element(P) :

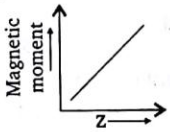
$$[Xe]4f^{14}5d^1 6s^2$$

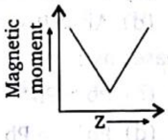
Then correct statement about element 'P' is :
(a) It belongs to 6th period and 1st group (b) It belongs to 6th period and 2nd group
(c) It belongs to 6th period and 3rd group (d) None of these

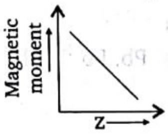
31. Which of the following metal is highest electropositive (metallic) in nature ?
(a) Be (b) Rb (c) Mn (d) Tl

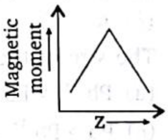
32. Which of the following species must have maximum number of electrons in 'd_{xy}' orbital ?
(a) Cr (b) Fe^{3+} (c) Cu^+ (d) Both (a) and (b)

33. Which of the following graph is correct representation between atomic number (Z) and magnetic moment of *d*-block elements? [Outer electronic configuration : $(n-1)d^x ns^{1 \text{ or } 2}$]

(a) 

(b) 

(c) 

(d) 

34. If IUPAC name of an element is "unununium" then correct statement regarding element is :
(a) It is a inner transition element (b) It belongs to 8th period in periodic table
(c) It is transition element (d) It is a non-transition element

35. Which property decreases from left to right across the periodic table and increases from top to bottom?
(i) Atomic radius (ii) Electronegativity (iii) Ionisation energy (iv) Metallic character
(a) (i) only (b) (i), (ii) and (iii)

(c) (i), (iii) and (iv) (d) (i) and (iv)

36. Consider the following information about element P and Q :

	Period number	Group number
P	2	15
Q	3	2

Then formula of the compound formed by P and Q element is :

(a) PQ (b) P_3Q_2 (c) P_2Q_3 (d) PQ_2

37. Which electronic configuration must represent an atom in an excited state?

(a) $1s^2,2s^22p^1$ (b) $1s^2,2s^22p^2$ (c) $1s^2,2s^22p^2,3s^1$ (d) $1s^2,2s^22p^5$

Atomic/Ionic Radius

38. Which of the following anion has the smallest radius?

(a) H^- (b) F^- (c) Cl^- (d) Br^-

39. The ionic radii of Li^+, Be^{2+} and B^{3+} follow the order :

(a) $Be^{2+} > B^{3+} > Li^+$ (b) $Li^+ > B^{3+} > Be^{2+}$

(c) $B^{3+} > Be^{2+} > Li^+$ (d) $Li^+ > Be^{2+} > B^{3+}$

40. Largest in size out of Na^+, Ne and F^- is :

(a) Na^+ (b) Ne (c) F^- (d) all are equal

41. Which of the following atom or ions has the smallest size?

(a) F (b) F^- (c) O (d) N

42. The single covalent radius of P is 0.11 nm. The single covalent radius of Cl will be :

(a) smaller than P (b) greater than P (c) same as P (d) twice of P

43. Which of the following is arranged in decreasing order of size?

(a) $Mg^{2+} > Al^{3+} > O^{2-}$ (b) $O^{2-} > Mg^{2+} > Al^{3+}$

(c) $Al^{3+} > Mg^{2+} > O^{2-}$ (d) $Al^{3+} > O^{2-} > Mg^{2+}$

44. The correct order of increasing atomic radius of the following elements is :

(a) S < O < Se < C (b) O < C < S < Se

(c) O < S < Se < C (d) C < O < S < Se

45. The correct order of increasing radius of the elements Si, Al, Na and P is :

(a) Si < Al< P < Na (b) P < Si < Al < Na

(c) Al < Si < P < Na (d) Al < P < Si < Na

46. The size of the species, Pb, Pb^{2+}, Pb^{4+} decreases as :

(a) $Pb^{4+} > Pb^{2+} > Pb$ (b) $Pb > Pb^{2+} > Pb^{4+}$

(c) $Pb > Pb^{4+} > Pb^{2+}$ (d) $Pb^{4+} > Pb > Pb^{2+}$

47. Incorrect order of radius is :

(a) $Sr^{2+} < Rb^+ < Br^- < Se^{2-}$ (b) $Nb^{5+} < Zr^{4+} < Y^{3+}$

(c) $Co > Co^{2+} > Co^{3+} > Co^{4+}$ (d) $Ba^{2+} < Cs^+ < Se^{2-} < As^{3-}$

48. The correct order of atomic/ionic radii is :

(a) Sc > Ti > V > Cr (b) Co > Ni > Cu > Zn

(c) $S^{2-} > Cl^- > O^{2-} > N^{3-}$ (d) None of these

49. The radius of which ion is closest to that of Li^+ ion?
(a) Na^+ (b) Be^{2+} (c) Mg^{2+} (d) Al^{3+}

Ionisation Energy

50. The first, second and third ionisation energies (E_1, E_2 and E_3) for an element are 7 eV, 12.5 eV and 42.5 eV respectively. The most stable oxidation state of the element will be:
(a) +1 (b) +4 (c) +3 (d) +2

51. Element having highest I.P. value is:
(a) Ne (b) He (c) Be (d) N

52. The order of ionisation potential between He^+ ion and H-atom (both species are in gaseous state) is:
(a) I.P. (He^+) = I.P. (H) (b) I.P. (He^+) < I.P. (H)
(c) I.P. (He^+) > I. P. (H) (d) cannot be compared

53. Which of the following metal is expected to have the highest third ionization enthalpy?
(a) Cr ($Z=24$) (b) V ($Z=23$) (c) Mn ($Z=25$) (d) Fe($Z=26$)

54. Second ionization potential of Li, Be and B is in the order :
(a) Li > Be > B (b) Li > B > Be
(c) Be > Li > B (d) B > Be > Li

55. The ionization energy of boron is less than that of beryllium because :
(a) beryllium has a higher nuclear charge than boron
(b) beryllium has a lower nuclear charge than boron
(c) the outermost electron in boron occupies a 2*p*-orbital
(d) the 2*s* and 2*p*-orbitals of boron are degenerate

56. The first four I.E. values of an element are 284, 412, 656 and 3210 kJ mol^{-1}. The number of valence electrons in the element are :
(a) one (b) two (c) three (d) four

57. The first I.E. of Na, Mg, Al and Si are in the order :
(a) Na < Mg < Al < Si (b) Na < Al < Mg < Si
(c) Na < Al < Si < Mg (d) Na > Mg > Al > Si

58. The ionization energy will be higher when the electron is removed from :
(a) *s*-orbital (b) *p*-orbital (c) *d*-orbital (d) *f*-orbital

59. Which of the following isoelectronic ion has the lowest ionization energy?
(a) K^+ (b) Cl^- (c) Ca^{2+} (d) S^{2-}

60. Amongst the following elements, the highest ionization energy is :
(a) $[Ne]3s^2 3p^1$ (b) $[Ne]3s^2 3p^3$
(c) $[Ne]3s^2 3p^2$ (d) $[Ar]3d^{10} 4s^2 4p^3$

61. The ionization potentials of Li and K are 5.4 and 4.3 eV respectively. The ionization potential of Na will be :
(a) 9.7 eV (b) 1.1 eV
(c) 4.9 eV (d) cannot be calculated

62. Which of the following electronic configuration is associated with the biggest jump between the second and third ionization energies?

(a) $1s^22s^22p^2$ (b) $1s^22s^22p^63s^1$
(c) $1s^22s^22p^63s^2$ (d) $1s^22s^22p^1$

63. The second ionization energy is maximum for :
(a) boron (b) beryllium
(c) magnesium (d) aluminium

64. A large difference between the fourth and fifth ionization energies indicates the presence of :
(a) 5 valence electrons in an atom (b) 6 valence electrons in an atom
(c) 4 valence electrons in an atom (d) 8 valence electrons in an atom

65. For which of the following reaction ΔH° value is equal to the first ionization energy of Ca is ?
(a) $Ca^+(g) \longrightarrow Ca^{2+}(g) + e$ (b) $Ca(g) \longrightarrow Ca^+(g) + e$
(c) $Ca(s) \longrightarrow Ca^+(g) + e$ (d) $Ca(g) \longrightarrow Ca^{2+}(g) + 2e$

66. Ionization enthalpy of an atom is equal to :
(a) Electron gain enthalpy of the cation (b) Electronegativity of the ion
(c) Ionization enthalpy of the cation (d) None of these

67. From the ground state electronic configuration of the elements given below, pick up the one with highest value of second ionization energy :
(a) $1s^22s^22p^63s^2$ (b) $1s^22s^22p^63s^1$
(c) $1s^22s^22p^6$ (d) $1s^22s^22p^5$

68. An element has successive ionization enthalpies as 940 (first), 2080, 3090, 4140, 7030, 7870, 16000 and 19500 kJ mol^{-1}. To which group of the periodic table does this element belong?
(a) 14 (b) 15 (c) 16 (d) 17

69. The second ionization potential of elements is invariable higher than first ionization potential because :
(a) The size of cation is smaller than its atom
(b) It is easier to remove electron from cation
(c) Ionization is an endothermic process
(d) None of above

70. The first, second and third ionisation energies (E_1, E_2 & E_3) for an element are 7eV, 12.5eV and 42.5eV respectively. The most stable oxidation state of the element will be :
(a) +1 (b) +4 (c) +3 (d) +2

71. Which of the following electronic configurations represents a sudden large gap between the values of second and third ionisation energies of an element?
(a) $1s^2, 2s^22p^3$ (b) $1s^2, 2s^22p^6, 3s^23p^3$
(c) $1s^2, 2s^22p^6, 3s^23p^1$ (d) $1s^2, 2s^22p^6, 3s^2$

72. Element having highest I.P. value is :
(a) Ne (b) He (c) Be (d) N

73. Which of the following atomic species has maximum ionisation energy?
(a) O^- (b) S^- (c) Se^- (d) Te^-

74. The correct order of I.E.$_2$. is:
(a) Na > F > O > N (b) O > F > Ne > N
(c) Ne > O > F > N (d) O > Ne > F > N

75. Which of the following transformation least energy is required?

(a) $F^-_{(g)} \longrightarrow F_{(g)} + e^-$ (b) $P^-_{(g)} \longrightarrow P_{(g)} + e^-$

(c) $S^-_{(g)} \longrightarrow S_{(g)} + e^-$ (d) $Cl^-_{(g)} \longrightarrow Cl_{(g)} + e^-$

Electronaffinity

76. The amount of energy released on the addition of an electron in outermost shell of an atom is called :

(a) Ionization enthalpy (b) Hydration enthalpy

(c) Electronegativity (d) Electron gain enthalpy

77. To which of the following atom, the attachment of electron is most difficult?

(a) Radon (b) Nitrogen

(c) Oxygen (d) Radium

78. Which of the following processes involves absorption of energy?

(a) $S(g) + e^- \longrightarrow S^-(g)$ (b) $S^- + e^- \longrightarrow S^{2-}(g)$

(c) $Cl(g) + e^- \longrightarrow Cl^-(g)$ (d) None of these

79. Arrange N, O and S in order of decreasing electron affinity :

(a) $S > O > N$ (b) $O > S > N$

(c) $N > O > S$ (d) $S > N > O$

80. Among the following configurations, the element which has the highest electron affinity is :

(a) $[Ne]3s^13p^2$ (b) $[Ne]3s^23p^5$

(c) $[Ne]3s^23p^4$ (d) $[Ne]3s^23p^63d^54s^1$

81. The increasing order of electron affinity of the electronic configurations of element is :

(I) $1s^22s^22p^63s^23p^5$ (II) $1s^22s^22p^3$

(III) $1s^22s^22p^5$ (IV) $1s^22s^22p^63s^1$

(a) II < IV < III < I (b) I < II < III < IV

(c) I < III < II < IV (d) IV < III < II < I

82. Second electron gain enthalpy :

(a) is always negative (b) is always positive

(c) can be positive or negative (d) is always zero

83. The element having very high ionization enthalpy but zero electron affinity is :

(a) H (b) F (c) He (d) Be

84. Which of the following represents correct order of electron affinity?

(a) Cl > F > S > O (b) F > O > S > Cl

(c) F > Cl > S > O (d) Cl > S > O > F

85. The process requiring absorption of energy is :

(a) $N \longrightarrow N^-$ (b) $F \longrightarrow F^-$

(c) $Cl \longrightarrow Cl^-$ (d) $H \longrightarrow H^-$

Electronegativity

86. The electronegativity of the following elements increases in the order :

(a) C < N < Si < P (b) Si < P < C < N

(c) N < C < P < Si (d) C < Si < N < P

87. Which of the following order is incorrect ?
(a) Electronegativity of central atom : $CF_4 > CH_4 > SiH_4$
(b) Hydration energy : $Al^{3+} > Be^{2+} > Mg^{2+} > Na^+$
(c) Electrical conductance : $F^-_{(aq.)} > Cl^-_{(aq.)} > S^{2-}_{(aq.)}$
(d) Magnetic moment : $Ni^{4+} > V^{3+} > Sr^{2+}$

88. Correct expression of "Allred and Rochow's" scale is :
(a) Electronegativity $= 0.744 \frac{Z_{eff.}}{r^2} + 0.359$
(b) Electronegativity $= 0.359 \frac{r^2}{Z_{eff.}} + 0.744$
(c) Electronegativity $= 0.359 \frac{Z_{eff.}}{r} + 0.744$
(d) Electronegativity $= 0.359 \frac{Z_{eff.}}{r^2} + 0.744$

Hydration Energy

89. The hydration energy of Mg^{2+} ions is lesser than that of :
(a) Al^{3+}
(b) Ba^{2+}
(c) Na^+
(d) None of these

90. Among the following, which has the maximum hydration energy?
(a) OH^-
(b) NH_4^+
(c) F^-
(d) H^+

91. Which of the following is arranged in order of increasing radius?
(a) $K^+(aq) < Na^+(aq) < Li^+(aq)$
(b) $Na^+(aq) < K^+(aq) < Li^+(aq)$
(c) $K^+(aq) < Li^+(aq) < Na^+(aq)$
(d) $Li^+(aq) < Na^+(aq) < K^+(aq)$

92. Which of the following compounds has a negative enthalpy of solution?
(a) KCl
(b) KBr
(c) KF
(d) KI

Lattice Energy

93. Amongst sodium halides (NaF, NaCl, NaBr and NaI), NaF has the highest melting point because of :
(a) High oxidising power
(b) Lowest polarity
(c) Maximum lattice energy
(d) Minimum ionic character

94. Among the following oxides, which has the maximum lattice energy?
(a) MgO
(b) CaO
(c) SrO
(d) BaO

95. Which of the following compounds has a positive enthalpy of solution?
(a) LiF
(b) LiCl
(c) LiBr
(d) LiI

96. Born-Haber cycle can be used to estimate :
(a) Lattice energy of ionic crystals
(b) Electron gain enthalpy
(c) Electronegativity
(d) Both (a) and (b)

Nature of Oxide

97. Which of the following is different from other three oxides?
(a) MgO (b) SnO
(c) ZnO (d) PbO

98. Select the amphoteric substance in the following :
(a) SO_3 (b) NaOH
(c) CO_2 (d) $Al(OH)_3$

99. Which of the following compound is most acidic?
(a) Cl_2O_7 (b) P_4O_{10}
(c) SO_3 (d) B_2O_3

Level 2

Periodic Table

1. A compound contains three elements A, B and C, if the oxidation number of $A = +2$, $B = +5$ and $C = -2$, the possible formula of the compound is :
(a) $A_3(B_4C)_2$ (b) $A_3(BC_4)_2$ (c) $A_2(BC_3)_2$ (d) ABC_2

2. Consider the following four elements, which are represented according to long form of periodic table.

	Y	
W	X	Z

Here W, Y and Z are left, up and right elements with respect to the element 'X' and 'X' belongs to 16th group and 3rd period. Then according to given information the incorrect statement regarding given elements is :
(a) Maximum electronegativity : Y (b) Maximum catenation property : X
(c) Maximum electron affinity : Z (d) Y exhibits variable covalency

3. Which of the following sequence represents atomic number of only representative elements?
(a) 55, 12, 48, 53 (b) 13, 33, 54, 83 (c) 3, 33, 53, 87 (d) 22, 33, 55, 66

4. The ground state electronic configurations of the elements, U, V, W, X, and Y (these symbols do not have any chemical significance) are as follows :

U $1s^2 2s^2 2p^3$
V $1s^2 2s^2 2p^6 3s^1$
W $1s^2 2s^2 2p^6 3s^2 3p^2$
X $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$
Y $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

Determine which sequence of elements satisfy the following statements :
(i) Element forms a carbonate which is not decomposed by heating
(ii) Element is most likely to form coloured ionic compounds
(iii) Element has largest atomic radius
(iv) Element forms only acidic oxide
(a) $V\ W\ Y\ U$ (b) $V\ X\ Y\ W$
(c) $V\ W\ Y\ X$ (d) $V\ X\ W\ U$

5. When magnesium burns in air, compounds of magnesium formed are magnesium oxide and :
(a) Mg_3N_2 (b) $MgCO_3$
(c) $Mg(NO_3)_2$ (d) $MgSO_4$

6. Which of the following ions is most unlikely to exist?
(a) Li^- (b) Be^-
(c) B^- (d) F^-

7. A, B and C are hydroxy-compounds of the elements X, Y and Z respectively. X, Y and Z are in the same period of the periodic table. A gives an aqueous solution of pH less than seven. B reacts with both strong acids and strong alkalis. C gives an aqueous solution which is strongly alkaline.

Which of the following statements is/are true ?

I : The three elements are metals.

II : The electronegativities decrease from X to Y to Z.

III : The atomic radius decreases in the order X, Y and Z.

IV : X, Y and Z could be phosphorus, aluminium and sodium respectively.

(a) I, II, III only correct
(b) I, III only correct
(c) II, IV only correct
(d) II, III, IV only correct

8. La (lanthanum) having atomic number 57 is a member of :
(a) *s*-block elements
(b) *p*-block elements
(c) *d*-block elements
(d) *f*-block elements

9. If the aufbau principle had not been followed, Ca ($Z = 20$) would have been placed in the :
(a) *s*-block
(b) *p*-block
(c) *d*-block
(d) *f*-block

10. What is the atomic number of the element with the maximum number of unpaired $4p$ electrons?
(a) 33
(b) 26
(c) 23
(d) 15

11. The electronic configuration of four elements are :
(I) $[Kr]5s^1$
(II) $[Rn]5f^{14}6d^1 7s^2$
(III) $[Ar]3d^{10}4s^2 4p^5$
(IV) $[Ar]3d^6 4s^2$

Consider the following statements :
(i) I shows variable oxidation state
(ii) II is a *d*-block element
(iii) The compound formed between I and III is covalent
(iv) IV shows single oxidation state

Which statement is True (T) or False (F)?
(a) FTFF
(b) FTFT
(c) FFTF
(d) FFFF

12. If period number and group number of any representative element(s) are same then which of the following statement is incorrect regarding such type element(s) in their ground state? (Period number and group number are according to modern form of periodic table)
(a) The possible value of principal quantum number is 2
(b) The possible value of azimuthal quantum number is zero
(c) The possible value of magnetic quantum number is 1
(d) The species could be paramagnetic

13. How does the energy gap between successive energy levels in an atom vary from low to high *n* values?
(a) All energy gaps are the same
(b) The energy gap decreases as *n* increases
(c) The energy gap increases as *n* increases
(d) The energy gap changes unpredictably as *n* increases

14. Which of the following properties of the alkaline earth metals increase from Be to Ba?

(i) Atomic radius (ii) Ionisation energy (iii) Nuclear charge

(a) (i) and (ii) (b) (i) and (iii)

(c) (ii) and (iii) (d) (i), (ii) and (iii)

15. Which of the following is the incorrect match for atom of element ?

(a) $[Ar]3d^5 4s^1$ → 4^{th} period, 6^{th} group

(b) $[Kr]4d^{10}$ → 5^{th} period, 12^{th} group

(c) $[Rn]6d^2 7s^2$ → 7^{th} period, 3^{th} group

(d) $[Xe]4f^{14} 5d^2 6s^2$ → 6^{th} period, 4^{th} group

Atomic/Ionic Radius

16. The set representing the correct order of ionic radius is:

(a) $Na^+ > Mg^{2+} > Al^{3+} > Li^+ > Be^{2+}$ (b) $Na^+ > Li^+ > Mg^{2+} > Al^{3+} > Be^{2+}$

(c) $Na^+ > Mg^{2+} > Li^+ > Al^{3+} > Be^{2+}$ (d) $Na^+ > Mg^{2+} > Li^+ > Be^{2+}$

17. In which of the following pair, both the species are isoelectronic but the first one is large in size than the second?

(a) S^{2-}, O^{2-} (b) Cl^-, S^{2-} (c) F^-, Na^+ (d) N^{3-}, P^{3-}

18. The correct order of ionic size of $N^{3-}, Na^+, F^-, Mg^{2+}$ and O^{2-} is :

(a) $Mg^{2+} > Na^+ > F^- > O^{2-} < N^{3-}$ (b) $N^{3-} < F^- > O^{2-} > Na^+ > Mg^{2+}$

(c) $Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$ (d) $N^{3-} > O^{2-} > F^- > Na^+ < Mg^{2+}$

19. The order of increasing ionic radius of the following is :

(a) $K^+ < Li^+ < Mg^{2+} < Al^{3+}$ (b) $K^+ < Mg^{2+} < Li^+ < Al^{3+}$

(c) $Li^+ < K^+ < Mg^{2+} < Al^{3+}$ (d) $Al^{3+} < Mg^{2+} < Li^+ < K^+$

20. If the ionic radii of K^+ and F^- are nearly the same (*i.e.*, 1.34 Å), then the atomic radii of K and F respectively are :

(a) 1.34 Å, 1.34 Å (b) 0.72 Å, 1.96 Å (c) 1.96 Å, 0.72 Å (d) 1.96 Å, 1.34 Å

21. Incorrect order of ionic size is :

(a) $La^{3+} > Gd^{3+} > Eu^{3+} > Lu^{3+}$ (b) $V^{2+} > V^{3+} > V^{4+} > V^{5+}$

(c) $Tl^+ > In^+ > Sn^{2+} > Sb^{3+}$ (d) $K^+ > Sc^{3+} > V^{5+} > Mn^{7+}$

Ionisation Energy

22. $X_{(g)} \longrightarrow X^+{}_{(g)} + e^-$, $\Delta H = +720\,\text{kJ mol}^{-1}$

Calculate the amount of energy required to convert 110 mg of 'X' atom in gaseous state into X^+ ion. (Atomic wt. for $X = 7$ g/mol)

(a) 10.4 kJ (b) 12.3 kJ (c) 11.3 kJ (d) 14.5 kJ

23. Consider the following changes :

$$M(s) \longrightarrow M(g) \quad ...(1)$$

$$M(s) \longrightarrow M^{2+}(g) + 2e^- \quad ...(2)$$

$$M(g) \longrightarrow M^+(g) + e^- \quad ...(3)$$

$$M^+(g) \longrightarrow M^{2+}(g) + e^- \qquad ...(4)$$

$$M(g) \longrightarrow M^{2+}(g) + 2e^- \qquad ...(5)$$

The second ionization energy of M could be calculated from the energy values associated with :

(a) 1 + 3 + 4 (b) 2 − 1 + 3 (c) 1 + 5 (d) 5 − 3

24. The correct order of second I.E. of C, N, O and F are in the order :

(a) F > O > N > C (b) C > N > O > F

(c) O > N > F > C (d) O > F > N > C

25. Which is the correct order of ionization energies?

(a) $F^- > F > Cl^- > Cl$ (b) $F > Cl > Cl^- > F^-$

(c) $F^- > Cl^- > Cl > F$ (d) $F^- > Cl^- > F > Cl$

26. Which of the following statements is incorrect?

(a) The second ionization energy of sulphur is greater than that of chlorine

(b) The third ionization energy of phosphorus is greater than that of aluminium

(c) The first ionization energy of aluminium is approximately the same as that of gallium

(d) The second ionization energy of boron is greater than that of carbon

27. First ionization energy is the lowest with :

(a) Lead (b) Carbon (c) Silicon (d) Tin

28. The incorrect statement among the following is :

(a) The first ionization potential of Al is less than the first ionization potential of Mg

(b) The second ionization potential of Mg is greater than the second ionization potential of Na

(c) The first ionization potential of Na is less than the first ionization potential of Mg

(d) The third ionization potential of Mg is greater than the third ionization potential of Al

29. The correct values of ionization enthalpies (in $kJ\,mol^{-1}$) of Si, P, Cl and S respectively are :

(a) 786, 1012, 999, 1256 (b) 1012, 786, 999, 1256

(c) 786, 1012, 1256, 999 (d) 786, 999, 1012, 1256

30. The third ionization energy is maximum for :

(a) Nitrogen (b) Phosphorus (c) Aluminium (d) Boron

31. Consider the following ionisation reactions :

	I.E. ($kJ\,mol^{-1}$)		I.E. ($kJ\,mol^{-1}$)
$A_{(g)} \longrightarrow A^+_{(g)} + e^-$,	A_1	$B_{(g)} \longrightarrow B^+_{(g)} + e^-$,	B_1
$B^+_{(g)} \longrightarrow B^{2+}_{(g)} + e^-$,	B_2	$C_{(g)} \longrightarrow C^+_{(g)} + e^-$,	C_1
$C^+_{(g)} \longrightarrow C^{2+}_{(g)} + e^-$,	C_2	$C^{2+}_{(g)} \longrightarrow C^{3+}_{(g)} + e^-$,	C_3

If monovalent positive ion of A, divalent positive ion of B and trivalent positive ion of C have zero electron. Then incorrect order of corresponding I.E. is :

(a) $C_3 > B_2 > A_1$ (b) $B_1 > A_1 > C_1$

(c) $C_3 > C_2 > B_2$ (d) $B_2 > C_3 > A_1$

32. The incorrect statement is :

(a) The second ionisation energy of Se is greater than that of second ionisation energy of As

(b) The first ionisation energy of C^{2+} ion is greater than that of first ionisation energy of N^{2+} ion

(c) The third ionisation energy of F is greater than that of third ionisation energy of O
(d) Helogens have highest I.E. in respective period

33. First three ionisation energies (in kJ/mol) of three representative elements are given below :

Element	IE_1	IE_2	IE_3
P	495.8	4562	6910
Q	737.7	1451	7733
R	577.5	1817	2745

Then incorrect option is :
(a) *Q*: Alkaline earth metal (b) *P*: Alkali metals
(c) *R*: *s*-block element (d) They belong to same period

Electronaffinity

34. Which of the following statement is correct regarding following process?
(i) $Cl \xrightarrow{E.A.} Cl^-$ (ii) $Cl^- \xrightarrow{I.E.} Cl$ (iii) $Cl \xrightarrow{I.E.} Cl^+$ (iv) $Cl^+ \xrightarrow{I.E.} Cl^{2+}$
(a) |I.E. of process (ii)| = |E.A. of process (i)|
(b) |I.E. of process (iii)| = |I.E. of process (ii)|
(c) |I.E. of process (iv)| = |E.A. of process (i)|
(d) |I.E. of process (iv)| = |I.E. of process (iii)|

35. The correct order of increasing electron affinity of the following elements is :
(a) $O < S < F < Cl$ (b) $O < S < Cl < F$
(c) $S < O < F < Cl$ (d) $S < O < Cl < F$

36. The second electron gain enthalpies (in kJ mol^{-1}) of oxygen and sulphur respectively are :
(a) −780, +590 (b) −590, +780 (c) +590, +780 (d) +780, +590

37. Which of the following statements is correct?
(a) The magnitude of the second electron affinity of sulphur is greater than that of oxygen
(b) The magnitude of the second electron affinity of sulphur is less than that of oxygen
(c) The first electron affinities of bromine and iodine are approximately the same
(d) The first electron affinity of fluorine is greater than that of chlorine

38. Which one of the following statements is incorrect?
(a) Greater is the nuclear charge, greater is the electron gain enthalpy
(b) Nitrogen has almost zero electron gain enthalpy
(c) Electron gain enthalpy decreases from fluorine to iodine in the group
(d) Chlorine has highest electron gain enthalpy

39. The formation of the oxide ion $O^{2-}(g)$ requires first an exothermic and then an endothermic step as shown below :

$$O(g) + e^- \longrightarrow O^-(g); \quad \Delta H = -142 \text{ kJ mol}^{-1}$$
$$O^-(g) + e \longrightarrow O^{2-}(g); \quad \Delta H = 844 \text{ kJ mol}^{-1}$$

This is because :
(a) O^- ion has comparatively larger size than oxygen atom
(b) Oxygen has high electron affinity
(c) O^- ion will tend to resist the addition of another electron
(d) Oxygen is more electronegative

40. In which of the following processes energy is absorbed?
(a) $Cl + e^- \longrightarrow Cl^-$ (b) $O^- + e^- \longrightarrow O^{2-}$
(c) $O^{2-} - e^- \longrightarrow O^-$ (d) $Na^+ + e^- \longrightarrow Na$

41. The electron affinity of the following elements can be arranged :
(a) Cl > O > N > C (b) Cl >O > C > N (c) Cl > N > C > O (d) Cl > C > O > N

42. In which of the following arrangements, the order is not correct according to the property indicated against it?
(a) Increasing size : $Al^{3+} < Mg^{2+} < Na^+ < F^-$
(b) Increasing $I.E._1 : B < C < N < O$
(c) Increasing $E.A._1 : I < Br < F < Cl$
(d) Increasing metallic radius : Li < Na < K < Rb

43. Which of the following statements is/are wrong?
(a) van der Waals' radius of iodine is more than its covalent radius
(b) All isoelectronic ions belong to same period of the periodic table
(c) $I.E._1$ of N is higher than that of O while $I.E._2$ of O is higher than that of N
(d) The electron affinity N is almost zero while that of P is 74.3 kJ mol^{-1}

44. Consider the following conversions :
(i) $O_{(g)} + e^- \longrightarrow O^-_{(g)}, \ \Delta H_1$ (ii) $F_{(g)} + e^- \longrightarrow F^-_{(g)}, \ \Delta H_2$
(iii) $Cl_{(g)} + e^- \longrightarrow Cl^-_{(g)}, \ \Delta H_3$ (iv) $O^-_{(g)} + e^- \longrightarrow O^{2-}_{(g)}, \ \Delta H_4$
That according to given information the incorrect statement is :
(a) ΔH_3 is more negative than ΔH_1 and ΔH_2
(b) ΔH_1 is less negative than ΔH_2
(c) $\Delta H_1, \Delta H_2$ and ΔH_3 are negative whereas ΔH_4 is positive
(d) ΔH_1 and ΔH_3 are negative whereas ΔH_2 and ΔH_4 are positive

Electronegativity

45.

Element	Electronegative value
W	2.7
X	2.1
Y	0.8
Z	3.4

The incorrect statement regarding given information is :
(a) *WZ* does not conduct electricity in solid and fused state
(b) *YZ* conducts electricity in fused as well as solution state
(c) *XZ* conducts electricity only in solution state
(d) *WX* conducts electricity only in fused state

46. In the compound $M — O — H$, the $M — O$ bond will be broken if:
(a) Δ (E.N.) of *M* and O < Δ (E.N.) of O and H
(b) Δ (E.N.) of *M* and O = Δ (E.N.) of O and H
(c) Δ (E.N.) of *M* and O > Δ (E.N.) of O and H
(d) Cannot be predicated according Δ (E.N.) data

47. Aqueous solutions of two compounds M_1-O-H and M_2-O-H are prepared in two different beakers. If, the electronegativity of $M_1 = 3.4, M_2 = 1.2, O = 3.5$ and $H = 2.1$, then the nature of two solutions will be respectively :

(a) acidic, basic (b) acidic, acidic (c) basic, acidic (d) basic, basic

48. If the ionization enthalpy and electron gain enthalpy of an element are 275 and 86 kcal mol^{-1} respectively, then the electronegativity of the element on the Pauling scale is :

(a) 2.8 (b) 0.0 (c) 4.0 (d) 2.6

49. Consider the following statements :

(I) The radius of an anion is larger than that of the parent atom.

(II) The ionization energy generally increases with increasing atomic number in a period.

(III) The electronegativity of an element is the tendency of an isolated atom to attract an electron.

Which of the above statements is/are correct?

(a) I alone (b) II alone

(c) I and II (d) II and III

50. Which of the following order is correct for the property mentioned in brackets ?

(a) $S^{2-} > Cl^- > K^+ > Ca^{2+}$ (Ionisation energy)

(b) $C < N < F < O$ (2nd Ionisation energy)

(c) $B > Al > Ga > In > Tl$ (Electronegativity)

(d) $Na^+ > Li^+ > Mg^{2+} > Be^{2+} > Al^{3+}$ (Ionic radius)

Hydration Energy

51. Which among the following factors is the most important in making fluorine, the strongest oxidising halogen ?

(a) Bond dissociation energy (b) Ionisation enthalpy

(c) Hydration enthalpy (d) Electron affinity

Level 3

PASSAGE 1

The energy required to pull the most loosely bound electron form an atom is known as ionization potential. It is expressed in electron volts. The value of ionization potential depends on three factors: (i) the charge on the nucleus (ii) the atomic radius and (iii) the screening effect of inner electron shells.

1. Ionization potential of Na would be numerically the same as:
(a) electron affinity of Na^+ (b) electronegativity of Na^+
(c) electron affinity of Na (d) ionization potential of Mg

2. Which of the following elements has the least ionization potential?
(a) Lithium (b) Cesium (c) Magnesium (d) Calcium

3. Incorrect order of ionisation energy is :
(a) Pb (I.E.) > Sn (I.E.) (b) Na^+ (I.E.) > Mg^+ (I.E.)
(c) Li^+ (I.E.) < O^+ (I.E.) (d) Be^+ (I.E.) < C^+ (I.E.)

PASSAGE 2

All the elements, on the basis of long form of periodic table, can be divided into four blocks, *s*, *p*, *d* and *f*. The ionization energies, electron affinities, electronegativities, atomic and ionic radii and other physical properties usually shown a regular pattern of change within a group or along period with some irregularities.

1. On moving from Li to F in the second period, there would be a decrease in:
(a) non-metallic property (b) atomic radius
(c) ionization potential (d) electronegativity

2. Which of the following element has the maximum value of electronegativity?
(a) Aluminium (b) Silicon (c) Phosphorus (d) Sulphur

3. Which of the following element has the maximum electron affinity?
(a) Nitrogen (b) Oxygen (c) Fluorine (d) Chlorine

PASSAGE 3

The second ionisation energies are higher than the first ionisation energies. This is mainly due to the fact that after the removal of the first electron, the atom changes into monovalent positive ion. In the ion, the number of electrons decreases but the nuclear charge remains the same. As a result of this, the remaining electrons are held more tightly by the nucleus and it becomes difficult to remove the second electron. Therefore , the value of second ionisation energy. (IE_2), is greater than that of the first ionisation energy (IE_1). Similarly third ionisation energy (IE_3) is greater than that of second IE_2 .

1. Successive ionisation energy of an atom is greater than previous one, because:

(a) $\frac{p}{e}$ ratio increases
(b) $\frac{p}{e}$ ratio decreases
(c) $\frac{p}{e}$ ratio remains constant
(d) none of these

2. Correct order of ionisation potential of coinage metals is:

(a) Au > Ag > Cu
(b) Cu > Ag > Au
(c) Au > Cu > Ag
(d) Ag > Cu > Au

3. IE_1 and IE_2 of Mg metal are 178 and 348 kcal/mol respectively. The energy required for the given reaction is:

$$Mg(g) \longrightarrow Mg^{+2}(g) + 2e^-$$

(a) +170 kcal/mol
(b) +526 kcal/mol
(c) −170 kcal/mol
(d) −526 kcal/mol

PASSAGE 4

Nuclear charge actually experienced by an electron is termed as effective nuclear charge. The effective nuclear charge Z^* actually depends on type of shell and orbital in which electron is actually present. The relative extent to which the various orbitals penetrate the electron clouds of other orbitals is.

$$s > p > d > f \text{ (for the same value of } n)$$

The phenomenon in which penultimate shell electrons act as screen or shield in between nucleus and valence shell electrons and thereby reducing nuclear charge is known as shielding effect. The penultimate shell electrons repel the valence shell electron to keep them loosely held with nucleus. It is thus evident that more is the shielding effect, lesser is the effective nuclear charge and lesser is the ionization energy.

1. Which of the following valence electron experience maximum effective nuclear charge?

(a) $4s^1$
(b) $4p^1$
(c) $3d^1$
(d) $2p^3$

2. Which of the following is not concerned to effective nuclear charge?

(a) Higher ionization potential of carbon than boron
(b) Higher ionization potential of magnesium than aluminium
(c) Higher values of successive ionization energy
(d) Higher electronegativity of higher oxidation state

3. Ionization energy is not influenced by :

(a) Size of atom
(b) Effective nuclear charge
(c) Electrons present in inner shell
(d) Change in entropy

PASSAGE 5

Ionization energies of five elements in kcal/mol are given below :

Atom	I	II	III
P	300	549	920
Q	99	734	1100
R	118	1091	1652
S	176	347	1848
T	497	947	1500

1. Which element is a noble gas ?
(a) *P* (b) *T* (c) *R* (d) *S*

2. Which element form stable unipositive ion ?
(a) *P* (b) *Q* (c) *R* (d) *T*

3. The element having most stable oxidation state +2 is ?
(a) *Q* (b) *R* (c) *S* (d) *T*

4. Which is a non-metal (excluding noble gas)?
(a) *P* (b) *Q* (c) *R* (d) *S*

5. If *Q* reacts with fluorine and oxygen, the molecular formula of fluoride and oxide will be respectively :
(a) QF_3, Q_2O_3 (b) QF, Q_2O (c) QF_2, QO (d) None of these

6. Which of the following pair represents elements of same group ?
(a) *Q, R* (b) *P, Q* (c) *P, S* (d) *Q, S*

PASSAGE 6

The I.E.$_1$, and the I.E.$_2$ in kJ mol^{-1} of a few elements designated by *P, Q, R, S* are shown below:

Atom	I.E.$_1$	I.E.$_2$
P	2372	5251
Q	520	7300
R	900	1760
S	1680	3380

Based on the above information, answer the following questions :

1. Which of the element is likely to be reactive metal?
(a) *P* (b) *Q* (c) *R* (d) *S*

2. Which of the elements is likely to be reactive non-metal?
(a) *P* (b) *Q* (c) *R* (d) *S*

3. Which represents a noble gas?

(a) P (b) Q (c) R (d) S

4. Which of the above elements forms a stable binary halide of the formula MX_2?

(a) P (b) Q (c) R (d) S

PASSAGE 7

Elements with their electronic configurations are given below :

Answer the following questions :

I : $1s^2 2s^2$ II : $1s^2 2s^2 2p^6$ III : $1s^2 2s^2 2p^6 3s^2$ IV : $1s^2 2s^2 2p^3$ V : $1s^2 2s^2 2p^5$

1. The element with highest I.E. is :

(a) I (b) III

(c) II (d) V

2. The element with lowest electron gain enthalpy is :

(a) I (b) II

(c) III (d) IV

3. The most ionic compound will be formed between :

(a) I and IV (b) I and V

(c) III and IV (d) III and V

4. Which of the following is the correct order of increasing size?

(a) I < III < IV < V (b) V < IV < III < I

(c) I < IV < V < III (d) V < IV < I < III

PASSAGE 8

J.C. Slater proposed an empirical constant that represents the cumulative extent to which the other electrons of an atom shield (or screen) any particular electron from the nuclear charge. Thus, Slater's screening constant σ is used as : $Z^* = Z - \sigma$

Here, Z is the atomic number of the atom, and hence is equal to the actual number of protons in the atom. The parameter Z^* is the effective nuclear charge, which according to is smaller than Z, since the electron in question is screened (shielded) from Z by an amount σ. We found that in cases for which screening is small, the effective nuclear charge Z^* is large. Conversely, an electron that is well shielded from the nuclear charge Z experiences a small effective nuclear charge Z^*.

The value of σ for any one electron in a given electron configuration (*i.e.*, in the presence of the other electrons of the atom in question) is calculated using a set of empirical rules developed by Slater. According to these rules, the value of σ for the electron in question is the cumulative total provided by the various other electrons of the atom.

1. The effective nuclear charge at the periphery of chromium atom [$Z = 24$]:

(a) 4.25 (b) 2.60

(c) 3.60 (d) 1.21

2. Which of the following statement is correct?

(a) A 4*s*-orbital is filled earlier than a 3*d*-orbital because, Z^* for $3d > Z^*$ for 4*s*.

(b) A 4*s*-orbital is filled earlier than a 3*d*-orbital because, Z^* for $4s > Z^*$ for 3*d*

(c) The effective nuclear charge for 3*d*-and 4*s*-orbitals are same, but energy of 3*d*-orbital becomes higher.

(d) The effective nuclear charge for 3*d* and 4*s*-orbitals are same, but energy of 4*s*-orbital becomes higher.

3. According to Slater's rule, order of effective nuclear charge (Z^*) for last electron in case of Li, Na and K.

(a) Li > Na > K (b) K > Na > Li

(c) Na > Li > K (d) K = Na > Li

PASSAGE 9

Metals have few electrons in their valence shell while non-metals generally have more electrons in their valence shell. Metallic character is closely related to atomic radius and ionisation enthalpy. Metallic character increases from top to bottom in a group and decreases from left to right in a period of periodic table. Metallic character is inversely related to electronegativity of element.

1. The electronegativity of the following elements increase in the order :

(a) C, N, Si, P (b) N, Si, C, P

(c) Si, P, C, N (d) P, Si, N, C

2. Considering the elements B, Al, Mg and K, the correct order of their metallic character is :

(a) B > Al > Mg > K (b) Al > K > B > Mg

(c) Mg > Al > K > B (d) K > Mg > Al > B

3. $3\ N_0/2$ atoms of $X_{(g)}$ are converted in to $X^+_{(g)}$ by energy E_1, $2\ N_0/3$ atoms of $X_{(g)}$ are converted in to $X^-_{(g)}$ by energy E_2. Hence, ionisation potential and electron affinity of $X_{(g)}$ are: (N_0 = Avogadro's number)

(a) $\frac{2E_1}{3N_0}, \frac{2E_2}{3N_0}$ (b) $\frac{2E_1}{3N_0}, \frac{3E_2}{2N_0}$

(c) $\frac{3E_1}{2N_0}, \frac{3E_2}{2N_0}$ (d) $\frac{3E_1}{2N_0}, \frac{2E_2}{3N_0}$

PASSAGE 10

The value of four quantum number for the last electron of atom of element 'X' are $n = 7, l = 1, m = +1$ and $s = +1/2$ or $-1/2$ and value of spin magnetic momentum for element 'X' is zero. Element 'X' has two isotopes (I) $^{A}_{Z}X$ and, (II) $^{B}_{Z}X$.

(Given: "$B - A = B - 2Z = 18$", where A and B are atomic masses and Z is atomic number.)

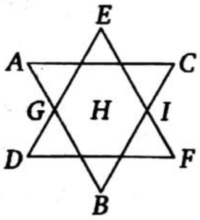
1. The incorrect statement regarding element 'X' is :
(a) Element 'X' belongs to 18th group.
(b) Number of unpaired electrons in element 'X' is zero
(c) Atomic number of element 'X' is 118
(d) 'X' is representative element

2. The value of A and B respectively are :
(a) 118 and 136
(b) 218 and 236
(c) 236 and 254
(d) 226 and 244

3. The possible value of all four quantum numbers for 90th electron of atom of element 'X' is :

	n	l	m	s
(a)	6	2	0	$-1/2$
(b)	5	2	-1	$+1/2$
(c)	6	0	0	$+1/2$
(d)	5	3	-2	$-1/2$

PASSAGE 11



There are nine elements A to I. These are belongs to p-block element other than halogen. If atomic number of B is average of atomic number of A and C and atomic number of E is average of atomic number of D and F and atomic number of H is average of atomic number of G and I. Atomic numbers of B, E and H are 7, 15 and 83 respectively and atomic numbers of C, I and F are greater than A, G and D respectively.

1. The incorrect order is :
(a) $F > E$: Second ionisation energy
(b) $B > C$: Z_{eff} on valence shell
(c) $I > H$: First ionisation energy
(d) $C > F > E$: Electronegativity

2. The correct statement is :
(a) +5 oxidation state of H is more stable than its +3 oxidation state.

(b) G^{2+} is better oxidising agent than G^{4+}

(c) +3 oxidation state of E is more stable than its +5 oxidation state

(d) Ionisation energy of G is greater than that of "Tin".

3. Which of the following statement is incorrect ?

(a) B_2C_5 is acidic in nature
(b) AC_2 is acidic in nature
(c) FC_3 is basic in nature
(d) GC_2 is amphoteric in nature

PASSAGE 12

If P, Q, R and S are elements of 3rd period of p-block in Modern Periodic Table, among these one element is metal and rest are non-metals and their order of electronegativity is given as :

$$P < Q < R < S$$

1. In which of the following linkage release of H^+ is relatively more easier?

(a) $P—O—H$
(b) $S—O—H$
(c) $Q—O—H$
(d) $R—O—H$

2. Which element is expected to form amphoteric oxide?

(a) P
(b) Q
(c) R
(d) S

3. Chloride compound of which element is hypovalent?

(a) S
(b) Q
(c) R
(d) P

PASSAGE 13

Consider the following representation based on long form of periodic table.

A		U	V	W
B		T		
C	D	X	S	R
		E		Q
H	G	F		P

Value of all four quantum number for last electron of element 'X' in their ground state is $n = 4$, $l = 1$, $m = 1$ and $s = -\frac{1}{2}$ and spin multiplicity of element 'X' in their ground state is 4.

1. Which of the following order is incorrect ?

(a) Magnetic moment : $U > V > A$
(b) Atomic radius : $E > X > T$
(c) Ionisation energy : $R > X > B$
(d) Stability : $F^{3+} < E^{3+} < X^{3+}$

2. The correct order is :

(a) Ionisation energy of V > ionisation energy of U
(b) Electron affinity of X > electron affinity of S
(c) Electron affinity of X > ionisation energy of D
(d) $|\Delta H_{EG}|$ of T > $|\Delta H_{EG}|$ of U

3. Which of the following statement is incorrect?
(a) Element *P* is radioactive
(b) Elements *B* and *C* have their almost similar size
(c) Element *G* is more stable in +4 oxidation state
(d) Element *G* has electron with $n = 4, l = 3, m = 0$ and $s = +\frac{1}{2}$ quantum numbers

PASSAGE 14

Consider the following elements with their electronegativity value.

Elements	*A*	*B*	*C*	*D*
Electronegativity (Pauling scale)	3.77	1.12	2.25	3.10

1. Incorrect statements is :
(a) *A*OH is more acidic than *D*OH
(b) *B*OH is more basic than *C*OH
(c) '*AB*' molecule is predominantly ionic
(d) '*D* — OH' bond is more weaker than '*B* — OH' bond in polar solvent

2. Select correct statement :
(a) Oxide of element *D* is more acidic than that of *A*
(b) Oxides of elements *C* and *D* are basic in nature
(c) Oxide of element *B* is acidic in nature
(d) *B*OH is more basic than H_2O

PASSAGE 15

In the modern periodic table, elements are arranged in order of increasing atomic numbers which is related to the electronic configuration. Depending upon the type of orbitals receiving the last electron, the elements in the periodic table have been divided into four blocks, *viz.*, *s*, *p*, *d*, and *f*. The modern periodic table consists of 7 periods and 18 groups. Each period begins with the filling of a new energy shell. In accordance with the Aufbau principle, the seven periods (1 to 7) have 2, 8, 8, 18, 18, 32 and 32 elements respectively. The seventh period is still incomplete. To avoid the periodic table being too long, the two series of *f*-block elements, called lanthanoids and actinoids are placed at the bottom of the main body of the periodic table.

1. Which of the elements whose atomic numbers are given below, cannot be accommodated in the present set up of the long form of the periodic table?
(a) 107 (b) 118 (c) 126 (d) 102

2. The element with atomic number 57 belongs to :
(a) *s*-block (b) *p*-block (c) *d*-block (d) *f*-block

ONE OR MORE ANSWERS IS/ARE CORRECT

Periodic Table

1. Assign the position of the element having outer electronic configuration,

(A) ns^2np^2 $(n = 6)$
(B) $(n-1)\ d^2ns^2$ $(n = 4)$
(C) $(n-2)\ f^7\ (n-1)\ d^{-1}ns^2$ $(n = 6)$

Which of the following statement(s) is/are correct?

(a) The element '*A*' belong to 3rd period and 16th group.
(b) The element '*B*' belong to 4th period and 4th group.
(c) The element '*C*' belong to 6th period and 3rd group and is lanthanide element.
(d) All *A*, *B*, *C* elements are metals

2. Which of the following statement(s) regarding periodic properties is/ are incorrect?

(a) Alkali metals have highest I.E. in respective period
(b) Noble gas have highest I.E. in respective period
(c) First electron affinity of nitrogen is less than oxygen
(d) F atom has smallest radius in periodic table

3. Which of the following properties among halogens decrease(s) from fluorine to iodine?

(a) Electronegativity (b) Bond energy
(c) Ionisation energy (d) Electron affinity

4. In halogens, which of the following decreases from fluorine to iodine?

(a) Bond length (b) Electronegativity
(c) The ionization energy of the element (d) Oxidizing power

5. Mark the correct statements out of the following :

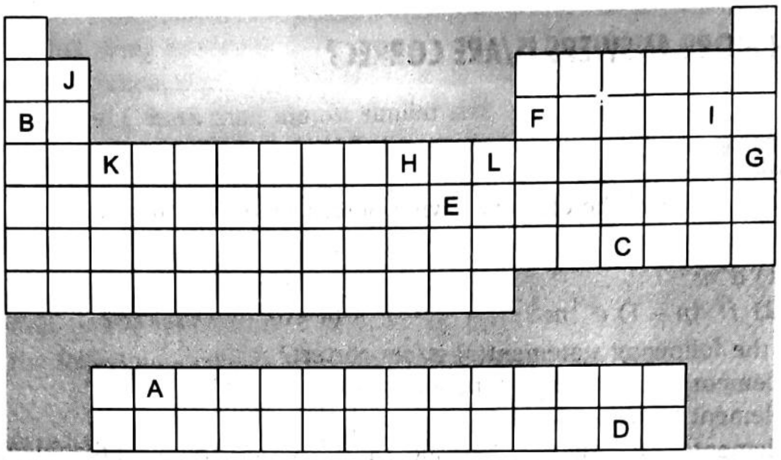
(a) He has the highest I.E.$_1$ in the periodic table
(b) Cl has the highest E.A. out of all the elements in the periodic table
(c) Hg and Br are liquid at room temperature
(d) In any period, the atomic radius of the noble gas is lowest

6. *S*, *T* and *U* are the aqueous chlorides of the elements *X*, *Y* and *Z* respectively. *X*, *Y* and *Z* are in the same period of the periodic table. *U* gives a white precipitate with NaOH but this white precipitate dissolves as more NaOH is added. When NaOH is added to *T*, a white precipitate forms which does not dissolve when more base is added. *S* does not give precipitate with NaOH.

Which of the following statements are correct ?

(a) The three elements are metals
(b) The electronegativity decreases from *X* to *Y* to *Z*.
(c) *X*, *Y* and *Z* could be sodium, magnesium and aluminium respectively.
(d) The first ionization increases from *X* to *Y* to *Z*.

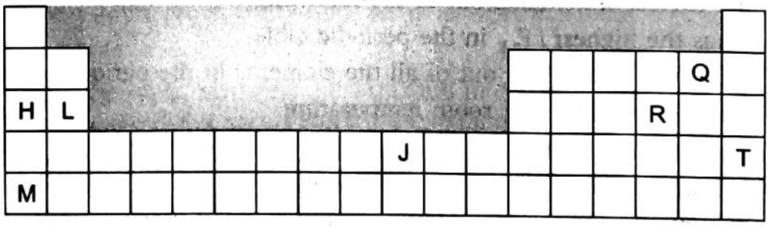
7. The diagram below shows part of the skeleton of the periodic table in which elements are indicated by letters which are not their usual symbols.



Answer the following on the basis of modern periodic table :

(I) Alkali metal(s)
(II) An elements with the outer configuration of d^8s^2
(III) Lanthanoids
(IV) Representative element(s)
(V) Elements with incomplete *f*-subshell
(VI) Halogen(s)
(VII) *s*-block element(s)
(VIII) Transition element(s)
(IX) Noble gase(s)
(X) Non-transition element(s)

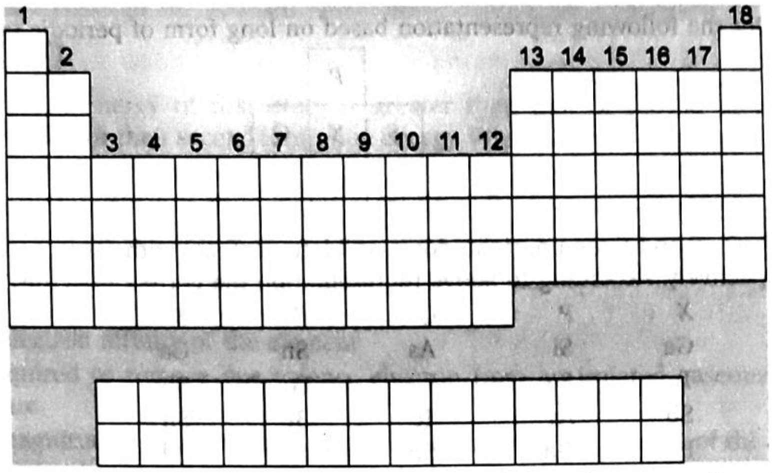
8. The diagram below shows part of the skeleton of the periodic table in which elements are indicated by letters which are not their usual symbols.



Answer the following on the basis of periodic table :

(I) Element having greatest ionic character in its compound
(II) Metal cation which is coloured in its aqueous solution
(III) Element(s) of which carbonate salt is/are water soluble
(IV) Which element is monoatomic gas at room temperature

9. Answer the following on the basis of modern periodic table.



(I) Group no. of the elements with the valence shell ground state electron configuration ns^2np^5

(II) Group no. of the elements with the valence shell ground state electron configuration ns^2np^3

(III) Group no. of the elements that have only three unpaired p electron in ground state

(IV) Alkaline earth metals

(V) Group 3A elements

10. Which of the following statements concerning elements with atomic number 10 is true?
(a) It forms a covalent network solid
(b) Element is monoatomic
(c) It has a almost zero value of electron affinity
(d) It has extremely high value of ionization energy

11. Which of the following pairs of elements have same number of electrons in their outermost shell ?
(a) Mn, Fe (b) Na, Sr (c) As, Bi (d) Se, Te

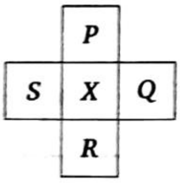
12. A change of Zn to Zn^{2+} is a accompanied by a decrease in :
(a) number of valence electrons (b) atomic mass
(c) atomic number (d) number of shells

13. The elements which are radioactive and have been named after the names of planets are :
(a) Hg (b) Np (c) Pu (d) Ra

14. The properties which are common to both groups 1 and 17 elements in the periodic table are :
(a) Electropositive character increases down the groups
(b) Reactivity decreases from top to bottom in these groups
(c) Atomic radii increases as the atomic number increases
(d) Electronegativity decreases on moving down a group

15. There are three elements A, B and C. Their atomic number are Z_1, Z_2 and Z_3 respectively. If $Z_1 - Z_2 = 2$ and $\frac{Z_1 + Z_2}{2} = Z_3 - 2$ and the electronic configuration of element A is $[Ar]3d^6 4s^2$, then correct order of magnetic momentum is/are :
(a) $B^+ > A^{2+} > C^{2+}$ (b) $A^{3+} > B^{2+} > C$
(c) $B > A > C^{2+}$ (d) $B = A^{3+} > C^{3+}$

16. Consider the following representation based on long form of periodic table.



Here P, Q, R and S are up, right, down and left elements with respect to the central element 'X' respectively. According to above representation the correct match is/are :

	X	P	Q	R	S
(a)	Ge	Si	As	Sn	Ga
(b)	Te	Se	I	Po	Sb
(c)	Sb	As	Te	Bi	Sn
(d)	In	Ga	Sn	Tl	Cd

17. Which of the following match is/are correct regarding B, Al, C and S elements?

(a) The highest first ionisation enthalpy : C

(b) The largest atomic size : Al

(c) The most negative electron gain enthalpy : C

(d) The most metallic character : Al

18. Consider the value of all four quantum number for last electron and spin multiplicity $(2s+1)$ for given two element 'X' and 'Y' in their ground state :

	n	l	m	s	$\|2s+1\|$
X:	2	0	0	$+1/2$	1
Y:	2	1	-1	$-1/2$	4

The according to given information the correct statement is :

(a) The bond angle ($H-Y-H$) of possible hydride of element Y is less than 109°28'

(b) The possible halide of 'X' has two vacant p-orbitals on its central atom.

(c) Magnetic moment of Y is greater than X

(d) X and Y element exhibits only single oxidation state

19. An element 'X' present in its ground state, the value of principal and azimuthal quantum number for last electron of element 'X' is $n=3$ and $l=1$ and spin multiplicity for given element is 4. Then according to given information correct statement(s) regarding given element 'X' is/are :

(a) Element 'X' is 3rd period and 15th group element

(b) In valence shell of element 'X' electron density is symmetrically distributed.

(c) Element 'X' has full filled valence shell.

(d) None of the above

Atomic/Ionic Radius

20. Which of the following pairs have approximately the same atomic radii?

(a) Zr and Hf (b) Al and Mg (c) Al and Ga (d) Na and Ne

21. The correct order of radii is/are :

(a) $Pb > Pb^{2+} > Pb^{4+}$

(b) $In^{+} > Sn^{2+} > Sb^{3+} > Te^{4+}$

(c) Co > Ni > Cu > Zn

(d) $K^{+} > Li^{+} > Mg^{2+} > Al^{3+}$

Ionisation Energy

22. The first ionisation energy of first atom is greater than that of second atom, whereas reverse order is true for their second ionisation energy. Which set of elements is in accordance to above statement ?

(a) C > B (b) P > S (c) Be > B (d) Mg > Na

23. Ionization energy of an element is :

(a) Equal in magnitude but opposite in sign to the electron gain enthalpy of the cation of the element

(b) Same as electron affinity of the element

(c) Energy required to remove one valence electron from an isolated gaseous atom in its ground state

(d) Equal in magnitude but opposite in sign to the electron gain enthalpy of the anion of the element

24. Consider the following ionization steps :

$$M(g) \longrightarrow M^+(g) + e^-; \quad \Delta H = +100 \text{ eV}$$

$$M(g) \longrightarrow M^{2+}(g) + 2e^-; \quad \Delta H = +250 \text{ eV}$$

Select correct statement(s) :

(a) I.E.$_1$ of $M(g)$ is 100 eV (b) I.E.$_1$ of $M^+(g)$ is 150 eV

(c) I.E.$_2$ of $M(g)$ is 250 eV (d) I.E.$_2$ of $M(g)$ is 150 eV

25. Select the correct order of periodic properties of species :

(a) $Fe^{2+} < Fe^{3+}$: ionic radii (b) N < O : second ionisation energy

(c) Cu < Zn : atomic radius (d) In < Tl : first ionisation energy

26. Select the incorrect statement(s)/order(s) :

(a) *d*-orbital can accommodate 10 electrons

(b) $\underset{2s^22p^63s^1}{\text{Na}} \xrightarrow{\text{I.E.}_1} \underset{2s^22p^6}{\text{Na}^+} \xrightarrow{\text{I.E.}_2} \underset{2s^22p^5}{\text{Na}^{2+}} \xrightarrow{\text{I.E.}_3} \underset{2s^22p^4}{\text{Na}^{3+}}$, order of successive I.E. is I.E.$_1$ < I.E.$_2$ > I.E.$_3$

(c) Number of unpaired electrons in Co^{2+} cation > Number of unpaired electrons in Co^{3+} cation

(d) First ionisation energy of Pt is greater than that of Pd

27. Consider the following values of I.E.(eV) for elements *W* and *X* :

Element	I.E.$_1$	I.E.$_2$	I.E.$_3$	I.E.$_4$
W	10.5	15.5	24.9	79.8
X	8	14.8	78.9	105.8

Other two element *Y* and *Z* have outer electronic configuration ns^2np^4 and ns^2np^5 respectively. Then according to given information which of the following compound(s) is/are not possible?

(a) W_2Y_3 (b) X_2Y_3 (c) WZ_2 (d) XZ_2

28. The sum of IE$_1$ and IE$_2$, IE$_3$ and IE$_4$ for element *P* and *Q* are given below :

	IE$_1$ + IE$_2$	IE$_3$ + IE$_4$
(*P*)	2.45	8.82
(*Q*)	2.85	6.11

Then according to the given information the correct statement(s) is/are :

(a) P^{2+} is more stable than Q^{2+} (b) P^{2+} is less stable than Q^{2+}

(c) P^{4+} is more stable than Q^{4+} (d) P^{4+} is less stable than Q^{4+}

29. Consider value of all four quantum number of last electrons and magnetic moment and valence electrons of elements W, X, Y and Z in their ground state :

Element	***n***	***l***	***m***	***s***	**Magnetic moment (μ)**	**Valence electrons**
W	3	0	0	$+\frac{1}{2}$	0	2
X	3	1	+1	$-\frac{1}{2}$	$\sqrt{3}$	3
Y	3	1	−1	$+\frac{1}{2}$	$\sqrt{15}$	5
Z	3	1	0	$-\frac{1}{2}$	$\sqrt{8}$	6

Then according to given information the correct statement(s) is/are :

(a) $I.E._1$ of element W is greater than $I.E._1$ of element X

(b) $I.E._1$ of element Y is greater than $I.E._1$ of element Z

(c) $I.E._2$ of element X is greater than $I.E._2$ of element W

(d) $I.E._2$ of element Z is greater than $I.E._2$ of element Y

30. Consider the successive ionisation energy for an element 'A'.

IE_1, IE_2, IE_3, IE_4, IE_5 are 100 eV, 150 eV, 181 eV, 2000 eV, 2200 eV.

Select correct statement(s) for element 'A' :

(a) Element 'A' may be metal

(b) Element 'A' may form trivalent cation

(c) Oxide of element 'A' may be amphoteric

(d) Element 'A' may be non-metal

31. According to Slater's rule, correct order of $Z_{eff.}$ on valence shell electron is :

(a) $Fe > Fe^{2+} > Fe^{3+}$ (b) $N^{3-} < O^{2-} < F^-$

(c) $Na^+ < Mg^{2+} < Al^{3+}$ (d) $Tl^{2+} < V^{3+} < Mn^{5+}$

Electronaffinity

32. Which of the following order is/are correct?

(a) Mg^{2+} (size) > Li^+ (size) (b) S (E.A.)>O(E.A.)

(c) Hg (I.E.)>Cd(I.E.) (d) P(I.E.)>S(I.E.)

33. Correct order of electron affinity is/are:

(a) S > O (b) Al > B (c) Mg > Na (d) P > N

34. Which of the following statement(s) is/are correct?

(a) van der Waals' radius of iodine is more than its covalent radius.

(b) All isoelectronic ions of corresponding elements belong to the same period of the periodic table.

(c) IE of N-atom is higher than that of O-atom, while IE_2 of O-atom is higher than that of N-atom.

(d) The electron affinity of fluorine is greater than that of chlorine.

35. Electron affinity of the elements or ions shown correctly?

(a) $S > O^-$ (b) $P > N^-$ (c) $O^- > S^-$ (d) $N^- > P$

36. Which of the following statement regarding halogens is/are correct?

(a) Ionization energy decreases with increase in atomic number
(b) Electronegativity decreases with increase in atomic number
(c) Electron affinity decreases with increase in atomic number
(d) Enthalpy of fusion increases with increase in atomic number

37. Which of the following statements are correct?

(a) F is the most electronegative and Cs is the most electropositive element
(b) The ionization energy of halogens decreases from F to I
(c) The electron affinity of Cl is higher than that of F through their electronegativities are in the reverse order
(d) The electron affinity of noble gases is almost zero

38. Consider the order $O^{2-} < F^+ < Na^+ < Mg^{2+}$. Then correct statement(s) is/are :

(a) Increasing order of Z_{eff}
(b) Increasing order of size
(c) Increasing order of I.E.
(d) Increasing order of E.A.

39. Consider the following reactions :

(i) $O_{(g)} + e^- \longrightarrow O^-_{(g)},\ \Delta H_1$
(ii) $F_{(g)} + e^- \longrightarrow F^-_{(g)},\ \Delta H_2$
(iii) $Cl_{(g)} + e^- \longrightarrow Cl^-_{(g)},\ \Delta H_3$
(iv) $O^-_{(g)} + e^- \longrightarrow O^{2-}_{(g)},\ \Delta H_4$

Then according to given information the correct statement is/are:

(a) ΔH_3 is more negative than ΔH_1 and ΔH_2
(b) ΔH_1 is less negative than ΔH_2
(c) $\Delta H_1, \Delta H_2$ and ΔH_3 are negative whereas ΔH_4 is positive.
(d) ΔH_1 and ΔH_3 are negative whereas ΔH_2 and ΔH_4 are positive.

40. Which of the following is incorrect order of property as indicated ?

(a) $Na^+ < F^- < O^{2-} < Ne < Ar$: Atomic size
(b) Br < Se < As < Ge : Metallic character
(c) Na < Al < Si < Mg : Ionisation energy
(d) I < Br < Cl < F : Electron affinity

41. Which of the following is/are correct order ?

(a) Atomic radius : $F < O < F^- < O^{2-}$
(b) 2nd ionisation energy : C < N < F < O
(c) Electron affinity : I < Br < F < Cl
(d) Z_{eff} (effective nuclear change) : $Al < Al^+ < Al^{3+} < Al^{2+}$

42. Consider the following sequence of reaction :

$$\begin{tikzcd}
X^- \arrow[r, bend left, "\Delta H_5"] & X \arrow[l, "\Delta H_1"'] \arrow[r, "\Delta H_1"] & X^+ \arrow[r, "\Delta H_2"] \arrow[l, bend left, "\Delta H_6"] & X^{2+} \arrow[r, "\Delta H_3"] & X^{3+}
\end{tikzcd}$$

If electronic configuration of element X is $[Ne]3s^1$, then which of the following order is correct regarding given enthalpies?

(a) $|\Delta H_4| = |\Delta H_5|$ (b) $|\Delta H_2| > |\Delta H_1|$
(c) $|\Delta H_2| > |\Delta H_3|$ (d) $|\Delta H_1| = |\Delta H_6|$

Electronegativity

43. The correct statement is/are :
(a) Zirconium (Zr) and hafnium (Hf) have almost same size
(b) Correct order of ionisation energy of coinage metals is : Cu > Ag < Au
(c) Carbon atom in CCl_4 is more electronegative than carbon atom in CF_4
(d) Pb^{2+} is more stable than Pb^{4+}

44. Which of the following statements is true about electronegativity?
(a) Electronegativity of an element depends upon its effective nuclear charge
(b) Electronegativity of a cation is proportional to charge on the cation
(c) Electronegativity increases as the *s*-character in hybrid orbital increases
(d) Electronegativity of a anion is proportional to charge on the anion

45. Which of the following elements have the similar value of electronegativity?
(a) H (b) S
(c) Te (d) P

46. Which of the following parameters cannot be estimated by using Born-Haber cycle?
(a) Hydration energy of ion (b) Electron gain enthalpy
(c) Lattice energy (d) Electronegativity

47. Select correct order(s) of electronegativity of element is/are :
(a) Paulling scale (E.N. of F-atom) > Mulliken scale (E.N. of F-atom)
(b) Cl_2O_7 (E.N. of Cl-atom) > Cl_2O_5 (E.N. of Cl-atom)
(c) CH_4 (E.N. of C-atom) > CO_2 (E.N. of C-atom)
(d) Cu^{2+} (E.N.) > Cu^+ (E.N.)

Hydration Energy

48. Choose the correct statement(s) :
(a) H^+ is the smallest size cation in the periodic table.
(b) van der Waals' radius of chlorine is more than covalent radius.
(c) Ionic mobility of hydrated Li^+ is greater than that of hydrated Na^+.
(d) He atom is having highest I.E. in the periodic table.

Lattice Energy

49. Select equations having endothermic step :
(a) $S^-(g) \longrightarrow S^{2-}(g)$
(b) $Na^+(g) + Cl^-(g) \longrightarrow NaCl(s)$
(c) $N(g) \longrightarrow N^-(g)$
(d) $Al^{2+}(g) \longrightarrow Al^{3+}(g)$

50. Consider the following Born-Haber's cycle :

$$\begin{tikzcd}
2B_{(s)} + \arrow[d, "\Delta H_2"'] & \frac{3}{2}X_{2(g)} \arrow[d, "\Delta H_3"] \arrow[r, "\Delta H_1"'] & B_2X_{3(s)} \\
2B_{(g)} \arrow[d, "\Delta H_4"'] & 3X_{(g)} \arrow[d, "\Delta H_5"] & \\
2B^{3+}_{(g)} \arrow[r, dash] & 3X^{2-}_{(g)} \arrow[uur, "\Delta H_6"'] &
\end{tikzcd}$$

(Where ΔH_1, ΔH_2, ΔH_3, ΔH_4, ΔH_5 and ΔH_6 are in kJ/mol)
Then according to given information the correct statement is/are :

(a) ΔH_2 and ΔH_3 are always positive

(b) $\Delta H_1 = 2\Delta H_2 + \frac{3}{2}\Delta H_3 + 2\Delta H_4 + 3\Delta H_5 + \Delta H_6$

(c) Second electron gain enthalpy of X is negative

(d) ΔH_1 must be negative for formation of $B_2X_3(s)$

Nature of Oxide

51. Which of the following oxides is/are amphoteric?

(a) Na_2O (b) CaO (c) Al_2O_3 (d) SnO_2

52. Which of the following show amphoteric behaviour?

(a) $Zn(OH)_2$ (b) $Be(OH)_2$

(c) $Al(OH)_3$ (d) $Pb(OH)_2$

MATCH THE COLUMN

Entries of Column-I are to be matched with entries of Column-II. Each entry of Column-I may have the matching with one or more than one entries of Column-II.

1.

Column-I (elements with at no.)	**Column-II (types of elements)**
(A) *X* (at. no. = 52)	(P) Inner-transition element
(B) *Y* (at. no. = 57)	(Q) Representative element
(C) *Z* (at. no. = 48)	(R) Non-transition element
	(S) *d*-block element

2.

Column-I	**Column-II**
(A) Increasing order of I.E.	(P) $F < O < S < Se$
(B) Increasing order of electron affinity	(Q) $O < N < F < Ne$
(C) Increasing order of atomic size	(R) $Na < Mg < Al < Si$
	(S) $O^{2-} < O^{-} < O < O^{+}$

3.

Column-I	**Column-II**
(A) $F > Cl > Br > I$	(P) Ionisation energy
(B) $Fe^{3+} > Fe^{2+} > Fe$	(Q) Size
(C) $I^{-} > I > I^{+}$	(R) Magnitude of ΔH_{eg}
(D) $O > C > B > N$	(S) Effective nuclear charge

4.

	Column-I		**Column-II**
	$(IE)_1$	$(IE)_2$	
(A)	2372	5251	(P) More reactive metal
(B)	520	7300	(Q) Reactive non-metal
(C)	900	1760	(R) Noble gas
(D)	1680	3380	(S) Metal forms a stable binary halide of the formula AX_2
			(T) Exhibit+2 electrovalency

5.

Column-I (atomic number of element)	Column-II (IUPAC name)
(A) 105	(P) Uun
(B) 107	(Q) Uns
(C) 109	(R) Unp
(D) 110	(S) Une

6.

Column-I (atomic number)	Column-II (position in the periodic table)
(A) 52	(P) *s*-block
(B) 56	(Q) *p*-block
(C) 57	(R) *d*-block
(D) 60	(S) *f*-block

7.

Column-I (type of elements)	Column-II (outer electronic configuration)
(A) Inert gas elements	(P) ns^{1-2} to ns^2np^5
(B) Representative elements	(Q) $1s^2$ and ns^2np^6
(C) Transition elements	(R) $(n-2)\,f^{1-14}\,(n-1)\,d^{1\text{ or }0}\,ns^2$
(D) Inner transition elements	(S) $(n-1)\,d^{1-10}\,ns^{1\text{ or }2}$

8.

Column-I (elements)	Column-II (periodic properties)
(A) F	(P) Maximum ionization energy
(B) Cl	(Q) Maximum electronegativity
(C) Fe	(R) Maximum electron affinity
(D) He	(S) Variable oxidation state

9.

Column-I	Column-II
(A) Fullerene	(P) Actinoids
(B) Promethium	(Q) Lewis base
(C) Water	(R) Allotrope
(D) Lawrencium	(S) Lanthanoids

10.

Column-I	Column-II
(A) $1s^2,2s^22p^6,3s^23p^1$	(P) Largest $(I.E.)_1$
(B) $1s^2,2s^22p^6,3s^23p^5$	(Q) Largest $(I.E.)_4$
(C) $1s^2,2s^22p^6,3s^23p^6,4s^1$	(R) Largest $(I.E.)_3$
(D) $1s^2,2s^22p^6,3s^23p^6$	(S) Lowest $(I.E.)_1$
	(T) Largest $(I.E.)_2$

11.

Column-I (Electronic configuration)	Column-II (Corresponding elements)
(A) $[Xe]4f^{14}5d^{10}6s^2$	(P) *s*-block element
(B) $[Rn]5f^{14}6d^1 7s^2$	(Q) Transition element
(C) $[Xe]4f^{14}5d^{10}6s^26p^67s^2$	(R) *d*-block element
(D) $[Xe]4f^{14}5d^26s^2$	(S) Representative element
	(T) Inner-transition element

12.

Column-I Elements (Electrons in K, L, M, N...)	Column-II Statements
(A) $W(2,8,7)$	(P) Paramagnetic
(B) $X(2,8,18,8)$	(Q) 3rd group element
(C) $Y(2,8,14,2)$	(R) Last electron does not enter to valence shell
(D) $Z(2,8,18,25,8,2)$	(S) Reactive non-metal
	(T) Diamagnetic

13.

Column-I (Outer electronic configuration of element in ground state)	Column-II (Characteristics/period and group number in long from of periodic table)
(A) $(n-1)d^5ns^1$	(P) Highest spin magnetic moment
(B) $(n-1)d^1ns^2$	(Q) 6th period element
(C) ns^2np^3	(R) Period number and group number are same
(D) $(n-2)f^1(n-1)d^1ns^2$	(S) Period number is double than group number
	(T) Symmetrical distribution of electron density

ASSERTION-REASON TYPE QUESTIONS

These questions consist of two statements each, printed as assertion and reason, while answering these questions you are required to choose any one of the following responses.

(A) If both assertion and reason are true and the reason is the correct explanation of assertion

(B) If both assertion and reason are true but reason is not the correct explanation of assertion

(C) If assertion is true but the reason is false

(D) If assertion is false but the reason is true

1. **Assertion :** In CsF salt, size of Cs^+ is slight higher than size of F^-.
   Reason : Cs^+ is largest monoatomic cation and F^- is smallest anion.
2. **Assertion :** First electron affinity of all elements is positive.
   Reason : Successive electron affinity of all elements is negative.
3. **Assertion :** Helium atom has highest ionisation energy among all the elements.
   Reason : Helium is smallest atom among all the elements.
4. **Assertion :** F^- ion has highest hydrated radius among the other halide ions.
   Reason : Ionic radius of F^- is smallest in the periodic table.
5. **Assertion :** Magnitude of electron gain enthalpy of oxygen is less than that of fluorine but greater than that of nitrogen.
   Reason : Ionisation enthalpy order is as follows : $N > O < F$.
6. **Assertion :** Formation of Cl^- ion is exothermic whereas O^{2-} ion formation is endothermic.
   Reason : EA_2 of oxygen is endothermic and greater than its exothermic EA_1 value of oxygen.
7. **Assertion :** The electron gain enthalpy of N is +ve while that of P is –ve.
   Reason : Smaller atomic size of N in which there is a considerable electron-electron repulsion and hence the additional electron is not accepted easily.
8. **Assertion :** The formation of $F^-_{(g)}$ from $F_{(g)}$ is exothermic, whereas that of $O^{2-}_{(g)}$ from $O_{(g)}$ is endothermic.
   Reason : The addition of second electron to a monovalent anion is difficult because both have the same charge and experience more repulsion.
9. **Assertion :** Na^+ and Al^{3+} are isoelectronic but ionic radius Al^{3+} is less than that of Na^+.
   Reason : The magnitude of effective nuclear charge on the outershell electrons in Al^{3+} is greater than that in Na^+.
10. **Assertion :** The third period contains only 8 electrons and not 18 like 4th period.
    Reason : In III period filling starts from $3s^1$ and complete at $3p^6$ whereas in IV period it starts from $4s^1$ and complete after $3d^{10}$ and $4s^2$.
11. **Assertion :** Cs and F_2 combines violently to form CsF.
    Reason : Cs is most electropositive and F is most electronegative.
12. **Assertion :** Second E.A. for halogens is almost zero.
    Reason : Fluorine has maximum value of electron affinity.

13. Assertion : F atom has less electron affinity than Cl atom.
Reason : Additional electrons are repelled more strongly by 3*p* electrons in Cl atom than by 2*p* electrons in F atom.

14. Assertion : Among the halogens bond energy of F_2 is minimum.
Reason : Among halogens F atom is small in size.

15. Assertion : The first ionization energy of Be is greater than that of B.
Reason : 2*p*-orbital is lower in energy than 2*s*-orbital.

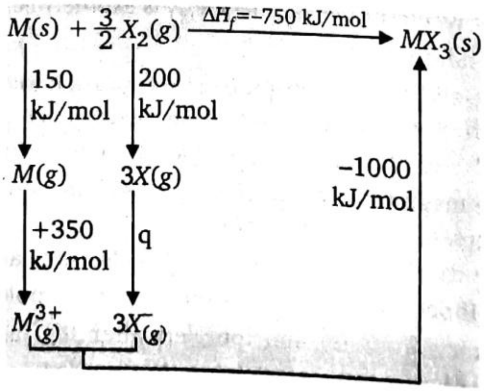
16. Assertion : Noble gases have highest ionization enthalpies in their respective periods.
Reason : Noble gases have stable closed shell electronic configuration.

17. Assertion : Helium and beryllium have similar outer electronic configuration of the type ns^2.
Reason : Both are chemically inert.

18. Assertion : The first ionization enthalpy of aluminium is lower than that of magnesium.
Reason : Ionic radius of aluminium cation is smaller than that of magnesium cation.

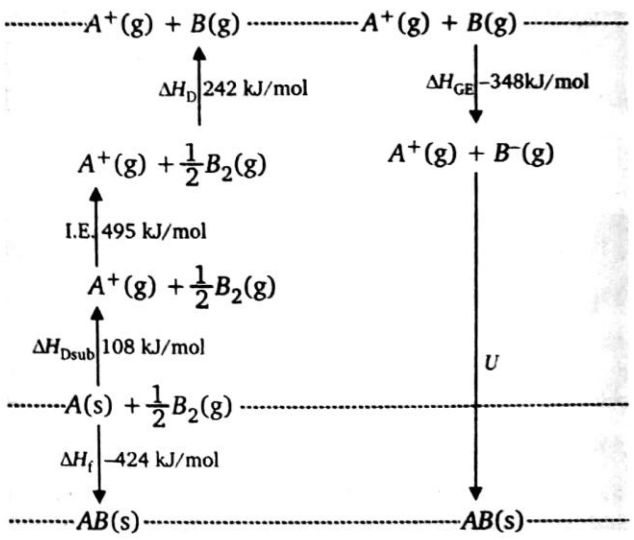
SUBJECTIVE PROBLEMS

1. The number of electrons for Zn^{2+} cation that have the value of azimuthal quantum number = 0 is :
2. Calculate the electronegativity of silicon atom using Allred-Rochow's method. If covalent radius of silicon is 1.0A. (rounded in nearest integer value)
3. If heat of solution for $AB(s)$ is -0.95×10^{x} kcal/mol and lattice energy for $AB(s)$ is 700 kcal/mol and hydration energy for $A^{+}(g)$ is –1000 kcal/mol and $B^{-}(g)$ is –650 kcal/mol then calculate value of x.
4. Consider the following Born-Haber's cycle for formation of $MX_3(s)$.



Then calculate value $\frac{q_1}{50}$, here q_1 is electron affinity of $X(g)$ in kJ/mol.

5. Calculate the value of $-U/100$, for $AB(s)$, from following data of Born-Haber's cycle. [where U is lattice energy in kJ/mol]



6. Consider the following orders :

(i) HF > HCl > HBr > HI : Lewis basic character

(ii) $CH_4 < CCl_4 < CF_4$: Electronegativity of central 'C'-atom

(iii) $Mg^{2+} < K^+ < S^{2-} < Se^{2-}$: Ionic radius

(iv) Ni > Pd > Pt : Ionisation energy

(v) $As^{5+} > Sb^{5+} > Bi^{5+}$: Stable oxidation state

(vi) LiF > NaF > KF > RbF: Lattice energy

(vii) $F^-_{(aq.)} > Cl^-_{(aq.)} > Br^-_{(aq.)} > I^-_{(aq.)}$: Electrical conductance

(viii) $Li^+ < Mg^{2+} < Al^{3+}$: Hydration energy

(ix) Cl > Br > F > I : Electron affinity

(x) $BeCl_2 < AlCl_3 < SiCl_4$: Lewis acidic character

Then calculate value of $|x - y|^2$, where x and y are correct and incorrect orders respectively.

7. Find out total number of representative elements in the given elements :

Cd, Nb, Ta, Te, Ra, Mo, Po, Pd, Tc

8. An element 'X' has its electronic configuration of 'K' shell is $(n-5)s^2$ and it has total number of electrons in its outermost, penultimate and antipenultimate shell are 2, 8 and 25 respectively, then find out total number of unpaired electrons in element 'X' in their ground state.

9. If value of spin quantum number(s) $= -1/2, 0, +1/2$ then calculate number of groups in the new form of periodic table if all other rules of electronic configurations are remain same.

10. How many pairs are, in which first species has lower ionisation energy than second species:

(i) N and O
(ii) Br and K
(iii) Be and B
(iv) I and I^-
(v) Li and Li^+
(vi) O and S
(vii) Ba and Sr

11. Total number of element(s) which have only single oxidation state (other than zero) in their corresponding stable compounds : Cs, Ba, F, Zn, Be, Al, Sr, Ga, Pb

ANSWERS

Level 1

1. (b)	**2.** (a)	**3.** (c)	**4.** (c)	**5.** (a)	**6.** (b)	**7.** (d)	**8.** (c)	**9.** (c)	**10.** (d)
11. (b)	**12.** (a)	**13.** (a)	**14.** (b)	**15.** (c)	**16.** (c)	**17.** (c)	**18.** (c)	**19.** (b)	**20.** (d)
21. (c)	**22.** (d)	**23.** (d)	**24.** (c)	**25.** (b)	**26.** (b)	**27.** (b)	**28.** (c)	**29.** (b)	**30.** (c)
31. (b)	**32.** (c)	**33.** (d)	**34.** (c)	**35.** (d)	**36.** (c)	**37.** (c)	**38.** (b)	**39.** (d)	**40.** (b)
41. (a)	**42.** (a)	**43.** (b)	**44.** (b)	**45.** (b)	**46.** (b)	**47.** (d)	**48.** (a)	**49.** (c)	**50.** (d)
51. (b)	**52.** (c)	**53.** (c)	**54.** (b)	**55.** (c)	**56.** (c)	**57.** (b)	**58.** (a)	**59.** (d)	**60.** (b)
61. (c)	**62.** (c)	**63.** (a)	**64.** (c)	**65.** (b)	**66.** (a)	**67.** (b)	**68.** (c)	**69.** (a)	**70.** (d)
71. (d)	**72.** (b)	**73.** (b)	**74.** (c)	**75.** (b)	**76.** (d)	**77.** (a)	**78.** (b)	**79.** (a)	**80.** (b)
81. (a)	**82.** (b)	**83.** (c)	**84.** (a)	**85.** (a)	**86.** (b)	**87.** (c)	**88.** (d)	**89.** (a)	**90.** (d)
91. (a)	**92.** (c)	**93.** (c)	**94.** (a)	**95.** (a)	**96.** (d)	**97.** (a)	**98.** (d)	**99.** (a)	

Level 2

1. (b)	**2.** (d)	**3.** (c)	**4.** (b)	**5.** (a)	**6.** (b)	**7.** (c)	**8.** (c)	**9.** (c)	**10.** (a)
11. (d)	**12.** (c)	**13.** (b)	**14.** (b)	**15.** (d)	**16.** (b)	**17.** (c)	**18.** (c)	**19.** (d)	**20.** (c)
21. (a)	**22.** (c)	**23.** (d)	**24.** (d)	**25.** (b)	**26.** (b)	**27.** (d)	**28.** (b)	**29.** (c)	**30.** (d)
31. (d)	**32.** (d)	**33.** (c)	**34.** (a)	**35.** (a)	**36.** (d)	**37.** (b)	**38.** (c)	**39.** (c)	**40.** (b)
41. (b)	**42.** (b)	**43.** (b)	**44.** (d)	**45.** (d)	**46.** (c)	**47.** (a)	**48.** (a)	**49.** (c)	**50.** (b)
51. (c)									

Level 3

Passage-1	**1.** (a)	**2.** (b)	**3.** (c)
Passage-2	**1.** (b)	**2.** (d)	**3.** (d)
Passage-3	**1.** (a)	**2.** (c)	**3.** (b)
Passage-4	**1.** (d)	**2.** (b)	**3.** (d)

Passage–5	1.	(b)	2.	(b)	3.	(c)	4.	(a)	5.	(b)	6.	(a)
Passage–6	1.	(b)	2.	(d)	3.	(a)	4.	(c)				
Passage–7	1.	(c)	2.	(b)	3.	(d)	4.	(d)				
Passage–8	1.	(b)	2.	(b)	3.	(d)						
Passage–9	1.	(c)	2.	(d)	3.	(b)						
Passage–10	1.	(d)	2.	(c)	3.	(d)						
Passage–11	1.	(c)	2.	(d)	3.	(c)						
Passage–12	1.	(b)	2.	(a)	3.	(d)						
Passage–13	1.	(d)	2.	(d)	3.	(c)						
Passage–14	1.	(d)	2.	(d)								
Passage–15	1.	(c)	2.	(c)								

One or More Answers is/are correct

1. (b, c, d) **2.** (a, d) **3.** (a, c) **4.** (b, c, d) **5.** (a, b, c) **6.** (a, c)

7. (I) (B) (II) H (III) A (IV) B, C, F, J, I (V) A (VI) I
(VII) B, J (VIII) E, H, K (IX) G (X) L

8. (I) M (II) J^{2+} (III) H, M (IV) T

9. (I) 17 (II) 15 (III) 15 (IV) 2 (V) 13

10. (b, c, d) **11.** (c, d) **12.** (a, d) **13.** (b, c) **14.** (a, c, d) **15.** (a, b, c)

16. (a, b, c, d) **17.** (a, b, d) **18.** (a, b, c) **19.** (a, b) **20.** (a, c) **21.** (a, b, d)

22. (a, b, c, d) **23.** (a, c) **24.** (a, b, d) **25.** (b, c, d) **26.** (a, b, c) **27.** (b, c)

28. (a, d) **29.** (a, b, c, d) **30.** (a, b, c, d) **31.** (b, c, d) **32.** (b, c, d) **33.** (a, b)

34. (a, c) **35.** (a, b) **36.** (a, b, d) **37.** (a, b, c, d) **38.** (a, c, d) **39.** (a, b, c)

40. (b, c, d) **41.** (a, b, c) **42.** (a, b, d) **43.** (a, b, d) **44.** (a, b, c) **45.** (a, c, d)

46. (a, d) **47.** (a, d) **48.** (a, b, d) **49.** (a, c, d) **50.** (a, b, d) **51.** (c, d)

52. (a, b, c, d)

Match the Column

1. A→ Q; B→ S; C→ R, S
2. A→ Q; B→ S; C→ P
3. A→ P, S; B→ P, R, S; C→ Q; D→ R
4. A→ R; B→ P; C→ S, T; D→ Q
5. A→ R; B→ Q; C→ S; D→ P
6. A→ Q; B→ P; C→ R; D→ S
7. A→ Q; B→ P; C→ S; D→ R
8. A→ Q; B→ R; C→ S; D→ P
9. A→ R; B→ S; C→ Q; D→ P
10. A→ Q; B→ R; C→ S, T; D→ P
11. A→ R; B→ T; C→ P, S; D→ Q, R
12. A→ P, S; B→ T; C→ P, R; D→ P, Q, R
13. A→ P, Q, R, T; B→ Q, S; C→ Q, T; D→ Q, S

Assertion-Reason Type Questions

1. (A) **2.** (D) **3.** (C) **4.** (A) **5.** (B) **6.** (A) **7.** (A) **8.** (A) **9.** (A) **10.** (A)

11. ([illegible]) **12.** (C) **13.** (C) **14.** (D) **15.** (C) **16.** (A) **17.** (C) **18.** (B)

Subjective Problems

1. (6) **2.** (2) **3.** (3) **4.** (4) **5.** (8) **6.** (16) **7.** (3) **8.** (7) **9.** (27) **10.** (2)

11. (7)

Hints and Solutions

Level 1

26. (b) Ununtrium for atomic number = 113; for$Z > 86$ pd. no. = 7

$113\,[\text{Rn}]7s^2,5f^{14},6d^{10},7p^1$

p-block

27. (b) Tantalum ($Z = 73$) is a transition element.

28. (c)

Period number	Group number	Element
5	7	Tc
6	13	Tl
6	5	Ta

30. (c) $[\text{Xe}]4f^{14}5d^1 6s^2$

Atomic number = 71 Period number = 6th Group number = 3rd

31. (b) Rubidium is most electropositive in nature.

32. (c) (a) Cr : $4s^1 3d^5$ (each d-orbital has $1e^-$)

(b) Fe^{3+} : $4s^0 3d^5$ (each d-orbital has $1e^-$)

(c) Cu^+: $4s^0 3d^{10}$ (each d-orbital has $2e^-$)

33. (d) Magnetic moment $= \sqrt{n(n+2)}$ BM

N : Number of unpaired e^-

As atomic number increases in d-block element number of unpaired e^- first increases upto middle then decreases.

34. (c) "Unununium" : At number = 111

It is a transition element. Period number = 7th; Group number = 11

35. (d) Atomic radius and metallic character decreases from left to right across the period and increases from top to bottom down the group.

36. (c) P is trivalent non-metal Q is divalent metal hence formula of compound is P_2Q_3.

37. (c) $1s^2,2s^2 2p^2,3s^1$ (Excited state)

47. (d) In (a) and (b) use (z/e) concept for isoelectronic specie.

In (c) size of neutral atom is greater than its cation.

In (d) Se^{2-} and As^{3-} related with 4th period, while Ba^{2+} and Cs^+ related with 6th period. (These are not isoelectronic species.)

48. (a) (a) Sc > Ti > V > Cr (size decrease initially in $3d$-series)

(b) Correct order : Zn > Cu > CO ≈ Ni

(c) Correct order : $\text{S}^{2-} > \text{Cl}^- > \text{N}^{3-} > \text{O}^{2-}$

49. (c) Due to diagonal relationship radius of Li^+ is close to Mg^{2+} ion.

74. (c) The correct order of IE_2 is Ne > O > F > N

75. (b) If we consider the opposite process :

(a) $\text{F}_{(g)} + e^- \longrightarrow \text{F}^-_{(g)}$; ΔH_1

(b) $\text{P}_{(g)} + e^- \longrightarrow \text{P}^-_{(g)}$; ΔH_2

(c) $\text{S}_{(g)} + e^- \longrightarrow \text{S}^-_{(g)}$; ΔH_3

(d) $\text{Cl}_{(g)} + e^- \longrightarrow \text{Cl}^-_{(g)}$; ΔH_4

Order of energy releases is : $\Delta H_4 > \Delta H_1 > \Delta H_3 > \Delta H_2$

So, $P^-_{(g)} \longrightarrow P_{(g)} + e^-$; Requires least energy.

84. (a) Correct order of electron affinity is : $Cl > F > S > O$

Electron affinity of 2nd period non-metals is less than that of respective 3rd period non-metals.

85. (a) Nitrogen has stable $2p^3$ configuration and also due to high e^- charge density at outermost orbital it requires energy to add one extra e^- in its outer most shell *i. e.*, its first electron gain enthalpy is positive.

88. (d) According to Allred and Rochow scale

(c) $EN_{(AR)} = 0.359 \frac{Z_{eff.}}{r} + 0.744$ (r : radius in Å)

95. (a) LiF is sparingly soluble at room temperature due to its high lattice energy.

99. (a) Oxidation state of non-metal increases acidic nature of oxide increase $\overset{+7}{Cl_2}O_7$ is most acidic.

Level 2

1. (b) Sum of oxidation numbers of all atoms in a neutral molecule is zero.

$\rightarrow A_3(B_4C)_2 : +2 \times 3 + 2 \times [4 \times 5 - 2] = 42 \neq 0$

$\rightarrow A_3(BC_4)_2 : +2 \times 3 + 2 \times [+5 - 8] = 0$

$\rightarrow A_2(BC_3)_2 : +2 \times 2 + 2 \times [+5 - 6] = +2 \neq 0$

$\rightarrow ABC_2 : +2 + 5 + (-2) \times 2 = +3 \neq 0$

2. (d) W : Phosphorus Y : Oxygen X : Sulphur Z : Chlorine

Electronegativity : $O > Cl > S > P$ Catenation : $S > P > O > Cl$

Electron Affinity : $Cl > O > S > P$ Oxygen exhibits covalency of two only

4. (b) (i) Alkali metal carbonates do not decompose even at red hot → V

(ii) Transition metal ions having unpaired d-electrons are coloured in aq. sol./compounds → X

(iii) In case of Kr van der Waals' radius is considered, which is largest atomic radius → Y

(iv) Si atom has only acid $SiO_2 \rightarrow W$

11. (d) (I) $[Kr]5s^1$, shows only single oxidation state +1

(II) $[Rn]5f^{14}6d^17s^2$, it is f-block element ($Z = 103$)

(III) The compound formed between I and III is ionic.

(IV) $[Ar]3d^64s^2$, ($Z = 26$) Fe shows variable oxidation state.

12. (c)

	Possible elements	Period number	Group number	Electronic configuration
(i)	H	1	1	$1s^1$
(ii)	Be	2	2	$1s^22s^2$

13. (b) As value of n increases, energy gap decreases due to increasing $Z_{eff.}$ on valence shell.

14. (b) Atomic radius and nuclear charge increases from top to bottom because number of shell and atomic mass increases down the group.

15. (d)

(a) $[Ar]3d^54s^1 \rightarrow Cr(24) \rightarrow$ 4th period, 6th group

(b) $[Kr]4d^{10} \rightarrow Pd(46) \rightarrow$ 5th period, 12th group

(c) $[Rn]6d^27s^2 \rightarrow Th(90) \rightarrow$ 7th period, 3rd group

(d) $[Xe]\,4f^{14}5d^26s^2 \rightarrow Hf(72) \rightarrow$ 6th period, 4th group

21. (a) Correct order : $La^{3+} > Gd^{3+} > Eu^{3+} > Lu^{3+}$

23. (d) Second ionization energy is amount of energy required to take out an electron from the monopositive cation.

Hence, $M(g) \longrightarrow M^{2+} + 2e^-$ ...(5)

$M(g) \longrightarrow M^+ + e^-$ ...(3)

31. (d) $A \Rightarrow H(1s^1)$

$B \Rightarrow He(1s^2)$

$C \Rightarrow Li(1s^2 2s^1)$

$A_1 = IE_1(A)$ $\quad B_2 = IE_2(B)$

$B_1 = IE_1(B)$ $\quad C_2 = IE_2(C)$

$C_1 = IE_1(C)$ $\quad C_3 = IE_3(C)$

$B_1 > A_1 > C_1$ $\quad C_3 > B_2 > A_1$ $\quad C_3 > C_2 > B_2$

$He > H > Li$ $\quad Li^{2+}\ He^+\ H$ $\quad Li^{2+}\ Li^+\ He^+$

$1s^2\ 1s^1\ 2s^1$ $\quad 1s^1\ 1s^1\ 1s^1$ $\quad 1s^2\ 1s^2\ 1s^1$

32. (d)

(a) $\underset{4p^4}{Se} \xrightarrow{I.E._1} \underset{4p^3}{Se^+} \xrightarrow{I.E._2} \underset{4p^2}{Se^{2+}}$ $\quad \underset{4p^3}{As} \xrightarrow{I.E._1} \underset{4p^2}{As^+} \xrightarrow{I.E._2} \underset{4p^1}{As^{2+}}$

(b) $\underset{2p^2}{C} \longrightarrow \underset{2p^1}{C^+} \longrightarrow \underset{2s^2}{C^{2+}}$ $\quad \underset{2p^3}{N} \longrightarrow \underset{2p^2}{N^+} \longrightarrow \underset{2p^1}{N^{2+}}$ $\quad \underset{2p^4}{O} \longrightarrow \underset{2p^3}{O^+} \longrightarrow \underset{2p^2}{O^{2+}}$

(c) $\underset{2p^5}{F} \xrightarrow{I.E._1} \underset{2p^4}{F^+} \xrightarrow{I.E._2} \underset{2p^3}{F^{2+}} \xrightarrow{I.E._3} F^{3+}$ $\quad \underset{2p^4}{O} \xrightarrow{I.E._1} \underset{2p^3}{O^+} \xrightarrow{I.E._2} \underset{2p^2}{O^{2+}} \xrightarrow{I.E._3} O^{3+}$

(d) In respective period, noble gases have highest I.E.

33. (c) R is p-block element, because difference between IE_2 and IE_3 is not very high as compared to between IE_1 and IE_2; hence stable oxidation state of R will be higher than $+2$.

43. (b) In the isoelectronic species, all isoelectronic anions belong to the same period and cations to the next period.

44. (d) Order of electron gain enthalpy : $Cl > F > O$

Second electron gain enthalpy for an element is always positive.

47. (a) The electronegativity difference between M_1 and O is 0.1, which indicates $M_1 - O$ bond will be covalent, since O—H bond having more ionic character thus bond will break and H^+ ions will release and acidic solution is formed. Whereas difference between electronegativity of $M_2 - O$ bond is 2.3, thus, M_2—OH bond will break. Hence, solution will be basic in nature.

48. (a) $I.E. + E.A. = 275 + 86 = 361 \text{ kcal mol}^{-1}$

$$= 361 \times 4.184 = 1510.42 \text{ kJ mol}^{-1}$$

$$\therefore \text{ Electronegativity} = \frac{1510.42}{540} = 2.797 = 2.8$$

50. (b)

(a) Correct order → $Ca^{2+} > K^+ > Cl^- > S^{2-}$ (Ionisation energy)

For isoelectronic species (I.E. $\propto Z_{eff}$)

(b) Correct order → $C < N < F < O$ (2^{nd}I.E.)

Second electron removal from oxygen requires more energy as it acquires stable $2s^2 2p^3$ configuration after removal of one electron.

(c) Correct order → $B > Tl > In > Ga > Al$ (Electronegativity)

In general EN increases in boron family from top to bottom due to increase in Z_{eff} on valence shell while boron has highest E.N. due to its vary small size.

(d) Correct order → $Na^+ > Li^+ > Mg^{2+} > Al^{3+} > Be^{2+}$ (Ionic radius)

Ionic radius depends on Z_{eff} and number of shells.

Level 3

Passage-4

1. (d) Electrons closer to nucleus will experience higher effective nuclear charge.

$2p^3$ is closer to $4s^1$ as principal quantum number is concerned first.

2. (b) Magnesium having higher ionization potential due to more stable electronic arrangement [Ne] $3s^2$ in comparison to aluminium [Ne] $3s^2 3p^1$.

3. (d) Ionization enrgy is not affected by entropy.

Passage-5

1. (b) T has abnormally higher I.E._1 value.

2. (b) There is sudden jump in I.E._2 of Q, *i.e.*, unipositive has noble gas configuration.

3. (c) I.E._3 of S is abnormally higher.

4. (a) High I.E. values show its non-metallic nature.

5. (b) Q is alkali metal as it shows group in I.E._2 value.

6. (a) Both Q and R shows group in I.E._2 values and belong to alkali metals.

Passage-8

1. (b) ${}_{24}\text{Cr} \Rightarrow 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^1$

So extra electron now coming in $4s^1$ orbital.

$\sigma = (1 \times 0.35) + (13 \times 0.85) + (10 \times 1.0) = 21.40$

$Z^* = Z - \sigma = 24.0 - 21.4 = 2.6$

3. (d) ${}_3\text{Li} \Rightarrow 3 - (0.85 \times 2) \Rightarrow 1.3$

${}_{11}\text{Na} \Rightarrow 11 - (0.85 \times 8 + 1 \times 2) = 11 - 8.8 = 2.2$

${}_{19}\text{K} \Rightarrow 19 - (0.85 \times 8 + 1 \times 10) = 19 - 16.8 = 2.2$

Passage-10

1. (d) For last e^- of element 'X' $\rightarrow \overset{n}{7}\ \ \overset{l}{1}\ \ \overset{m}{+1}\ \ \overset{s}{+1/2}$ or $-1/2$ so last e^- present in "$7p$" subshell and spin magnetic momentum for element 'X' is zero so their is no unpaird e^- in element 'X' so outer electronic configuration of element 'X' will be $7p^6$.

(a) According to electronic configuration element 'X' belongs to 18th group.

(b) Spin magnetic momentum zero so their is no unpaired e^-.

(c) Element 'X' belongs to 7th period and 18th group so atomic number is 118.

(d) 'X' is nobel gas not representative element according to Bohr's classification.

2. (c) $Z = 118$, $B - 2Z = 18$, so $B = 254$

and $B - A = 18$ so $A = 236$

3. (d) 90th e^- goes to $5f$ subshell so possible four quantum numbers are 5, 3, −2 and −1/2 or +1/2.

Passage-11

1. (c) The correct order of IE_1 $H_{(\text{Bi})} > I_{(\text{Po})}$

2. (d)

(a) +5 oxidation state of H(Bi) is more stable than its +3 oxidation state. (false)

(b) $G^{2+}(\text{Pb})^{2+}$ is better oxidising agent than $G^{4+}(\text{Pb})^{4+}$. (false)

(c) +3 oxidation state of E(P) is more stable than its +5 oxidation state. (false)

(d) Pb > Sn(Tin): IE_1 (true)

3. (c)

(a) $B_2C_5(\text{N}_2\text{O}_5)$ is acidic in nature

(b) $AC_2(\text{CO}_2)$ is acidic in nature

(c) $FC_3(\text{SO}_3)$ is acidic in nature

(d) $GC_2(\text{PbO}_2)$ is amphoteric in nature

Passage-12

1. (b) In $X—O—H$, linkage as X is more electronegative the shared electron pair between $O—H$ shifts more towards oxygen atom and $O—H$ bond weakens which facilitates release of H^+.
2. (a) According to the given information, element P is aluminium which forms amphoteric oxide: Al_2O_3
3. (d) According to the given information, element P, belongs to 13th group and rest elements belong to higher groups, hence chloride of 13th group will only be hypovalent.

Passage-13

X is "As" $\Rightarrow$ $[Ar]3d^{10}4s^24p^3$ $\quad 2s+1=4, \quad s=\frac{3}{2}$

So unpaired electron in element X is 3.

B		N	O	F
Al		P		
Ga	Ge	As	Se	Br
		Sb		I
Tl	Pb	Bi		At

Passage-14

1. (b) Bond energy is inversely proportional to difference of electronegativity in polar solvent.
   Hence, '$B—OH$' is more basic '$D—OH$'.
2. (d) Due to more difference of electronegativity in $B—O$ bond, $B—OH$ is more basic than water.

Passage-15

1. (c) In present set up of long form of periodic table element with atomic number > 118 can not be accommodated.
2. (c) $[Xe]^{54}6s^25d^1$ (last e^- inters to d-orbitals)

One or more Answers is/are Correct

5. Elements (a), (b) and (c) are correct. Statement (d) is incorrect as in any period, the atomic radius of the noble gas is largest.

13. Np, Pu and Ra are radioactive but Np and Pu have been named after the names of the planets Neptune and Pluto.

14. Statements (a), (c) and (d) are common to both the groups 1 and 17. Statement (b) is true only for group 17 elements.

15. A is Fe ($Z_1=26$), according to their electronic configuration.

$Z_1-Z_2=2, \qquad Z_1=26\ (\text{Fe}=A)$

$26-Z_2=2, \qquad Z_2=24\ (\text{Cr}=B)$

$\frac{26+24}{2}=Z_3-2, \qquad Z_3=27\ (\text{Co}=C)$

(Here, n is unpaired electrons)

(a) $B^+(n=5)>A^{2+}(n=4)>C^{2+}(n=3)$

(b) $A^{3+}(n=5)>B^{2+}(n=4)>C\ (n=3)$

(c) $B\ (n=6)>A\ (n=4)>C^{2+}(n=3)$

(d) $B\ (n=6)\neq A^{3+}(n=5)>C^{3+}(n=4)$

18. According to given information $\quad X\Rightarrow$ Be and $Y\Rightarrow$ N

(a) Possible hydride of N is NH_3 ($H—N—H$ bond angle is less than 109°28')

(b) In BeX_2, Be has two vacant p-orbitals

(c) Magnetic moment of N > Be. (Number of unpaired e^- in N > Be)

(d) N can exhibits variable oxidation state

21. The correct order of radii is : $Co \approx Ni < Cu < Zn$

25. (a) $\frac{p}{e} = \overset{Fe^{2+}}{\frac{26}{24}}, \overset{Fe^{3+}}{\frac{26}{23}}$, due to high p / e ratio, (high $Z_{eff.}$) in Fe^{3+}, ionic radii of $Fe^{2+} > Fe^{3+}$

(b) In case of second I.E. for 'O' e^- remove in stable configuration $(1s^2, 2s^2 2p^3)$ so $N(IE_2) < O(IE_2)$

(c) Due to high shielding effect atomic radius of Zn > Cu.

(d) Due to high $Z_{eff.}$ I.E. of Tl > In (due to poor shielding effect of $4f$ subshell)

26. (a) Any orbital can accommodate max. 2 electrons

(b) For same Z, successive I.E. increases due to increase in $\left(\frac{Z}{e}\right)$

(c) $_{27}Co$ $[Ar]3d^7 4s^2$
Co^{2+} $[Ar]3d^7 4s^0$, unpaired $e^- = 3$
Co^{3+} $[Ar]3d^6 4s^0$, unpaired $e^- = 4$

(d) I.E. of Pt (6 period) > I.E. of Pd (5 period) due to poor shielding effect of $4f$ subshell in 6 period elements.

27. W show +3 oxidation state and X show +2 oxidation state.
$Y = ns^2 np^4$, Y show −2 oxidation state
$Z = ns^2 np^5$, Z show −1 oxidation state Formed compounds :
(a) $W^{3+}Y^{2-} = W_2Y_3$ (d) $X^{2+}Z^{1-} = XZ_2$

28. (a) Sum of IE_1 and IE_2 is lower for element P
(d) Sum of first four IE is lower for element Q

30. According to the values of I.E. given it can be concluded that
* $IE_1 < IE_2 < IE_3 <<< IE_4 < IE_5$
* This shows that it achieved stable noble gas configuration after removing three e^-.
* It belongs to 13th group of periodic table
* It could be metal or non-metal or metalloid.
* It form stable trivalent cation.

31. (a) $Fe < Fe^{2+} < Fe^{3+} [Z_{eff.} \propto \text{charge on cation}]$ (b) $N^{3-} < O^{2-} < F^- [Z_{eff.} \propto \frac{1}{\text{Charge on anion}}]$
(c) $Na^+ < Mg^+ < Al^{3+}$ (d) $Tl^{2+} < V^{3+} < Mn^{5+}$

38. Increasing order of size : $Mg^{2+} < Na^+ < F^- < O^{2-}$

39. $\Delta H_1, \Delta H_2$ and ΔH_3 are negative whereas ΔH_4 is positive.

40. Correct order is :
(b) Ge > Se > As > Br : Metallic character
(c) Si > Mg > Al > Na : Ionisation energy
(d) Cl > F > Br > I : Electron affinity

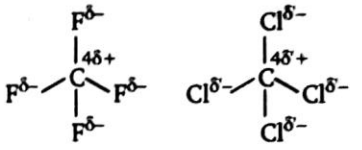
41. (a) The radius of isoelectronic species $\propto \frac{1}{\frac{Z}{e}\text{ ratio}}$

(b) Ionisation energy $\propto \frac{1}{\text{size}} \propto$ Effective nuclear charge

(c) Normally the electron affinity $(E_A) \propto \frac{1}{\text{Size of atom}}$

42. (a) $|\Delta H_4| = |\Delta H_5|$ $[(\Delta H_{eg.})_X = (\Delta H_{IE})_{X^-}]$
(b), (c) $\rightarrow \Delta H_3 > \Delta H_2 > \Delta H_1$ [Successive IE always higher than previous IE]

(c) $|\Delta H_1| = |\Delta H_6|$ $[(\Delta H_{\text{IE}})_X = (\Delta H_{\text{eg}})_{X^+}]$

43. 

Since $\delta > \delta'$, hence C-atom in CF_4 is more electronegative than in CCl_4.

45. On Pauling's scale electronegativities of H (2.1), Te (2.1) and P (2.1) are similar but the electronegativity of S (2.5) is differerent from the other three elements.

46. Electronegativity and hydration energy cannot be estimated by using Born-Haber cycle.

47. Electronegativity of central atom is directly proportional to oxidation states.

49. (a) $S^-(g) \longrightarrow S^{2-}(g)$; $\quad \Delta H_{e.g.} = (+)\text{ve}$

(b) $Na^+(g) + Cl^-(g) \longrightarrow Na^+Cl^-(s)$; $\quad \Delta H_{\text{L.E.}} = (-)\text{ve}$

(c) $N(g) \longrightarrow N^-(g)$; $\quad \Delta H_{e.g.} = (+)\text{ve}$

(d) $Al^{2+}(g) \longrightarrow Al^{3+}(g)$; $\quad \Delta H_{\text{I.E.}} = (+)\text{ve}$

50. $\Rightarrow \Delta H_1 = 2\Delta H_2 + \frac{3}{2}\Delta H_3 + 2\Delta H_4 - 3\Delta H_5 \Rightarrow$ second electron gain enthalpy of X will be positive.

Match the Column

6. 52 $[Kr]^{36}4d^{10}5s^25p^4$ ⇒ *p*-block
56 $[Xe]^{54}6s^2$ ⇒ *s*-block
57 $[Xe]^{54}5d^16s^2$ ⇒ *d*-block
60 $[Xe]^{54}4f^46s^2$ ⇒ *f*-block

11. (A) $[Xe]4f^{14}5d^{10}6s^2$, last e^- goes to $5d$ subshell so it is a *d*-block element and $5d$ subshell is fulfilled so it is not considered as transition element (A → R)

(B) $[Rn]5f^{14}6d^17s^2$, last e^- goes to $5f$ subshell so it is f-block or inner-transition element (B → T)

(C) $[Xe]4f^{14}5d^{10}6s^26p^67s^2$, last e^- goes to $7s$ subshell so it is a *s*-block or representative element (C → P, S).

(D) $[Xe]4f^{14}5d^26s^2$, last e^- goes to $5d$ subshell so it is a *d*-block element and $5d$ subshell is partially field so it is also considered as transition element (D → Q, R).

12. (a) $W(2,8,7)$ $\underset{(Z=17)}{Cl}$
→ (P) Paramagnetic (one unpaired e^-)
→ (S) Reactive non-metal

(b) $X(2,8,18,8)$ $\underset{(Z=36)}{Kr}$ → (T) Diamagnetic (zero unpaired e^-)

(c) $Y(2,8,14,2)$ $\underset{(Z=26)}{Fe}$
→ (P) Paramagnetic (4 unpaired e^-)
→ (R) Last e^- does not enter to valence shell (last e^- enter to $(n-1)$ shell)

(d) $Z(2,8,18,25,8,2)$ $\underset{(Z=63)}{Eu}$
→ (P) Paramagnetic (7 unpaired e^-)
→ (Q) 3rd group element
→ (R) Last e^- does not enter to valence shell (last e^- enter to $(n-2)$ shell)

Assertion-Reason Type Questions

13. Due to small size of F atom added electron is replaced more strongly by $2p$ electrons than in case of Cl atom.

Subjective Problems

1. Electronic configuration of Zn^{2+}: $\underline{1s^2}, \underline{2s^2}, 2p^6, \underline{3s^2}, 3p^6, 3d^6, 4s^0$

3.
$$-0.95 \times 10^x = 700 - 1000 - 650$$
$$-0.95 \times 10^x = -950$$
$$x = \mathbf{3}$$

4.
$$-750 = 150 + \frac{3}{2} \times 200 + 350 + q - 1000$$
$$q = 3 \times \Delta H_{EG} = -550;$$
$$q_1 = \frac{550}{3} = 183, \quad \frac{q_1}{50} = 3.66 \approx 4.0$$

5.
$$-424 = 108 + 495 + \frac{242}{2} - 348 + U$$
$$-424 = +376 + U$$
$$U = -424 - 376 = -800 \text{ kJ/mol}$$
$$-\frac{(-800)}{100} = 8$$

6. Correct orders

(i) HF > HCl > HBr > HI : Lewis basic character	(T)
(ii) $CH_4 < CCl_4 < CF_4$: Electronegativity of central 'C'-atom	(T)
(iii) $Mg^{2+} < K^+ < S^{2-} < Se^{2-}$: Ionic radius	(T)
(iv) Ni > Pd > Pt : Ionisation energy	(F)
(v) $As^{5+} > Sb^{5+} > Bi^{5+}$: Stable oxidation state	(T)
(vi) LiF > NaF > KF > RbF: Lattice energy	(T)
(vii) $F^-_{(aq.)} > Cl^-_{(aq.)} > Br^-_{(aq.)} > I^-_{(aq.)}$: Electrical conductance	(F)
(viii) $Li^+ < Mg^{2+} < Al^{3+}$: Hydration energy	(T)
(ix) Cl > Br > F > I : Electron affinity	(F)
(x) $BeCl_2 < AlCl_3 < SiCl_4$: Lewis acidic character	(T)

$$x = 7, \quad y = 3$$
$$|x - y|^2 = |7 - 3|^2 = 16$$

7. Te, Po, Ra

8. $X \Rightarrow \frac{1s^2}{K}$ so value of n is '6'

Electronic configurate of 'X' $\Rightarrow$ $\begin{array}{cccccc} 1s^2 & \_ & \_ & 25 & 8 & 2 \\ \hline K & L & M & N & O & P \\ 1 & 2 & 3 & 4 & 5 & 6 \end{array}$

$$1s^2 \ldots\ldots\ldots\ldots \underbrace{4s^2 4p^6 4d^{10} 4f^7}_{25} \underbrace{5s^2 5p^6 5d^0}_{8} \underbrace{6s^2}_{2}$$

Unpaired electron is 7.

10. (v) $Li < Li^+$ (vii) Ba < Sr

11.

Cs → (+1)	Zn → (+2)	Sr → (+2)
Ba → (+2)	Be → (+2)	Ga → (+1, +3)
F → (−1)	Al → (+3)	Pb → (+2, +4)

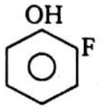
2

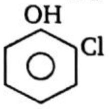
CHEMICAL BONDING

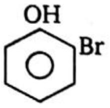
Level 1

Hydrogen Bond

1. The correct order of boiling point is :


(I)


(II)


(III)

(a) I > II > III
(b) III > II > I
(c) II > I > III
(d) III > I > II

2. Which of the following is not true about H_2O molecule?
(a) The molecule has $\mu = 0$
(b) The molecule can act as a base
(c) Shows abnormally high boiling point in comparison to the hydrides of other elements of oxygen group
(d) The molecule has a bent shape

3. The boiling points at atmospheric pressure of HF, H_2S, NH_3 can be arranged in the following order :
(a) $HF > NH_3 > H_2S$
(b) $HF > H_2S > NH_3$
(c) $HF < H_2S < NH_3$
(d) $HF < NH_3 < H_2S$

4. The correct order of strength of H-bond in the following compound :
(a) $H_2O > H_2O_2 > HF > H_2S$
(b) $HF > H_2O_2 > H_2O > H_2S$
(c) $HF > H_2O > H_2S > H_2O_2$
(d) $HF > H_2O > H_2O_2 > H_2S$

5. Which compound has electrovalent, covalent, co-ordinate as well as hydrogen bond?
(a) $[Cu(H_2O)_4]SO_4 \cdot H_2O$
(b) $[Zn(H_2O)_6]SO_4 \cdot H_2O$
(c) $[Fe(H_2O)_6]SO_4 \cdot H_2O$
(d) $[Fe(H_2O)_6]Cl_3$

6. Which statement is correct?
(a) m.p. of H_2O, NH_3 are maximum in their respective group due to intermolecular H-bonding
(b) b.p. of CH_4 out of CH_4, SiH_4, GeH_4 and SnH_4 is least due to weak intermolecular force of attraction
(c) formic acid forms dimer by H-bonding
(d) all are correct

7. Which of the following molecules are expected to exhibit intermolecular H-bonding?
(I) Acetic acid (II) *o*-nitrophenol (III) *m*-nitrophenol (IV) *o*-boric acid
Select correct alternate :
(a) I, II, III (b) I, II, IV (c) I, III, IV (d) II, III, IV

8. Which of the following compounds can form H-bonding with each other ?
(a) CH_3COOH and H_2O (b) Phenol and CH_4
(c) CHF_3 and acetone (d) PH_3 and HF

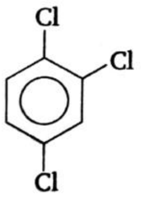
Dipole Moment

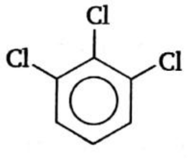
9. BF_3 and NF_3 both are covalent compounds but NF_3 is polar whereas BF_3 is non-polar. This is because :
(a) Nitrogen atom is smaller than boron atom
(b) N —F bond is more polar than B —F bond
(c) NF_3 is pyramidal whereas BF_3 is planar triangular
(d) BF_3 is electron deficient whereas NF_3 is not

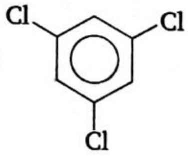
10. Dipole moment of NF_3 is smaller than :
(a) NH_3 (b) CO_2 (c) BF_3 (d) CCl_4

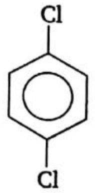
11. Which of the following molecules will have polar bonds but zero dipole moment?
(a) O_2 (b) $CHCl_3$
(c) CF_4 (d) none of these

12. Which has maximum dipole moment?

(a) 

(b) 

(c) 

(d) 

13. Which of the following compound is planar and non-polar ?
(a) XeO_4 (b) SF_4
(c) XeF_4 (d) CF_4

14. H_2O has a net dipole moment while BeF_2 has zero dipole moment because :
(a) F is more electronegativity than oxygen
(b) Be is more electronegativity than oxygen
(c) H_2O molecule is linear and BeF_2 is bent
(d) BeF_2 molecule is linear and H_2O is bent

15. Correct set of species with zero dipole moment is :

(i) CO_2 (ii) $COCl_2$ (iii) CH_2Cl_2 (iv) BCl_3

(a) (i) and (iv)
(b) (ii) and (iv)
(c) (iii) and (iv)
(d) (i), (iii) and (iv)

16. Which pair of molecules are polar species?

(a) CO_2 and H_2O
(b) BF_3 and PCl_3
(c) SO_2 and SCl_2
(d) CS_2 and SO_3

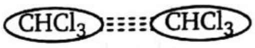
17. In which molecule does the chlorine atom has positive partial charge?

(a) HCl (b) BrCl (c) OCl_2 (d) SCl_2

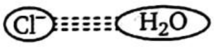
Molecular Forces

18. Which of the following attraction is strongest ?

(a) 

(b) 

(c) 

(d) 

19. Which is distilled first?

(a) Liquid H_2
(b) Liquid CO_2
(c) Liquid O_2
(d) Liquid N_2

20. The molecular size of ICl and Br_2 is approximately same, but b.p. if ICl is about 40°C higher than that of Br_2. It is because :

(a) ICl bond is stronger than Br—Br bond
(b) IE of iodine < IE of bromine
(c) ICl is polar while Br_2 is nonpolar
(d) I has larger size than Br

21. Which of the following order of molecular force of attraction among given species is incorrect?

(a) $HI > HBr > Cl_2$
(b) $CH_3Cl > CCl_4 > CH_4$
(c) *n*-pentane > *iso*-pentane > neo-pentane
(d) $OH_2 > O(CH_3)_2 > OBr_2$

22. Which gas should not be collected over water because of its high solubility in water?

(a) H_2 (b) N_2 (c) CH_4 (d) HCl

23. Low melting point is expected for a solid :

(a) Ionic solid
(b) Metallic solid
(c) Molecular solid
(d) Covalent solid

24. Which substance has the strongest London dispersion forces?

(a) SiH_4 (b) CH_4 (c) SnH_4 (d) GeH_4

25. Which of the following compounds has the lowest boiling point?

(a) HF (b) HCl (c) HBr (d) HI

26. When the substances Si, KCl, CH_3OH and C_2H_6 are arranged in order of increasing melting point, what is the correct order?

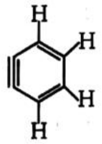
(a) Si, KCl, CH_3OH, C_2H_6
(b) CH_3OH, C_2H_6, Si, KCl
(c) KCl, Si, C_2H_6, CH_3OH
(d) C_2H_6, CH_3OH, KCl, Si

27. Which substance has the highest melting point?

(a) CO
(b) CO_2
(c) SiO_2
(d) P_2O_5

Hybridisation

28. How many sp^2 and sp-hybridised carbon atoms are present respectively in the following compound ?



(a) 4, 2 (b) 6, 0 (c) 3, 3 (d) 5, 1

29. Which one of the following is the correct set with respect to molecule, hybridization and shape?

(a) $BeCl_2, sp^2$, linear (b) $BeCl_2, sp^2$, triangular planar

(c) BCl_3, sp^2, triangular planar (d) BCl_3, sp^3, tetrahedral

30. The hybridization of the central atom in ICl_2^+ is :

(a) dsp^2 (b) sp (c) sp^2 (d) sp^3

31. The state of hybridization of the central atom is not the same as in the others :

(a) B in BF_3 (b) O in H_3O^+ (c) N in NH_3 (d) P in PCl_3

32. The number of sp^2 — s sigma bonds in benzene are :

(a) 3 (b) 6 (c) 12 (d) none of these

33. The hybridization of the central atom will change when :

(a) NH_3 combines with H^+ (b) H_3BO_3 combines with OH^-

(c) NH_3 forms NH_2^- (d) H_2O combines with H^+

34. $CH_3—CH_2—CH{=}CH_2$ has hybridisation:

(a) sp, sp, sp^2, sp^2 (b) sp^3, sp^3, sp^2, sp

(c) sp^3, sp^3, sp^2, sp^2 (d) sp^3, sp^2, sp^2, sp

35. What is the state of hybridisation of Xe in cationic part of solid XeF_6?

(a) sp^3d^3 (b) sp^3d^2 (c) sp^3d (d) sp^3

36. During the complete combustion of methane CH_4, what change in hybridisation does the carbon atom undergo?

(a) sp^3 to sp (b) sp^3 to sp^2 (c) sp^2 to sp (d) sp^2 to sp^3

37. The hybridisation of central iodine atom in IF_5, I_3^- and I_3^+ are respectively :

(a) sp^3d^2, sp^3d, sp^3 (b) sp^3d, sp^3d, sp^3 (c) sp^3d^2, sp^3d^2, sp^3 (d) sp^3d, sp^3d^2, sp^3

38. In which of the following combination hybridisation of central atom (*) does not change?

(a) $H_2O + \dot{C}O_2$ (b) $H_3\dot{B}O_3 + OH^-$

(c) $BF_3 + \dot{N}H_3$ (d) None of these

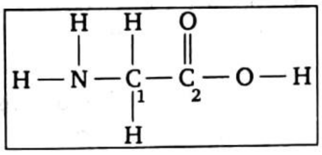
39. Which of the following species used both axial set of d-orbitals in hybridisation of central atom?

(a) PBr_4^+ (b) PCl_4^- (c) ICl_4^- (d) None of these

40. Which bonds are formed by a carbon atom with sp^2-hybridisation?
(a) 4π-bonds (b) 2π-bonds and 2σ-bonds
(c) 1π-bonds and 3σ-bonds (d) 4σ-bonds

41. What are the hybridisation of the carbon atoms labeled C_1 and C_2, respectively in glycine?

	C_1	C_2
(a)	sp^2	sp^2
(b)	sp^2	sp^3
(c)	sp^3	sp^2
(d)	sp^3	sp^3



42. The H—O—H bond angles in H_3O^+ are approximately 107°. The orbitals used by oxygen in these bonds are best described as :
(a) p-orbitals (b) sp-hybrid orbitals
(c) sp^2-hybrid orbital (d) sp^3-hybrid orbital

Coot Bond

43. Which pair of elements can form multiple bond with itself and oxygen?
(a) F, N (b) N, Cl (c) N, P (d) N, C

44. Which of the following is a covalent compound?
(a) Al_2O_3 (b) AlF_3 (c) $AlCl_3$ (d) $Al_2(SO_4)_3$

45. Which of the following is an example of super octet molecule?
(a) ClF_3 (b) PCl_5 (c) IF_7 (d) All the three

46. Which of the following molecule is theoretically not possible?
(a) SF_4 (b) OF_2 (c) OF_4 (d) O_2F_2

47. The phosphate of a metal has the formula $MHPO_4$. The formula of its chloride would be :
(a) MCl (b) MCl_2 (c) MCl_3 (d) M_2Cl_3

48. The compound that has the highest ionic character associated with the X — Cl bond is :
(a) PCl_5 (b) BCl_3 (c) CCl_4 (d) $SiCl_4$

49. The bond having the highest bond energy is :
(a) C=C (b) C=S (c) C=O (d) P=N

50. Which of the following species is neither hypervalent nor hypovalent ?
(a) ClO_4^- (b) BF_3 (c) SO_4^{2-} (d) CO_3^{2-}

51. In which of the following species central atom is NOT surrounded by exactly 8 valence electrons?
(a) BF_4^- (b) NCl_3 (c) PCl_4^+ (d) SF_4

52. Which atom can have more than eight valence electrons when it is forming covalent bonds?
(a) H (b) N (c) F (d) Cl

53. Which bond is expected to be the least polar?
(a) O—F (b) P—F (c) Si—N (d) B—F

54. Which set contains only covalently bonded molecules?
(a) BCl_3, $SiCl_4$, PCl_3 (b) NH_4Br, N_2H_4, HBr

(c) I_2, H_2S, NaI (d) Al, O_3, As_4

55. Which molecule does not exist?
(a) OF_2 (b) OF_4 (c) SF_2 (d) SF_4

Ionic Bond

56. Solid NaCl is a bad conductor of electricity because :
(a) in solid NaCl there are no ions
(b) solid NaCl is covalent
(c) in solid NaCl there is no mobility of ions
(d) in solid NaCl there are no electrons

57. An ionic compound A^+B^- is most likely to be formed when :
(a) the ionization energy of A high and electron affinity of B is low
(b) the ionization energy of A is low and electron affinity of B is high
(c) both, the ionization energy of A and electron affinity of B are high
(d) both, the ionization energy of A and electron affinity of B are low

58. A compound contains three elements A, B and C, if the oxidation of $A = +2, B = +5$ and $C = -2$, the possible formula of the compound is :
(a) $A_3(B_4C)_2$ (b) $A_3(BC_4)_2$ (c) $A_2(BC_3)_2$ (d) ABC_2

59. Which pair of atoms form strongest ionic bond?
(a) Al and As (b) Al and N
(c) Al and Se (d) Al and O

Resonance

60. The correct order of increasing C—O bond strength of CO, CO_3^{2-}, CO_2 is :
(a) $CO_3^{2-} < CO_2 < CO$ (b) $CO_2 < CO_3^{2-} < CO$ (c) $CO < CO_3^{2-} < CO_2$ (d) $CO < CO_2 < CO_3^{2-}$

61. Resonance structures can be written for :
(a) O_3 (b) NH_3 (c) CH_4 (d) H_2O

62. The correct order of Cl — O bond order is :
(a) $ClO_3^- < ClO_4^- < ClO_2^- < ClO^-$ (b) $ClO^- < ClO_4^- < ClO_3^- < ClO_2^-$
(c) $ClO^- < ClO_2^- < ClO_3^- < ClO_4^-$ (d) $ClO_4^- < ClO_3^- < ClO_2^- < ClO^-$

63. How many resonance forms can be written for the nitrate ion, (NO_3^-)?
(a) 1 (b) 2 (c) 3 (d) 4

Molecular Geometry/Shape

64. Among given species identify the isostructural pairs :
(a) [$NF_3$and BF_3] (b) [$BF_4^-$and NH_4^+] (c) [$BCl_3$and $BrCl_3$] (d) [NH_3 and NO_3^-]

65. 0.01 mole of H_3PO_x is completely neutralised by 0.56 gram of KOH hence :
(a) $x = 3$ and given acid is dibasic
(b) $x = 2$ and given acid is monobasic
(c) $x = 3$ and given acid is monobasic
(d) $x = 4$ and given acid forms three series of salt

66. Phosphorus pentachloride in the solid exists as :
(a) PCl_5 (b) $PCl_4^+Cl^-$ (c) $PCl_4^+PCl_6^-$ (d) $PCl_5 \cdot Cl_2$

67. The ratio of σ-bond and π-bond in tetracyano ethylene is :
(a) 2 : 1 (b) 1 : 1 (c) 1 : 2 (d) None of these

68. Bonds present in N_2O_5 (nitrogen pentaoxide) are :
(a) only ionic (b) only covalent
(c) covalent and co-ordinate (d) covalent and ionic

69. The pair of species with similar shape is :
(a) PCl_3, NH_3 (b) CF_4, SF_4 (c) $PbCl_2, CO_2$ (d) PF_5, IF_5

70. Which of the following statements is correct in the context of the allene molecule, C_3H_4?
(a) The central carbon is *sp* hybridized
(b) The terminal carbon atoms are sp^2 hybridized
(c) The planes containing the CH_2 groups are mutually perpendicular to permit the formations two separate π-bonds
(d) All are correct

71. Number of S — S bond is $H_2S_nO_6$:
(a) n (b) $(n-1)$ (c) $(n-2)$ (d) $(n+1)$

72. How many S — S bonds, S — O — S bonds, σ-bonds, π-bonds are present in trimer of sulphur trioxide?
(a) 0, 3, 16, 2 (b) 0, 3, 12, 6 (c) 0, 6, 12, 16 (d) 0, 4, 12, 6

73. Number of identical Cr—O bonds in dichromate ion $Cr_2O_7^{2-}$ is :
(a) 4 (b) 6 (c) 7 (d) 8

74. The nodal plane in the π-bond of ethene is located in :
(a) the molecular plane
(b) a plane parallel to the molecular plane
(c) a plane perpendicular to the molecular plane which bisects the carbon-carbon σ bond at right angle
(d) a plane perpendicular to the molecular plane which contains the carbon-carbon bond

75. Which of the following are isoelectronic and isostructural?

$$NO_3^-, \ CO_3^{2-}, \ ClO_3^-, \ SO_3$$

(a) NO_3^-, CO_3^{2-} (b) SO_3, NO_3^- (c) ClO_3^-, CO_3^{2-} (d) CO_3^{2-}, ClO_3^-

76. In the electronic structure of H_2SO_4, the total number of unshared electrons is :
(a) 20 (b) 16 (c) 12 (d) 8

77. Which of the following xenon compound has the same number of lone pairs as in I_3^-?
(a) XeO_4 (b) XeF_4 (c) XeF_2 (d) XeO_3

78. The shape of XeF_3^+ is :
(a) Trigonal planar (b) Pyramidal
(c) Bent T-shape (d) See-saw

79. Which of the following shape are not possible for possible value of 'n' in XeF_n molecule ?
(a) Linear (b) Square planar
(c) Trigonal planar (d) Capped octahedral

80. $BeCl_2$ is not isostructural with :
(a) ICl_2^- (b) C_2H_2 (c) XeF_2 (d) $GeCl_2$

81. Which statement is true about the most stable Lewis structure for CS_2?
(a) There are no lone pairs in molecule
(b) All bonds are double bonds
(c) The central atom does not have an octet of electrons
(d) A sulfur atom must be the central atom for the structure to be stable

82. SbF_5 reacts with XeF_4 and XeF_6 to form ionic compounds $[XeF_3^+][SbF_6^-]$ and $[XeF_5^+][SbF_6^-]$ then molecular shape of $[XeF_3^+]$ ion and $[XeF_5^+]$ ion respectively :
(a) Square pyramidal, T-shaped (b) Bent-T-shape, square pyramidal
(c) See-saw, square pyramidal (d) Square pyramidal, see-saw

VSEPR Theory

83. In which of the following species maximum atom can lie in same plane?
(a) XeF_2O_2 (b) PCl_5 (c) AsH_4^+ (d) XeF_4

84. Correct statement regarding molecules SF_4, CF_4 and XeF_4 are:
(a) 2, 0 and 1 lone pairs of central atom respectively
(b) 1, 0 and 1 lone pairs of central atom respectively
(c) 0, 0 and 2 lone pairs of central atom respectively
(d) 1, 0 and 2 lone pairs of central atom respectively

85. The geometrical arrangement of orbitals and shape of I_3^- are respectively :
(a) trigonal bipyramidal geometry, linear shape
(b) hexagonal geometry, T-shape
(c) triangular planar geometry, triangular shape
(d) tetrahedral geometry, pyramidal shape

86. Which of the following statements is incorrect for PCl_5?
(a) Its three P—Cl bond lengths are equal (b) It involves sp^3d hybridization
(c) It has an regular geometry (d) Its shape is trigonal bipyramidal

87. Molecular shapes of SF_4, CF_4 and XeF_4 are :
(a) the same with 2,0 and 1 lone pair of electrons respectively
(b) the same, with 1,1 and 1 lone pair of electrons, respectively
(c) different, with 0,1 and 2 lone pair of electrons, respectively
(d) different with 1,0 and 2 lone pair of electrons, respectively

88. The structure of the noble gas compound XeF_4 is :
(a) square planar (b) distorted tetrahedral
(c) tetrahedral (d) octahedral

89. The molecule exhibiting maximum number of non-bonding electron pairs (l.p.) around the central atom is :
(a) $XeOF_4$ (b) XeO_2F_2 (c) XeF_3^- (d) XeO_3

90. Which is the following pairs of species have identical shapes?
(a) NO_2^+ and NO_2^- (b) PCl_5 and BrF_5 (c) XeF_4 and ICl_4^- (d) $TeCl_4$ and XeO_4

91. The shapes of XeF_4, XeF_5^- and $SnCl_2$ are :

(a) octahedral, trigonal bipyramidal and bent
(b) square pyramidal, pentagonal planar and linear
(c) square planar, pentagonal planar and angular
(d) see-saw, T-shaped and linear

92. Which is not correctly matched?

(a) XeO_3—Trigonal bipyramidal (b) ClF_3—bent T-shape
(c) $XeOF_4$—Square pyramidal (d) XeF_2—Linear shape

93. Amongst $NO_3^-, AsO_3^{3-}, CO_3^{2-}, ClO_3^-, SO_3^{2-}$ and BO_3^{2-}, the non-planar species are :

(a) $CO_3^{2-}, SO_3^{2-}, BO_3^{3-}$ (b) $AsO_3^{3-}, ClO_3^-, SO_3^{2-}$
(c) $NO_3^-, CO_3^{2-}, BO_3^{3-}$ (d) $SO_3^{2-}, NO_3^-, BO_3^{3-}$

94. The geometry of ammonia molecule can be best described as :

(a) Nitrogen at one vertex of a regular tetrahedron, the other three vertices being occupied by three hydrogens
(b) Nitrogen at the centre of the tetrahedron, three of the vertices being occupied by three hydrogens
(c) Nitrogen at the centre of an equilateral triangle, three corners being occupied by three hydrogens
(d) Nitrogen at the junction of a T, three open ends being occupied by three hydrogens

95. Which molecular geometry is least likely to result from a trigonal bipyramidal electron geometry?

(a) Trigonal planar (b) See-saw (c) Linear (d) T-shaped

96. Give the correct order of initials **T** or **F** for following statements. Use **T** if statement is true and **F** if it is false :

(I) The order of repulsion between different pair of electrons is $l_p - l_p > l_p - b_p > b_p - b_p$
(II) In general, as the number of lone pair of electrons on central atom increases, value of bond angle from normal bond angle also increases
(III) The number of lone pair on O in H_2O is 2 while on N in NH_3 is 1
(IV) The structures of xenon fluorides and xenon oxyfluorides could not be explained on the basis of VSEPR theory

(a) TTTF (b) TFTF (c) TFTT (d) TFFF

97. Which species is planar?

(a) CO_3^{2-} (b) SO_3^{2-} (c) ClO_3^- (d) BF_4^-

98. What is the geometry of the IBr_2^- ion?

(a) Linear
(b) Bent shape with bond angle of about 90°
(c) Bent shape with bond angle of about 109°
(d) Bent shape with bond angle of about 120°

99. What is the shape of the ClF_3 molecule?

(a) Trigonal planar (b) Trigonal pyramidal

(c) T-shaped (d) Tetrahedral

100. Which species has the same shape as NH_3?

(a) SO_3^{2-} (b) CO_3^{2-}

(c) NO_3^- (d) SO_3

101. According to VSEPR theory, in which species do all the atoms lie in the same plane?

1. CH_3^+ 2. CH_3^-

(a) 1 only (b) 2 only

(c) both 1 and 2 (d) neither 1 nor 2

102. Which of the following species/molecules does not have same number of bond pairs and lone pairs?

(a) OCN^- (b) H_2O (c) $C_2H_2Cl_2$ (d) O_3

Bond Length

103. Least stable hydride is :

(a) stannane (b) silane (c) plumbane (d) germane

104. The lowest O — O bond length in the following molecule is :

(a) O_2F_2 (b) O_2 (c) H_2O_2 (d) O_3

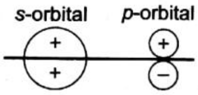
Valence Bond Theory

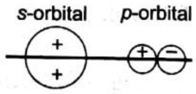
105. The fluorine molecules is formed by :

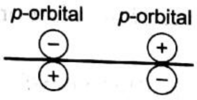
(a) *p-p* orbitals (sideways overlap) (b) *p-p* orbitals (end-to-end overlap)

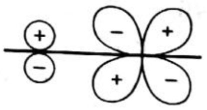
(c) *sp-sp* orbitals (d) *s-s* orbitals

106. Which of the following leads to bonding?

(a) 

(b) 

(c) 

(d) 

107. Which of the following overlaps is incorrect (assuming *Z*-axis is internuclear axis) ?

(A) $2p_y + 2p_y \longrightarrow \pi$-Bond formation (B) $2p_x + 2p_x \longrightarrow \sigma$ -Bond formation

(C) $3d_{xy} + 3dp_{xy} \longrightarrow \pi$-Bond formation (D) $2s + 2p_y \longrightarrow \pi$-Bond formation

(E) $3d_{xy} + 3d_{xy} \longrightarrow \delta$-Bond formation (F) $2p_z + 2p_z \longrightarrow \sigma$-Bond formation

(a) A, B, C (b) C, F

(c) B, E (d) B, C, D

108. Which of the following overlapping is not present in XeO_3 molecule ?

(a) $sp^3 + p_x$ (b) $sp^3 + p_y$ (c) $d_{xz} + p_x$ (d) $sp^3 + s$

109. How many sigma bonds are in a molecule of diethyl ether, $C_2H_5OC_2H_5$?

(a) 14 (b) 12 (c) 8 (d) 16

Lattice Energy

110. The lattice energies of KF, KCl, KBr and KI follow the order :

(a) KF > KCl > KBr > KI (b) KI > KBr > KCl > KF

(c) KF > KCl > KI > KBr (d) KI > KBr > KF > KCl

111. Which set of compounds in the following pair of ionic compounds has the higher lattice energy?

(i) KCl or MgO (ii) LiF or LiBr (iii) Mg_3N_2 or NaCl

(a) KCl, LiBr, Mg_2N_2 (b) MgO, LiBr, Mg_3N_2

(c) MgO, LiF, NaCl (d) MgO, LiF, Mg_3N_2

112. The incorrect order of lattice energy is :

(a) $AlF_3 > MgF_2$ (b) $Li_3N > Li_2O$

(c) $NaCl > LiF$ (d) $TiC > ScN$

113. Which ionic compound has the largest amount of lattice energy?

(a) NaF (b) AlF_3 (c) AlN (d) MgF_2

Bond Angle

114. Which one of the following compounds has the smallest bond angle?

(a) OH_2 (b) SH_2 (c) NH_3 (d) SO_2

115. Maximum bond angle is present in :

(a) BBr_3 (b) BCl_3 (c) BF_3 (d) none of these

116. The correct order of H — *M* — H bonds angle is :

(a) $NH_3 < PH_3 < SbH_3 < BiH_3$ (b) $AsH_3 < SbH_3 < PH_3 < NH_3$

(c) $NH_3 < PH_3 < BiH_3 < SbH_3$ (d) $BiH_3 < SbH_3 < AsH_3 < PH_3$

117. The correct increasing order of adjacent bond angle among BF_3, PF_3 and ClF_3 :

(a) $BF_3 < PF_3 < ClF_3$ (b) $PF_3 < BF_3 < ClF_3$

(c) $ClF_3 < PF_3 < BF_3$ (d) $BF_3 = PF_3 = ClF_3$

118. Among the following species, the least angle around the central atom is in :

(a) O_3 (b) I_3^- (c) NO_2^- (d) PH_3

119. The bond angles of NH_3, NH_4^+ and NH_2^- are in the order :

(a) $NH_2^- > NH_3 > NH_4^+$ (b) $NH_4^+ > NH_3 > NH_2^-$

(c) $NH_3 > NH_2^- > NH_4^+$ (d) $NH_3 > NH_4^+ > NH_2^-$

120. The H—C—H bond angle in CH_4 is 109.5°, due to lone pair repulsion, the H—O—H angle in H_2O will :

(a) remain the same (b) increase (c) decrease (d) become 180°

121. The molecule having the largest bond angle is :

(a) H_2O (b) H_2S (c) H_2Se (d) H_2Te

122. The compound MX_4 is tetrahedral. The number of $\angle XMX$ angles in the compound is :

(a) three (b) four

(c) five (d) six

123. The "O — N — O" bond angle is maximum in :

(a) N_2O (b) NO_2^+ (c) NO_2^- (d) NO_3^-

124. Which of the following is the correct order for increasing bond angle ?

(a) $NH_3 < PH_3 < AsH_3 < SbH_3$ (b) $H_2O < OF_2 < Cl_2O$

(c) $H_3Te^+ < H_3Se^+ < H_3S^+ < H_3O^+$ (d) $BF_3 < BCl_3 < BBr_3 < BI_3$

Level 2

Molecular Forces

1. The incorrect order of boiling point is :

(a) $H_2O > CH_3OH$
(b) $N(CH_3)_3 > NH(CH_3)_2$
(c) $H_3PO_4 > Me_3PO_4$
(d) $CH_3N_3 > HN_3$

2. Iodine molecules are held in the solid lattice by ....

(a) London forces
(b) dipole-dipole interactions
(c) covalent bonds
(d) coulombic force

3. Carbon dioxide is gas, while SiO_2 is solid because :

(a) CO_2 is a linear molecule, while SiO_2 is angular
(b) van der Waals' forces are very strong in SiO_2
(c) CO_2 is covalent, while SiO_2 is ionic
(d) Si cannot form stable bonds with O, hence Si has to form a 3D lattice

Hybridisation

4. Choose the correct code of characteristics for the given order of hybrid orbitals of same atom,

$$sp < sp^2 < sp^3$$

(i) Electronegativity
(ii) Bond angle between same hybrid orbitals
(iii) Size
(iv) Energy level
(a) (ii), (iii) and (iv)
(b) (iii), (iv)
(c) (ii) and (iv)
(d) (i), (ii), (iii) and (iv)

5. Which is correct statement?
As the *s*-character of a hybrid orbital decreases

(I) The bond angle decreases
(II) The bond strength increases
(III) The bond length increases
(IV) Size of orbitals increases
(a) (I), (III) and (IV)
(b) (II), (III) and (IV)
(c) (I) and (II)
(d) All are correct

6. Which of the following is incorrectly match ?

	Hybridisation	**Geometry**	**Orbitals use**
(a)	sp^3d	Trigonal bipyramidal	$s + p_x + p_y + p_z + d_{z^2}$
(b)	sp^3d^3	Pentagonal bipyramidal	$s + p_x + p_y + p_z + d_{x^2-y^2} + d_{z^2} + d_{xy}$
(c)	sp^3d^2	Capped octahedral	$s + p_x + p_y + p_z + d_{x^2-y^2} + d_{z^2}$
(d)	sp^3	Tetrahedral	$s + p_x + p_y + p_z$

Ionic Bond

7. The ionic bonds X^+Y^- are formed when :

(I) electron affinity of Y is high
(II) ionization energy of X is low
(III) lattice energy of XY is high
(IV) lattice energy of XY is low

Choose the correct code :

(a) I and II (b) I and III (c) I, II and III (d) All

8. In the Born-Haber cycle for the formation of solid common salt (NaCl), the largest contribution comes from:

(a) the low ionization potential of Na (b) the high electron affinity of Cl

(c) the low ΔH_{vap} of Na(s) (d) the lattice energy

Molecular Geometry/Shape

9. Species having maximum 'Cl—O' bond order is :

(a) ClO_3^- (b) ClO_3 (c) ClO_2 (d) ClO_2^-

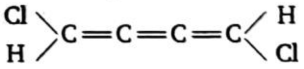
10. Which of the following species contains minimum number of atoms in '*XY*' plane?

(a) XeF_5^- (b) SF_6 (c) IF_7 (d) All

11. The molecule ML_x is planar with 7 pairs of electrons around *M* in the valence shell. The value of *x* is :

(a) 6 (b) 5 (c) 4 (d) 3

12. Choose the correct option for the following molecule in view of chemical bonding :



(a) non-planar (b) $\mu \neq 0$ (c) both (a) and (b) (d) $\mu = 0$

VSEPR Theory

13. Which of the following statement is correct about I_3^+ and I_3^- molecular ions ?

(a) Number of lone pairs at central atoms are same in both molecular ions

(b) Hybridization of central atoms in both ions are same

(c) Both are polar species

(d) Both are planar species

14. In which of the following molecular shape d_{z^2}-orbital must not be involved in bonding ?

(a) Pentagonal planar (b) Trigonal planar (c) Linear (d) Square planar

15. The correct statement regarding SO_2 molecule is:

(a) two $p\pi$ - $d\pi$ bonds

(b) molecule has 2 lone pair, 2σ bonds and 2π bonds

(c) two $p\pi$ - $p\pi$ bonds

(d) one $p\pi$ - $p\pi$ and one $p\pi$ - $d\pi$ bond

16. A molecule XY_2 contains two σ, two π-bonds and one lone pair of electron in the valence shell of *X*. The arrangement of lone pair as well as bond pairs is :

(a) square pyramidal (b) linear (c) trigonal planar (d) unpredictable

17. In which of the following pairs, both the species have the same hybridisation ?

(I) SF_4, XeF_4 (II) I_3^-, XeF_2 (III) $ICl_4^+, SiCl_4$ (IV) ClO_3^-, PO_4^{3-}

(a) I, II (b) II, III (c) II, IV (d) I, II, III

18. Which of the following possess two lone pair of electrons on the central atom and square planar in shape ?

(I) SF_4 (II) XeO_4 (III) XeF_4 (IV) ICl_4^-

(a) I, III (b) II, IV (c) III, IV (d) All

19. Select pair of compounds in which both have different hybridization but have same molecular geometry :

(a) BF_3, BrF_3 (b) $ICl_2^{\ominus}, BeCl_2$ (c) BCl_3, PCl_3 (d) PCl_3, NCl_3

20. The species having no $p\pi - p\pi$ bond but has bond order equal to that of O_2 :

(a) ClO_3^- (b) PO_4^{3-} (c) SO_4^{2-} (d) XeO_3

Bond Length

21. Which of the following fact is directly explained by the statement 'oxygen is a smaller atom than sulphur' ?

(a) H_2O boils at a much higher temperature than H_2S
(b) H_2O undergoes intermolecular hydrogen bonding
(c) H_2O is liquid and H_2S is gas at room temperature
(d) S—H bond is longer than O—H bond

22. Which of the following compound has maximum "C — C" single bond length ?

(a) CH_2CHCCH (b) HCCCCH
(c) CH_3CHCH_2 (d) $CH_2CHCHCH_2$

Valence Bond Theory

23. If two different non-axial *d*-orbitals having 'xz' nodal plane form π-bond by overlapping each other, then internuclear axis will be :

(a) *x* (b) *y*
(c) *z* (d) They don't form π-bond

24. Assuming pure 2*s* and 2*p* orbitals of carbon are used in forming CH_4 molecule, which of the following statement is false?

(a) Three C—H bonds will be at right angle
(b) One C—H bond will be weaker than other three C—H bonds
(c) The shape of molecule will be tetrahedral
(d) The angle of C—H bond formed by *s-s* overlapping will be uncertain with respect to other three bonds.

25. The strength of bonds formed by 2*s*-2*s*, 2*p*-2*p* and 2*p* – 2*s* overlap has the order :

(a) $s\text{-}s > p\text{-}p > p\text{-}s$ (b) $s\text{-}s > p\text{-}s > p\text{-}p$
(c) $p\text{-}p > p\text{-}s > s\text{-}s$ (d) $p\text{-}p > s\text{-}s > p\text{-}s$

26. Which of the following statements is incorrect for sigma and π-bonds formed between two carbon atoms?

(a) Sigma-bond is stronger than a π-bond
(b) Bond energies of sigma and π-bonds are of the order of 264 kJ/mol and 347 kJ/mol
(c) Free rotation of surrounding atoms about a sigma-bond is allowed but not in case of a π-bond
(d) Sigma-bond determines the direction between carbon atoms but a π-bond has no primary effect in this regard

27. Assuming the bond direction to the *z*-axis, which of the overlapping of atomic orbitals of two atom (*A*) and (*B*) will result in bonding?

(I) *s*-orbital of *A* and p_x-orbital of *B* (II) *s*-orbital of *A* and p_z orbital of *B*

(III) p_y-orbital of A and p_z orbital of B (IV) s-orbital of both (A) and (B)

(a) I and IV (b) I and II (c) III and IV (d) II and IV

28. Which of the following orbital can not form π as well as δ-Bond ?

(a) d_{xy} (b) d_{z^2}

(c) $d_{x^2-y^2}$ (d) d_{yz}

Lattice Energy

29. Incorrect statement is :

(a) $AlF_3 > MgO > MgF_2$: Lattice energy

(b) $Li > Na > Al > Mg$: Electron affinity

(c) $SF_6 > PF_5 > SiF_4$: Lewis acidic character

(d) $SiCl_4 > SiBr_4 > SiI_4$: Decreasing order of electronegativity of Si

Bond Angle

30. Which of the following set contains species having same angle around the central atom?

(a) SF_4, CH_4, NH_3 (b) NF_3, BCl_3, NH_3

(c) $BF_3, NF_3, AlCl_3$ (d) BF_3, BCl_3, BBr_3

31. Which of the following compound has the smallest bond angle ($X — A — X$) in each series respectively?

(A) OSF_2	$OSCl_2$	$OSBr_2$
(B) $SbCl_3$	$SbBr_3$	SbI_3
(C) PI_3	AsI_3	SbI_3

(a) OSF_2, $SbCl_3$ and PI_3 (b) $OSBr_2$, SbI_3 and PI_3

(c) OSF_2, SbI_3 and PI_3 (d) OSF_2, $SbCl_3$ and SbI_3

Level 3

PASSAGE 1

According to VSEPR model, molecules adopt geometries in which their valence electron pairs position themselves as far from each other as possible. The VSEPR model considers double and triple bonds to have slightly greater repulsive effects than single bonds because of the repulsive effect of π-electrons. However the lone pair creates the maximum repulsive effect.

1. Which of the following statement is false ?
(a) SbF_4^- and SF_4 are isostructural
(b) In IOF_5 the hybridization of central atom is sp^3d^2
(c) Double bond(s) in SOF_4 and XeO_3F_2, is/are occupying equatorial position(s) of their respective geometry
(d) None of these

2. Which of the following does not represent the isostructural pair?
(a) SF_5^- and IF_5 (b) ClO_2F_3 and SOF_4 (c) SeF_3^+ and XeO_3 (d) None

3. Select the incorrect statement with respect to SO_2Cl_2 molecule :
(a) It gives H_2SO_4 and HCl on hydrolysis at room temperature
(b) It has two $d\pi$-$p\pi$ bonds between S and O bonded atoms
(c) It is a polar molecule
(d) None

PASSAGE 2

According to VBT any covalent bond will be formed by overlapping of atomic orbitals of bonded atoms provided atomic orbitals must be half-filled and electrons be in opposite spin. According to type of overlapping covalent bonds can be classified as (a) σ-bond (b) π-bond (c) δ -bond:

1. Which of the following set of orbitals does not produce nodal plane in xz-plane ?
(a) $d_{yz} + d_{yz}$ (b) $d_{xy} + d_{xy}$ (c) $p_y + d_{xy}$ (d) None of these

2. The combination of orbital that can not produce non-bonding molecular orbital is (inter-nuclear axis is z-axis):
(a) $p_y + d_{x^2-y^2}$ (b) $p_z + d_{yz}$ (c) $s + d_{xz}$ (d) $d_{xy} + d_{xy}$

3. If $F_2C_1 = C_2$ part of $F_2C_1 = C_2 = C_3 = C_4F_2$ lies in yz-plane, then incorrect statement is :
(a) Nodal plane of π-bond between C_1 and C_2 lies in yz-plane, formed by sideways overlapping of p_x-orbitals
(b) Nodal plane of π-bond between C_2 and C_3 lies in xz-plane, formed by sideways overlapping of p_y-orbitals

(c) Nodal plane of π-bond between C_3 and C_4 lies in *yz*-plane, formed by sideways overlapping of p_y-orbitals

(d) Nodal plane of π-bond between C_2 and C_3 lies in *xy*-plane, formed by sideways overlapping of p_x-orbitals

PASSAGE 3

If the central atom is of third row or below this in the periodic table, then lone pair will occupy a stereochemically inactive *s*-orbital and bonding will be through almost pure *p*-orbitals and bond angles are nearly 90°, if the substituent's electronegativity value is $\leq$ 2.5.

1. In which of the following option, covalent bond is having maximum *s*% character?
(a) S — H bond in H_2S (b) P — H bond in PH_3
(c) N — H bond in NH_3 (d) All have equal *s*% character

2. Select incorrect statement regarding P_4 molecule.
(a) Each P atom is joined with three P-atoms
(b) P_4 molecule contains total 12 bond angles
(c) Lone pair of each P atom is present in almost pure *s*-orbital
(d) Lone pair of each P atom present in hybrid orbital

3. The hybridisation of atomic orbitals of central atom "Xe" in XeO_4, XeO_2F_2 and $XeOF_4$ respectively.
(a) sp^3, sp^3d^2, sp^3d^2 (b) sp^3d, sp^3d, sp^3d^2
(c) sp^3, sp^3d^2, sp^3d (d) sp^3, sp^3d, sp^3d^2

PASSAGE 4

According to V.B.T., atoms of element form bond only to pair up their unpaired electrons present in ground state or excited state. This pairing of unpaired electron will take place by overlapping of orbitals each one having one unpaired electron with opposite spin.

1. Which of the following orbital combination does not form π-bond?
(a) $p_x + p_x$ sideways overlapping (b) $d_{x^2-y^2} + p_y$ sideways overlapping
(c) $d_{xy} + d_{xy}$ sideways overlapping (d) $d_{yz} + p_y$ sideways overlapping

2. Which of the following orbital cannot form δ-bond?
(a) $d_{x^2-y^2}$ orbital (b) d_{xy} orbital
(c) d_{z^2} orbital (d) d_{zx} orbital

3. Which of the following combination of orbitals does not from any type of covalent bond (if *z*-axis is molecular axis)?
(a) $p_z + p_z$ (b) $p_y + p_y$
(c) $s + p_y$ (d) $s + s$

PASSAGE 5

The space model which is obtained by joining the points representing various bonded atoms gives the shape of the molecule. The geometry of the molecule is definite relative arrangement of the bonded atoms in a molecule. The shape and geometry of a molecule is explained by valence shell electron pair repulsion theory given by Gillespie and Nyholm.

1. Select the correct code for the following repulsion orders, according to VSEPR theory :
(I) lone pair–lone pair > lone pair–bond pair
(II) lone pair–bond pair > bond pair–bond pair
(III) lone pair–lone pair > bond pair–bond pair
(IV) lone pair–bond pair > lone pair–lone pair
(a) I, II & III (b) II & IV (c) I, II & IV (d) All

2. Which molecule has both shape and geometry identical?
(I) $SnCl_2$ (II) NH_3 (III) PCl_5 (IV) SF_6
(a) I, III & IV (b) II, III & IV
(c) III & IV (d) All

3. Which is not the electron geometry of covalent molecules?
(a) Pentagonal bipyramidal (b) Octahedral
(c) Hexagonal (d) Tetrahedral

PASSAGE 6

When hybridisation involving *d*-orbitals are considered then all the five *d*-orbitals are not degenerate, rather $d_{x^2-y^2}, d_{z^2}$ and d_{xy}, d_{yz}, d_{zx} form two different sets of orbitals and orbitals of appropriate set is involved in the hybridisation.

1. In sp^3d^2 hybridisation, which sets of *d*-orbitals is involved ?
(a) $d_{x^2-y^2}, d_{z^2}$ (b) d_{z^2}, d_{xy} (c) d_{xy}, d_{yz} (d) $d_{x^2-y^2}, d_{xy}$

2. In sp^3d^3 hybridisation, which orbitals are involved?
(a) $d_{x^2-y^2}, d_{z^2}, d_{xy}$ (b) d_{xy}, d_{yz}, d_{zx}
(c) $d_{x^2-y^2}, d_{xy}, d_{xz}$ (d) d_{z^2}, d_{yz}, d_{zx}

3. Molecule having trigonal bipyramidal geometry and sp^3d hybridisation, *d*-orbitals involved is:
(a) d_{xy} (b) d_{yz} (c) $d_{x^2-y^2}$ (d) d_{z^2}

4. Which of the following orbitals can not undergo hybridisation amongst themselves.
(I) $3d, 4s$ (II) $3d, 4d$
(III) $3d, 4s$ & $4p$ (IV) $3s, 3p$ & $4s$
(a) only II (b) II & III (c) I, II & IV (d) II & IV

PASSAGE 7

Ionic bond is defined as the electrostatic force of attraction holding the oppositely charged ions. Ionic compounds are mostly crystalline solid having high melting and boiling points, electrical conductivity in molten state, solubility in water etc. Covalent bond is defined as the force which binds atoms of same or different elements by mutual sharing of electrons in a covalent bond. Covalent compounds are solids, liquids or gases. They have low melting and boiling points compounds. They are more soluble in non-polar solvents.

1. The valence electrons are involved in formation of covalent bonds is/are called :

(a) non-bonding electrons (b) lone pairs

(c) unshared pairs (d) none of these

2. The amount of energy released when one mole of ionic solid is formed by packing of gaseous ion is called :

(a) Ionisation energy (b) Solvation energy

(c) Lattice energy (d) Hydration energy

3. Which of the following is arranged order of increasing boiling point ?

(a) $H_2O < CCl_4 < CS_2 < CO_2$ (b) $CO_2 < CS_2 < CCl_4 < H_2O$

(c) $CS_2 < H_2O < CO_2 < CCl_4$ (d) $CCl_4 < H_2O < CO_2 < CS_2$

PASSAGE 8

When an ionic compound is dissolved in water (polar solvent), it breaks up into its constituent ions. The given ionic compound will be dissolved in water if its hydration energy is more than lattice energy. If hydration energy is less than lattice energy then ionic compound is usually either sparingly soluble or insoluble in water.

1. Which of the following ionic compound is having maximum lattice energy :

(a) NaF (b) MgF_2 (c) AlF_3 (d) KF

2. Most hydrated cation is :

(a) $Ce^{4+}_{(aq.)}$ (b) $La^{3+}_{(aq.)}$ (c) $Ba^{2+}_{(aq.)}$ (d) $Cs^{+}_{(aq.)}$

PASSAGE 9

A covalent bond will be formed by the overlapping of atomic orbitals having single electron of opposite spin, according to the overlapping of atomic orbitals the covalent bond may be of two types :

(i) Sigma bond (σ) (ii) Pi bond (π)

Sigma bond is stronger bond than the Pi-bond. If atomic orbitals overlap about the nuclear axis then sigma bond is formed but when atomic orbitals overlap sideway then Pi-bond is formed.

1. The correct order of increasing C — O bond length of CO, CO_3^{2-}, CO_2 is :

(a) $CO_3^{2-} < CO_2 < CO$ (b) $CO_2 < CO_3^{2-} < CO$

(c) $CO < CO_3^{2-} < CO_2$ (d) $CO < CO_2 < CO_3^{2-}$

2. Compound having maximum bond angle is :

(a) BBr_3 (b) BCl_3

(c) BF_3 (d) None of these

3. The strength of bonds formed by $2s-2s$, $2p-2p$ and $2p-2s$ overlap has the order :

(a) $s-s>p-p>p-s$ (b) $s-s>p-s>p-p$

(c) $p-p>p-s>s-s$ (d) $p-p>s-s>p-s$

PASSAGE 10

According to VBT the extent of overlapping depends upon types of orbitals involved in overlapping and nature of overlapping. More will be the overlapping and the bond energy will also be high.

1. The incorrect order of bond dissociation energy will be :

(a) $H-H>Cl-Cl>Br-Br$

(b) $Si-Si>P-P>Cl-Cl$

(c) $C-C>N-N>O-O$

(d) $H-Cl>H-Br>H-I$

2. Which of the following combination of orbitals does not form covalent bond (x-axis is inter nuclear axis) :

(a) $s+p_y$ (b) p_y+p_y

(c) $d_{yz}+d_{yz}$ (d) $d_{xy}+d_{xy}$

3. Which of the following compound does not form $p\pi-p\pi$ bond ?

(a) SO_3 (b) NO_3^-

(c) SO_4^{2-} (d) CO_3^{2-}

PASSAGE 11

Consider the following elements with their period number and valence electrons.

Elements	Period number	Total valence e^-
P	2	4
Q	2	6
R	3	7
S	3	3
T	3	6
U	3	4

According to the given informations, answer the following questions :

1. Choose incorrect statement :

(a) R exhibits maximum covalency among all elements given

(b) Q does not exhibit variable covalency

(c) R exhibits minimum covalency among all elements given

(d) R and S combine each other and form SR_5 type of compound

2. Choose the correct statement :

(a) Q has maximum value of electron affinity

(b) R has maximum value of electronegativity

(c) S has maximum atomic size

(d) T and U are same group elements

3. Choose the incorrect statement :

(a) SR_3 is a hypovalent compound

(b) UR_4 can act as a Lewis acid

(c) PQ_2 can not acts as Lewis acid

(d) $UR_4 > SR_3$: Lewis acidic character

PASSAGE 12

Hybridisation involves the mixing of orbitals having comparable energies of same atom. Hybridised orbitals perform efficient overlapping than overlapping by pure *s*, *p* or *d* orbitals.

1. Which of the following is not correctly match between given species and type of overlapping ?

(a) XeO_3: Three $(d\pi - p\pi)$ bonds

(b) H_2SO_4: Two $(d\pi - p\pi)$ bonds

(c) SO_3: Three $(d\pi - p\pi)$ bonds

(d) $HClO_4$: Three $(d\pi - p\pi)$ bonds

2. Consider the following compounds and select the incorrect statement from the following :

$$NH_3,\ PH_3,\ H_2S,\ SO_2,\ SO_3,\ BF_3,\ PCl_3,\ IF_7,\ P_4,\ H_2$$

(a) Six molecules out of given compounds involves hybridisation

(b) Three molecules are hypervalent compounds

(c) Six molecules out of above compounds are non-planar in structure

(d) Two molecules out of given compounds involves $(d\pi - p\pi)$ bonding as well as also involves $(p\pi - p\pi)$ bonding

ONE OR MORE ANSWERS IS/ARE CORRECT

Hydrogen Bond

1. In which of the following there is intermolecular hydrogen bonding?
(a) Water (b) Ethanol (c) Acetic acid (d) H—F

Molecular Forces

2. Correct order of decreasing boiling points is :
(a) $HF > HI > HBr > HCl$ (b) $H_2O > H_2Te > H_2Se > H_2S$
(c) $Br_2 > Cl_2 > F_2$ (d) $CH_4 > GeH_4 > SiH_4$

Hybridisation

3. In which species the hybrid state of central atom is/are sp^3d ?
(a) I_3^- (b) SF_4 (c) PF_5 (d) IF_5

4. Select correct statement(s) is/are :
(a) In AsH_3 molecule lone pair at central atom is present in almost pure *s*-orbital
(b) Number of $p\pi - d\pi$ bond in SO_3 and SO_2 are same
(c) NF_3 is better Lewis base than NCl_3
(d) Stable oxidation state of Lead is +2

Coot Bond

5. Which of the following species does/do not exist?
(a) OF_4 (b) NH_2^- (c) NCl_5 (d) ICl_3^{2-}

6. Which of the following species is/are superoctet molecule?
(a) AlF_3 (b) $SiCl_4$ (c) XeF_2 (d) ICl_3

7. Which of the following statements is incorrect ?
(a) A σ-bond is weaker than a π-bond
(b) There are four co-ordinate bonds in the NH_4^+ ions
(c) The covalent bond is directional in nature
(d) HF is less polar than HCl

8. Which of the following species is/are capable of forming a coordinate bond with BF_3?
(a) PH_3 (b) NH_4^+ (c) OH^- (d) Mg^{2+}

Ionic Bond

9. Ionic compounds in general do not possess :
(a) high melting points and non-directional bonds
(b) high melting points and low-boiling points
(c) directional bonds and low-boiling points
(d) high solubilities in polar and non-polar solvents

10. Correct stability order of metal cation is/are :
(a) $Pb^{2+} < Sn^{2+}$ (b) $Pb^{4+} < Pb^{2+}$ (c) $Sn^{4+} < Sn^{2+}$ (d) $Pb^{4+} < Sn^{4+}$

Molecular/Geometry/Shape

11. Consider the following molecule :

$$\underset{(1)}{H_2C} = \underset{(2)}{C} = \underset{(3)}{C} = \underset{(4)}{C} = \underset{(5)}{CF_2}$$

If hybridization of $C_{(1)}$ carbon atom is $sp^2(s + p_y + p_z)$ and hybridization of $C_{(4)}$ carbon atom is $sp(s + p_z)$. Then according to given information the **correct** statement(s) is/are :

(a) Nodal plane of π-bond between $C_{(2)}$ and $C_{(3)}$ lies in *xz*-plane, formed by sideways overlapping of p_y-orbitals

(b) Nodal plane of π-bond between $C_{(3)}$ and $C_{(4)}$ lies in *yz*-plane, formed by side ways overlapping of p_x-orbitals

(c) The orbitals involve in hybridization of $C_{(5)}$ carbon atom are $s + p_x + p_z$

(d) Nodal plane of π-bond between $C_{(1)}$ and $C_{(2)}$ lies in *yz*-plane, formed by side ways overlapping of p_y-orbitals

12. Consider the following two molecules and according to the given information select correct statement(s) about AX_2 and AY_2 :

where A : 16th group of 3rd period element

X : more electronegative than (A) and same group number of (A)

Y : Less atomic size than (A) and same period number of (A)

(a) The hybridization of central atoms are different in both compounds

(b) The shape of both molecules are same

(c) Both compounds are planar

(d) The $X - A - X$ bond angle is less than $Y - A - Y$ bond angle

13. Which of the following statements are correct about sulphur hexafluoride ?

(a) all S — F bonds are equivalent

(b) SF_6 is a planar molecule

(c) oxidation number of sulphur is the same as number of electrons of sulphur involved in bonding

(d) sulphur has acquired the electronic structure of the gas argon

14. If AB_4^n, types species are tetrahedral, then which of the following is/are correctly match? (Where A is central atom, B is surrounding atom and n is charge on species.)

	A	B	n
(a)	Xe	O	0
(b)	Se	F	0
(c)	P	O	–3
(d)	N	H	+1

VSEPR Theory

15. Which of the following statements is correct ?

(a) ClF_3 molecule is bent T-shape

(b) In SF_4 molecule, F—S—F equatorial bond angle is 103° due to *lp* – *lp* repulsion

(c) In $[ICl_4]^-$ molecular ion, Cl—I—Cl bond angle is 90°

(d) In OBr_2, the bond angle is less than OCl_2

16. Which of the following combination of bond pair (b.p.) and lone pair (l.p.) give same shape?

(i) 3 b.p.+1 l.p. (ii) 2 b.p.+2 l.p. (iii) 2 b.p.+1 l.p. (iv) 2 b.p.+0 l.p.
(v) 3 b.p.+2 l.p. (vi) 2 b.p.+3 l.p.

(a) (ii) and (iii) (b) (iv) and (v) (c) (iv) and (vi) (d) (iii) and (vi)

17. Select the true statement(s) among the following :

(a) Pure overlapping of two d_{xy} orbitals along x-axis results in the formation of π-bond
(b) $NO_2^+ > NO_3^- > NO_2^-$ is the correct order of bond angle as well as N—O bond order
(c) $NF_3 < NCl_3 < NBr_3 < NI_3$ is the correct order of Lewis basic character as well as bond angle
(d) HF > HCl > HBr > HI is the correct order of dipole moment as well as boiling point

Valence Bond Theory

18. p_y-orbital can not form π-bond by lateral overlap with :

(a) d_{xz}-orbital (b) $d_{x^2-y^2}$-orbital
(c) d_{xy}-orbital (d) p_z-orbital

19. Which of the following orbital(s) cannot form δ -bond ?

(a) $d_{x^2-y^2}$-orbital (b) d_{xy}-orbital
(c) d_{z^2}-orbital (d) p_x-orbital

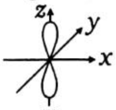
20. Select correct statement(s) regarding σ and π-bonds:

(a) σ-bond lies on the line joining the nuclei of bonded atoms
(b) π-electron cloud lies on either side to the line joining the nuclei of bonded atoms
(c) $(2p_\pi - 3d_\pi)$ π-bond is stronger than $(2p_\pi - 3p_\pi)$ π-bond.
(d) σ-bond has primary effect to decide direction of covalent bond, while π -bond has no primary effect in direction of bond

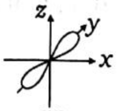
21. Which of the following statements is/are correct?

(a) All carbon to carbon bonds contain a sigma bond and one or more π-bonds
(b) All carbon to carbon bonds are sigma bonds
(c) All oxygen to hydrogen bonds are hydrogen bonds
(d) All carbon to hydrogen bonds are sigma bonds

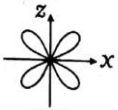
22. Consider the following three orbitals :



(i)



(ii)



(iii)

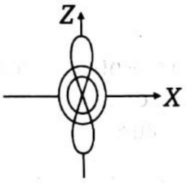
Correct statement(s) regarding given information is/are :

(a) Orbitals (i) and (ii) can never form any type of covalent bond
(b) If internuclear axis is 'x', then combination of (ii) and (iii) orbitals can form π-bond
(c) Orbital (iii) can form δ-bond with other orbital having same orientation of lobes
(d) If internuclear axis is 'x', then combination of (i) and (iii) orbitals can form π-bond

23. Which of the following combination of orbitals do/does not form bond (if x-axis is internuclear axis) ?

(a) $s + p_z$ (b) $s + s$ (c) $p_z + p_x$ (d) $d_{xy} + p_y$

24. Consider the following atomic orbitals :



Which of the following statement(s) is/are correct regarding given orbital ?

(a) It is a gerade atomic orbital

(b) It has zero nodal plane

(c) Circular electron density is present in 'XY' plane

(d) Opposite lobes of orbital have same sign of wave function (ψ)

MATCH THE COLUMN

Column-I and Column-II contains four entries each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

1.

Column-I	Column-II
(A) $B_3N_3H_6$	(P) Planar geometry
(B) I_3^-	(Q) Non-planar geometry
(C) B_2Cl_4 (Solid)	(R) Compound having coordinate bond
(D) SiF_4	(S) Compound having back bond
	(T) Non-polar compound

2.

Column-I (Shape)	Column-II (Hybridisation)
(A) Linear	(P) sp^3
(B) Angular	(Q) sp^3d^2
(C) Square planar	(R) sp^2
(D) Trigonal planar	(S) sp^3d

3.

Column-I	Column-II
(A) SO_3	(P) Largest bond angle
(B) $BeCl_2$	(Q) Lowest bond angle
(C) NH_3	(R) sp^2-hybridisation
(D) NO_2^-	(S) sp^3-hybridisation

4.

Column-I	Column-II
(A) Hypo phosphoric acid	(P) All hydrogen are ionizable in water
(B) Pyro phosphorous acid	(Q) Lewis acid in water
(C) Boric acid	(R) Monobasic
(D) Hypo phosphorous acid	(S) sp^3-hybridised central atom

5.

Column-I	Column-II
(A) NH_2^-	(P) Square pyramidal
(B) $XeOF_2$	(Q) V-shaped
(C) ICl_4^-	(R) T-shaped
(D) $[SbF_5]^{2-}$	(S) Square planar

6.

Column-I	Column-II
(A) ICl_2^-	(P) Linear
(B) BrF_2^+	(Q) Pyramidal
(C) ClF_4^-	(R) Tetrahedral
(D) $AlCl_4^-$	(S) Square planar
	(T) Angular

7.

Column-I	Column-II
(A) $Re_2Cl_8^{2-}$	(P) $p\pi - p\pi$ bonding
(B) NO_3^-	(Q) $p\pi - d\pi$ bonding
(C) SO_4^{2-}	(R) $d\pi - d\pi$ bonding
(D) SO_3	(S) δ-bonding

8.

Column-I (Bond order range)	Column-II (Oxyanions)
(A) 1.0 to 1.30	(P) NO_3^-
(B) 1.31 to 1.55	(Q) ClO_4^-
(C) 1.56 to 1.70	(R) PO_4^{3-}
(D) 1.71 to 2.0	(S) ClO_3^-
	(T) SO_4^{2-}

9.

Column-I	Column-II
(A) AsO_4^{3-}	(P) All three *p*-orbitals used in hybridisation
(B) ICl_2^+	(Q) Tetrahedral shape
(C) SOF_4	(R) Axial *d*-orbital with two nodal cones used in hybridisation
(D) $XeOF_4$	(S) All bond lengths are identical
	(T) $p\pi - d\pi$ bond(s) present

10.

Column-I σ-bond pairs + lone pairs around central atom of AB_x type compound	Column-II Characteristics/shape of compound
(A) 2 + 1	(P) Linear
(B) 2 + 3	(Q) Angular
(C) 4 + 2	(R) Polar
(D) 2 + 2	(S) Non-polar
	(T) Planar

11.

Column-I (Type of bond formed)	Column-II [Combining orbitals (Internuclear axis)]
(A) π-bond	(P) $d_{yz} + p_y$, (z)
(B) σ-bond	(Q) $s + p_x$, (y)
(C) δ-bond	(R) $d_{yz} + d_{yz}$, (x)
(D) Non-bonding	(S) $s + s$, (z)
	(T) $s + d_{xy}$, (y)

12.

Column-I	Column-II
(A) XeF_5^-	(P) d-orbital with zero nodal plane is used in hybridisation
(B) PBr_4^+	(Q) Non-axial d-orbital is used in hybridisation
(C) IOF_3	(R) Planar species
(D) NH_2^-	(S) Non-planar species
	(T) Bond angle 109°28' or less than 109°28'

13.

Column-I	Column-II
(A) $IO_2F_2^-$	(P) Trigonal pyramidal shape
(B) IOF_4^-	(Q) Square pyramidal shape
(C) $SeOF_2$	(R) See-saw shape
(D) $XeOF_2$	(S) Non-planar
	(T) One of the bond angle < 90°

ASSERTION-REASON TYPE QUESTIONS

These questions consist of two statements each, printed as assertion and reason, while answering these questions you are required to choose any one of the following responses.

(A) If assertion is true but the reason is false
(B) If assertion is false but reason is true
(C) If both assertion and reason are true and the reason is the correct explanation of assertion
(D) If both assertion and reason are true but reason is not the correct explanation of assertion

1. **Assertion :** Multiple bond between two bonded atoms can have more than three bonds.
Reason : Multiple bond between two bonded atoms can not have more than two π-bonds.

2. **Assertion** : 2^{nd} period elements do not involve in excitation of electron.
Reason : 2^{nd} period elements do not have vacant $2d$-orbitals.

3. **Assertion** : In SO_3 molecule bond dissociation energy of all $S{=}O$ bonds are not equivalent.
Reason : SO_3 molecule is having two types of $2p\pi - 3p\pi$ and $2p\pi - 3d\pi$ pi-bonds.

4. **Assertion** : PH_4^+ ion is having tetrahedron geometry.
Reason : P-atom is unhybridised in PH_4^+ ion.

5. **Assertion** : All diatomic molecules with polar bond have dipole moment.
Reason : Dipole moment is a vector quantity.

6. **Assertion** : Water is a good solvent for ionic compounds but poor for covalent compounds.
Reason : Hydration energy of ions releases sufficient energy to overcome lattice energy and break hydrogen bonds in water while covalent compounds interact so weakly that even van der Waals' forces between molecules of covalent compounds cannot be broken.

7. **Assertion** : Xe-atom in XeF_2 assumes *sp*-hybrid state.
Reason : XeF_2 molecule does not follow octet rule.

8. **Assertion** : The atoms in a covalent molecule are said to share electrons, yet some covalent molecules are polar.
Reason : In polar covalent molecule, the shared electrons spend more time on the average near one of the atoms.

9. **Assertion** : CCl_4 is a non-polar molecule.
Reason : CCl_4 has polar bonds.

10. **Assertion** : Geometry of ICl_3 is tetrahedral.
Reason : Its shape is T-shape, due to the presence of two lone pairs.

11. **Assertion** : The covalency of carbon is four in excited state.
Reason : The four half-filled pure orbitals of carbon form same kind of bonds with an atom as those are with hybridised orbitals.

12. **Assertion** : The shape of XeF_4 is square-planar.
Reason : In an octahedral geometry, a single lone pair can occupy any position but a second lone pair will occupy the opposite position to the first lone pair.

SUBJECTIVE PROBLEMS

1. Consider following compounds A to E :

(A) XeF_n (B) $XeF_{(n+1)}^+$ (C) $XeF_{(n+1)}^-$ (D) $XeF_{(n+2)}$

(E) $XeF_{(n+4)}^{2-}$,

If value of n is 4, then calculate value of "$p \div q$" here, 'p' is total number of bond pair and 'q' is total number of lone pair on central atoms of compounds (A) to (E).

2. Consider the following five groups (According to modern periodic table) of elements with their increasing order of atomic numbers :

Group 1 → A, B, C, D, E
Group 2 → F, G, H, I, J
Group 13 → K, L, M, N, O
Group 15 → P, Q, R, S, T
Group 17 → U, V, W, X, Y

If first and last element of each group belongs to 2nd and 6th period respectively and Z represents to carbonate ion (CO_3^{2-}) then consider the following orders.

(i) $O^+ > H^{2+}$; Polarising power
(ii) $T^{3+} > S^{3+} > R^{3+}$; Stability of cation
(iii) $U^-(aq) > V^-(aq) > W^-(aq) > X^-(aq)$; Size

(iv) $JV_2 < IV_2 < GV_2 < LV_3$; Covalent character
(v) GZ > IZ > JZ; Thermal stability
(vi) AV > BV > CV > DV > EV; Thermal stability
(vii) $C_3P > B_3P > A_3P$; Lattice energy
(viii) $KU_3 < KV_3 < KW_3 < KX_3$; Melting point

Then calculate value of $|p - q|^2$, here p and q are correct and incorrect orders in the given eight orders respectively.

3. Consider the following species and find out total number of species which are polar and can act as Lewis acid

CCl_4, CO_2, SO_2, $AlCl_3$, HCHO, SO_3, $SiCl_4$, BCl_3, CF_4

4. Consider the following table regarding interhalogen compounds, XY_n (where Y is more electronegative than X)

Value of *n* for respective interhalogen compound	**Total number of *d*-orbitals used in hybridization of central atom**	**Polarity**	**Planarity**
P_1	1	Polar	Planar
P_2	Q_1	Polar	Non-Planar
P_3	Q_2	Non-Polar	Non-Planar

Then according to given information calculate value of expression $P_2 \times \dfrac{(P_3 - P_1)}{(Q_1 + Q_2)}$.

5. What is covalency of chlorine atom in second excited state?

6. Sum of σ and π-bonds in NH_4^+ cation is .....

7. Calculate the value of $X - Y$, for $XeOF_4$. (X= Number of σ bond pair and Y= Number of lone pair on central atom)

8. The molecule ML_x is planar with 6 electron pairs around M in the valence shell. The value of x is :

9. Calculate value of $\dfrac{X+Y+Z}{10}$, here X is O—N—O bond angle in NO_3^- Y is O—N—O bond angle in NO_2^+ and Z is F—Xe—F adjacent bond angle in XeF_4.

10. Calculate $x + y + z$ for H_3PO_3 acid, where x is no. of lone pairs, y is no. of σ bonds and z is no. of π bonds.

11. How many right angle, bond angles are present in TeF_5^- molecular ion?

12. How may possible ∠ FSeF bond angles are present in SeF_4 molecule?

13. In IF_6^- and TeF_5^-, sum of axial d-orbitals which are used in hybridisation in both species.

14. Among the following, total no. of planar species is:

(i) SF_4
(ii) BrF_3
(iii) XeF_2
(iv) IF_5
(v) SbF_4^-
(vi) SF_5^-
(vii) SeF_3^+
(viii) CH_3^+
(ix) PCl_4^+

15. Calculate the value of "$x + y - z$" here x, y and z are total number of non-bonded electron pair(s), pie(π) bond(s) and sigma(σ) bonds in hydrogen phosphite ion respectively.

16. Consider the following table

Total number of electron pairs (l.p. $+\sigma$-bond)	**Total number of lone pairs**	**Shape**
5	....p....	linear
....q....	1	see-saw
4	....r....	Bent shape
....s....	2	Square planar
5	....t....	Bent 'T' shape

Then calculate value of "$p + q + r - s - t$".

17. In phosphorus acid, if X is number of non bonding electron pairs. Y is number of σ-bonds and Z is number of π-bonds. Then, calculate value of "$Y \times Z - X$".

18. Calculate the number of $p_\pi - d_\pi$ bond(s) present in SO_4^{2-} :

19. Sum of σ & π-bonds in NH_4^+ cation is ....

20. Consider the following orbitals :

(i) $3p_x$ (ii) $4d_{z^2}$ (iii) $3d_{x^2-y^2}$ (iv) $3d_{yz}$

Then calculate value of '$x + y - z$' here x is total number of gerade orbital and y is total number of ungerade orbitals and z is total number of axial orbital in given above orbitals.

21. Calculate value of $|x - y|$, here, x and y are the total number of bonds in benzene and benzyne respectively which are formed by overlapping of hybridized orbitals.

22. Consider the following compounds :

(i) IF_5 (ii) ClI_4^- (iii) XeO_2F_2 (iv) NH_2^-

(v) BCl_3 (vi) $BeCl_2$ (vii) $AsCl_4^+$ (viii) $B(OH)_3$

(ix) NO_2^- (x) ClO_2^+

Then calculate value of "$x + y - z$", here, x, y and z are total number of compounds in given compounds in which central atom used their all three p-orbitals, only two p-orbitals and only one p-orbital in hybridisation respectively.

23. Total number of species which used all three p-orbitals in hybridisation of central atoms and should be non-polar also.

XeO_2F_2, $SnCl_2$, IF_5, I_3^+, XeO_4, SO_2, XeF_7^+, SeF_4

24. Consider the following species NO_3^-, SO_4^{2-}, ClO_3^-, SO_3, PO_4^{3-}, XeO_3, CO_3^{2-}, SO_3^{2-}

Then calculate value of $|x - y|$, where

x : Total number of species which have bond order 1.5 or greater than 1.5

y : Total number of species which have bond order less than 1.5

25. Consider the following orbitals $3s$, $2p_x$, $4d_{xy}$, $4d_{z^2}$, $3d_{x^2-y^2}$, $3p_y$, $4s$, $4p_z$ and find total number of orbital(s) having even number of nodal plane.

26. For the following molecules :

PCl_5, BrF_3, ICl_2^-, XeF_5^-, NO_3^-, XeO_2F_2, PCl_4^+, CH_3^+

Calculate the value of $\frac{a+b}{c}$

a = Number of species having sp^3d-hybridisation

b = Number of species which are planar

c = Number of species which are non-planar

27. Find out number of transformation among following which involves the change of hybridisation of underlined atom.

(a) $H_2\underline{O} + H^+ \longrightarrow H_3\underline{O}^+$

(b) $NH_3 + \underline{B}F_3 \longrightarrow NH_3 \cdot \underline{B}F_3$

(c) $\underline{Xe}F_6 \longrightarrow \underline{Xe}F_5^+ + F^-$

(d) $2\underline{P}Cl_5 \longrightarrow \underline{P}Cl_4^+ + PCl_6^-$

(e) $\underline{C}H_3 - CH_3 \longrightarrow \underline{C}H_3^- + CH_3^+$

ANSWERS

Level 1

1. (b)	**2.** (a)	**3.** (a)	**4.** (d)	**5.** (a)	**6.** (d)	**7.** (c)	**8.** (a)	**9.** (c)	**10.** (a)
11. (c)	**12.** (b)	**13.** (c)	**14.** (d)	**15.** (a)	**16.** (c)	**17.** (c)	**18.** (d)	**19.** (a)	**20.** (c)
21. (d)	**22.** (d)	**23.** (c)	**24.** (c)	**25.** (b)	**26.** (d)	**27.** (c)	**28.** (b)	**29.** (c)	**30.** (d)
31. (a)	**32.** (b)	**33.** (b)	**34.** (c)	**35.** (b)	**36.** (a)	**37.** (a)	**38.** (c)	**39.** (c)	**40.** (c)
41. (c)	**42.** (d)	**43.** (d)	**44.** (c)	**45.** (d)	**46.** (c)	**47.** (b)	**48.** (d)	**49.** (c)	**50.** (d)
51. (d)	**52.** (d)	**53.** (a)	**54.** (a)	**55.** (b)	**56.** (c)	**57.** (b)	**58.** (b)	**59.** (d)	**60.** (a)
61. (a)	**62.** (c)	**63.** (c)	**64.** (b)	**65.** (b)	**66.** (c)	**67.** (b)	**68.** (c)	**69.** (a)	**70.** (d)
71. (b)	**72.** (b)	**73.** (b)	**74.** (a)	**75.** (a)	**76.** (b)	**77.** (c)	**78.** (c)	**79.** (c)	**80.** (d)
81. (b)	**82.** (b)	**83.** (d)	**84.** (d)	**85.** (a)	**86.** (c)	**87.** (d)	**88.** (a)	**89.** (c)	**90.** (c)
91. (c)	**92.** (a)	**93.** (b)	**94.** (b)	**95.** (a)	**96.** (b)	**97.** (a)	**98.** (a)	**99.** (c)	**100.** (a)
101. (a)	**102.** (d)	**103.** (c)	**104.** (b)	**105.** (b)	**106.** (b)	**107.** (d)	**108.** (d)	**109.** (a)	**110.** (a)
111. (d)	**112.** (c)	**113.** (c)	**114.** (b)	**115.** (d)	**116.** (d)	**117.** (c)	**118.** (d)	**119.** (b)	**120.** (c)
121. (a)	**122.** (d)	**123.** (b)	**124.** (c)						

Level 2

1. (d)	**2.** (a)	**3.** (d)	**4.** (b)	**5.** (a)	**6.** (c)	**7.** (c)	**8.** (d)	**9.** (b)	**10.** (b)
11. (b)	**12.** (d)	**13.** (d)	**14.** (b)	**15.** (d)	**16.** (c)	**17.** (c)	**18.** (c)	**19.** (b)	**20.** (d)
21. (d)	**22.** (c)	**23.** (d)	**24.** (c)	**25.** (c)	**26.** (b)	**27.** (d)	**28.** (b)	**29.** (c)	**30.** (d)
31. (d)									

Level 3

Passage-1	**1.** (d)	**2.** (d)	**3.** (d)	
Passage-2	**1.** (d)	**2.** (d)	**3.** (c)	
Passage-3	**1.** (c)	**2.** (d)	**3.** (d)	
Passage-4	**1.** (b)	**2.** (c)	**3.** (c)	
Passage-5	**1.** (a)	**2.** (c)	**3.** (c)	
Passage-6	**1.** (a)	**2.** (a)	**3.** (d)	**4.** (d)
Passage-7	**1.** (d)	**2.** (c)	**3.** (b)	
Passage-8	**1.** (c)	**2.** (a)		
Passage-9	**1.** (d)	**2.** (d)	**3.** (c)	
Passage-10	**1.** (b)	**2.** (a)	**3.** (c)	

Passage-11 1. (d) 2. (c) 3. (c)

Passage-12 1. (c) 2. (c)

One or More Answers is/are correct

1.	(a,b,c,d)	**2.**	(a,b,c)	**3.**	(a,b,c)	**4.**	(a,d)	**5.**	(a,c,d)	**6.**	(c,d)
7.	(a,b,d)	**8.**	(a,c)	**9.**	(b,c,d)	**10.**	(b,d)	**11.**	(a,b,c)	**12.**	(a,b,c)
13.	(a,c)	**14.**	(a,c,d)	**15.**	(a,c)	**16.**	(a,c)	**17.**	(a,c)	**18.**	(a,b,d)
19.	(c,d)	**20.**	(a,b,c,d)	**21.**	(d)	**22.**	(a,c,d)	**23.**	(a,c)	**24.**	(a,b,c,d)

Match the Column

1.	A→ P, S, T;	B→ P, R, T;	C→ P, S, T;	D→ Q, S, T
2.	A→ P, S;	B→ P, R;	C→ Q;	D→ R
3.	A→ R;	B→ P;	C→ Q, S;	D→ R
4.	A→ P, Q, S;	B→Q, S;	C→ Q, R;	D→ Q, R, S
5.	A→ Q;	B→ R;	C→ S;	D→ P
6.	A→ P;	B→ T;	C→ S;	D→ R
7.	A→ R, S;	B→P;	C→ Q;	D→ P, Q
8.	A→ R;	B→P, T;	C→ S;	D→ Q
9.	A→ P, Q, S, T;	B→P, S;	C→P, R, T;	D→ P, R, T
10.	A→ Q, R, T;	B→P, S, T;	C→ S, T;	D→ Q, R, T
11.	A→ P;	B→S;	C→ R;	D→ Q, T
12.	A→ P, Q, R, T;	B→ S, T;	C→ P, S, T;	D→ R, T
13.	A→ R, S, T;	B→Q, S, T;	C→P, S;	D→ T

Assertion-Reason Type Questions

1.	(D)	**2.**	(B)	**3.**	(B)	**4.**	(A)	**5.**	(D)	**6.**	(C)	**7.**	(B)	**8.**	(C)	**9.**	(D)	**10.**	(B)
11.	(A)	**12.**	(C)																

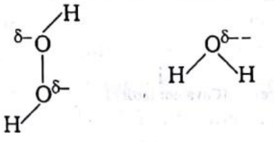
Subjective Problems

1.	4	**2.**	4 or 16	**3.**	2	**4.**	4	**5.**	5	**6.**	4	**7.**	4
8.	4	**9.**	39	**10.**	13	**11.**	0	**12.**	6	**13.**	4	**14.**	3
15.	3	**16.**	2	**17.**	0	**18.**	2	**19.**	4	**20.**	1	**21.**	1
22.	8	**23.**	2	**24.**	0	**25.**	5	**26.**	3	**27.**	3		

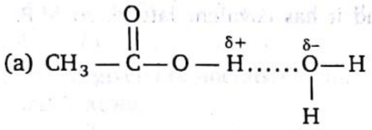
Hints and Solutions

Level 1

4. (d) Strength of H-bonding is higher in H_2O, than H_2O_2 because the amount of formal negative charge on oxygen atom in case of water is more than that of H_2O_2.



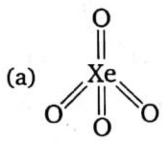
8. (a)



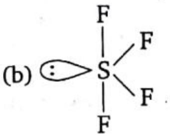
(a) $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-O-\overset{\delta+}{H}\ldots\ldots\underset{\underset{\displaystyle H}{|}}{\overset{\delta-}{O}}-H$

(b), (c), (d) → No scope of hydrogen bonding

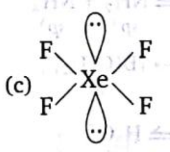
13. (c)



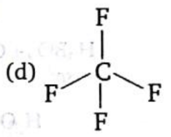
Non-polar
Non-planar



Polar
Non-planar

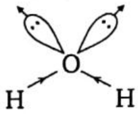


Non-polar
Planar

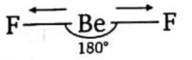


Non-polar
Non-planar

14. (d)

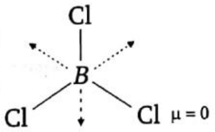


$\mu \neq 0$



$\mu = 0$

15. (a) $O=C=O$ ($\mu = 0$) is linear and



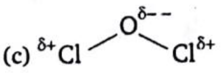
is trigonal planar hence net polarity of both molecules is zero.

16. (c) The net polarity of angular molecules SO_2 and SCl_2 is not equal to zero.

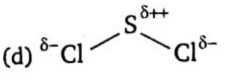
17. (c)

(a) $\overset{\delta+}{H}-\overset{\delta-}{Cl}$ $[EN_{(Cl)} > EN_{(H)}]$

(b) $\overset{\delta+}{Br}-\overset{\delta-}{Cl}$ $[EN_{(Cl)} > EN_{(Br)}]$



$[EN_{(O)} > EN_{(Cl)}]$



$[EN_{(S)} < EN_{(Cl)}]$

18. (d) Strength of molecular forces :

Ion-dipole > dipole-dipole > ion-induced dipole>dipole-induced dipole > London forces.

21. (d) Correct order of molecular force : $\underset{\text{H-bonds}}{H_2O} > \underset{\substack{\text{Dipole-dipole} \\ \propto \text{ molecular mass}}}{O\ Br_2} > O(C\ H_3)_2$

22. (d) HCl is highly soluble in water because it ionise in water and form ion-dipole interaction with water.

23. (c) Among given solid, molecular solid is weak, hence, it has low melting point.

24. (c) London dispersion force $\propto$ molecular mass of covalent molecule.

25. (b) HCl has least boiling point among all halogen acids because it contains V.W. force never contains H-bond $\underset{\text{V.W.}_{\text{force}}}{HCl < HBr < HI} < \underset{\text{H-bond}}{HF}$.

26. (d) $\underset{\text{(Molecular lattice)}}{C_2H_6} < \underset{\substack{\text{(Molecular lattice)} \\ \text{(with H-bonding)}}}{CH_3-OH} < \underset{\text{(Ionic lattice)}}{KCl} < \underset{\text{(Covalent lattice)}}{Si}$

27. (c) CO, CO_2 and P_2O_5 are covalent compounds having their molecular lattice. But SiO_2 is a covalent compound having 3-dimensional network structure and it has covalent lattice, so M.P. of SiO_2 is maximum.

33. (b)

$$\underset{sp^3}{\ddot{N}H_3} + H^+ \longrightarrow \underset{sp^3}{NH_4^+}$$

$$\underset{sp^3}{2NH_3} \rightleftharpoons \underset{sp^3}{NH_2^-} + \underset{sp^3}{NH_4^+}$$

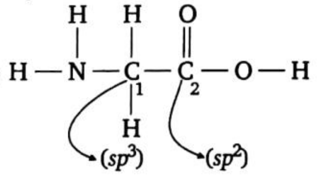
$$\underset{sp^2}{H_3BO_3} + OH^- \longrightarrow \underset{sp^3}{[B(OH)_4]^-}$$

$$\underset{sp^3}{H_2O} + H^+ \rightleftharpoons \underset{sp^3}{H_3O^+}$$

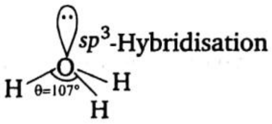
40. (c) By sp^2-hybridisation.

Hybridisation orbital = 3 [3σ-bonds] Unhydrised orbital = 1 [1π-bond]

41. (c)



42. (d)

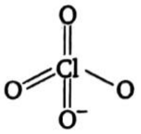


48. (d) In $SiCl_4$ difference between electronegativity of Si (1.8) and chlorine (3.0) is higher than in other given compounds.

49. (c) More effective axial and sideways overlapping between atomic orbitals of carbon and those of oxygen atom is higher due to smaller size of oxygen atom. Oxygen is more electronegative than oxygen atom, due to these factors CO has highest bond energy.

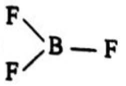
50. (d)

(a)

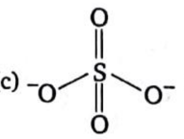


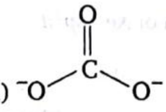
(14e^-, hypervalent),

(b)



(6e^-, hypovalent)

(c)  (12e^-, hypervalent)

(d)  (8e^-)

51. (d) In  molecule central S-atom is surrounded by 10 valence electrons and it is hypervalent compound.

52. (d) Due to presence of vacant *d*-orbital excitation occurs in Cl-atom and it can have more than eight valence electrons when it is forming hypervalent compound like $HClO_4$.

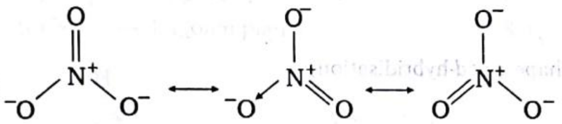
53. (a) Bond polarity is directly related to difference of electronegativity of bonded atoms.

54. (a) The set of compounds BCl_3, $SiCl_4$, PCl_3 are predominatly covalent compounds. NH_4Br and NaI ionic compounds and Al contains metallic lattice.

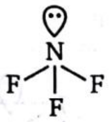
55. (b) Maximum covalency of oxygen atom is three, hence OF_4 does not exist.

58. (b) $A^{2+} + BC_4^{3-} \Rightarrow A_3(BC_4)_2$

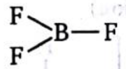
59. (d) Among given non-metals, O-atom has high electron affinity and strong ionic bond is formed between Al and O-atom.

63. (c) 

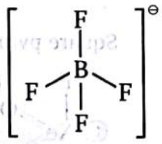
Number of resonating structures = 3

64. (b) 

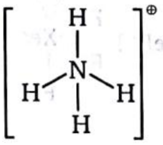
Pyramidal



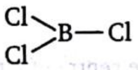
Trigonal planar

(b) 

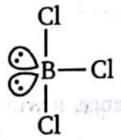
Tetrahedron



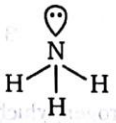
Tetrahedral

(c) 

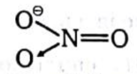
Trigonal planar



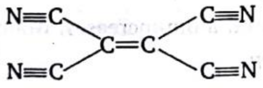
Bent-T-Shape

(d) 

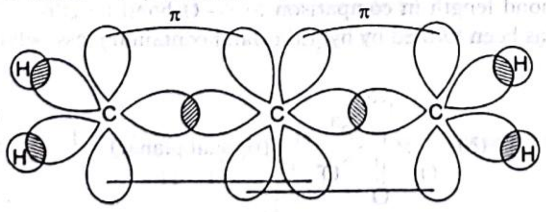
Pyramidal



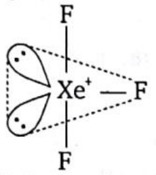
Trigonal planar

67. (b) 

σ-bonds = 9 ; π-bonds = 9

70. (d) 

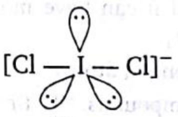
78. (c) XeF_3^+ hybridisation of Xe : sp^3d



Shape : Bent T

79. (c) In XeF_n, possible value of n is 2, 4, 6, 8, then compound should be XeF_2 (linear), XeF_4 (square planar), XeF_6 (capped octahedral). So in this case trigonal planar molecule does not possible.

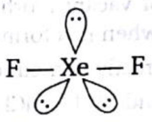
80. (d)

(a)


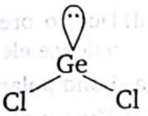
Linear

(b) $H - C \equiv C - H$

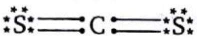
Linear

(c)


Linear

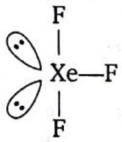
(d)


Bent shape

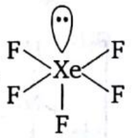
81. (b) CS_2


Total lone pairs = 4 Total double bond = 2

All the atoms have complete octet Sulphur is the central atom.

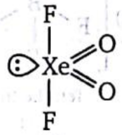
82. (b) $[XeF_3^+]$:


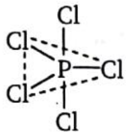
Bent-T-shape (sp^3d-hybridisation)

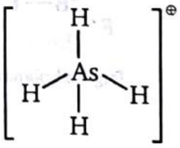
$[XeF_5^+]$:


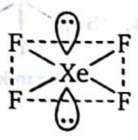
Square pyramidal (sp^3d^2-hybridisation)

83. (d)









Maximum atoms that → can lie in a plane 3 4 3 5

94. (b) In $\ddot{N}H_3$ central atom is nitrogen which is sp^3 hybridized hence, it will be at the centre of tetrahedron with H-atoms at three vertices.

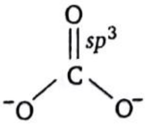
95. (a) In trigonal by pyramidal geometry lone pair electrons cannot occupy axial positions.

96. (b) (ii) (**F**) In general as the number of lone pair of electrons on central atom increases, value of bond angle from normal bond angle decreases due to $lp - lp > lp - bp$

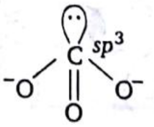
(iv) (**F**) Structures of xenon fluorides and xenon oxy fluoride are explained on the basis of VSEPR theory.

In $SOBr_2$, S—O bond has maximum bond length in comparison to S—O bond lengths in SOF_2 and $SOCl_2$, because in $SOBr_2$, S—O bond has been formed by hybrid orbital containing less s-character.

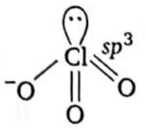
97. (a)

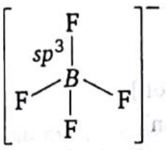
(a)


(Trigonal planar)

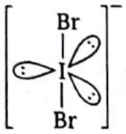
(b)


(Trigonal planar)

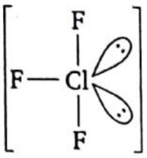
(c) 

(Trigonal pyramidal) (d) 

(Tetrahedral)

98. (a) 

IBr : $X = 2 + \frac{1}{2}[7 - 2 + 1]$ = (2σ-bonds + 3 **lone pairs)** sp^3-hybridisation Shape → Linear

99. (c) ClF_3 

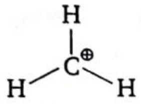
$X = 3 + \frac{1}{2}[7 - 3]$ = (3σ-bonds + 2 lone pairs) (sp^3d-hybridisation)

Shape → Bent - T - shape

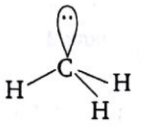
100. (a) NH_3 ⟶ Trigonal pyramidal

(a) SO_3^{2-} ⟶ Trigonal pyramidal (b) CO_3^{2-} ⟶ Trigonal planar

(c) NO_3^- ⟶ Trigonal planar (d) SO_3 ⟶ Trigonal planar

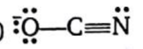
101. (a) 

(sp^3-hybrid)
(Trigonal planar)

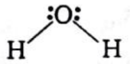


(sp^3-hybridised)
(Trigonal pyramidal)

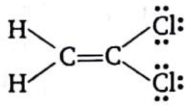
102. (d)

(a) 

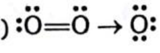
Bond pairs = 4, Lone pairs = 4

(b) 

Bond pairs = 2, Lone pairs = 2

(c) 

Bond pairs = 6 Lone pairs = 6

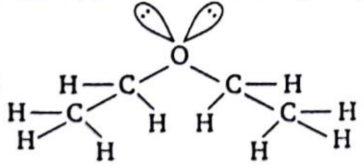
(d) 

Bond pairs = 3 Lone pairs = 6

103. (c) Stability order of carbon family hydride Silane > German > Stannane > Plumbane

107. (d) Incorrect overlaps (if internulcear axis = Z) :

(B) $2p_x + 2p_x \Rightarrow \pi$-bond; (C) $3d_{xy} + 3d_{xy} \Rightarrow \delta$-bond; (D) $2s + 2p_y \Rightarrow$ No bond formation.

109. (a) 

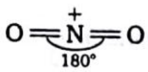
Number of σ-bonds = 14

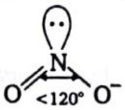
112. (c) $LE \propto \frac{q^+ \cdot q^-}{r^+ + r^-}$

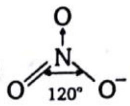
(a) $AlF_3 > MgF_2$ [Charge on cation]
(b) $Li_3N > Li_2O$ [Charge on anion]
(c) NaCl > LiF [Size of cation and anion]
(d) TiC > ScN [Charge on cation and anion]

113. (c) Lattice energy $\propto \frac{\text{Charge of cation} \times \text{charge of anion}}{\text{Inter ionic distance}}$

123. (b) (a) $\overset{-}{N} = \overset{+}{N} = O$ (There is no O—N—O bond angle)

(b) 

(c) 

(d) 

124. (c) Correct order of bond angle:

(a) $NH_3 < PH_3 < AsH_3 < SbH_3$ (As E.N. value of C.A. ↑ bond angle↓)
(b) $OF_2 < OH_2 < OCl_2$
(c) $H_3Te^+ < H_3Se^+ < H_3S^+ < H_3O^+$
(d) $BF_3 = BCl_3 = BBr_3 = BI_3$

Level 2

1. (d) Correct order of B.P.

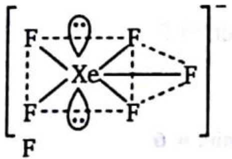
$CH_3N_3 < HN_3$

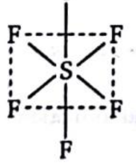
Among CH_3N_3 there are dipole-dipole interaction while among HN_3 intermolecular H-bonding occurs.

2. (a) (I—I)···(I—I)

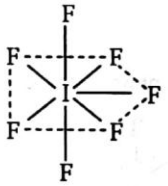
London forces between two I_2 molecules in solid lattice.

9. (b) (a) ClO_3^- B.O. = 1.66
(b) ClO_3 B.O. = 2 (max.)
(c) ClO_2 B.O. = 1.75
(d) ClO_2^- B.O. = 1.5

10. (b) (a) XeF_5^- 
Number of atoms in 'X-Y' plane =6

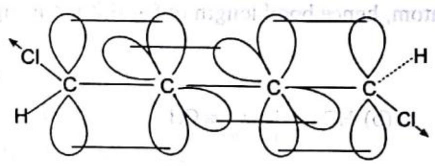
(b) SF_6 
Number of atoms in (X-Y) plane = 5

(c) IF_7



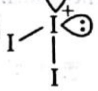
Number of atoms in (X-Y) plane = 5

12. (d)



hence, $\mu = 0$

13. (d)



Hyb. : sp^3	Hyb. : sp^3d
$\mu_D \neq 0$	$\mu_D = 0$
Planar	Planar

14. (b) (a) Pentagonal planar $\rightarrow sp^3d^3[s + p_x + p_y + p_z + d_{x^2-y^2} + d_{z^2} + d_{xy}]$

(b) Trigonal planar $\rightarrow sp^2[s +$ Any two $p]$

(c) Linear $\rightarrow sp^2[s +$ any one $p]$

$\rightarrow sp^2[s +$ any two $p]$

$\rightarrow sp^3[s + p_x + p_y + p_z]$

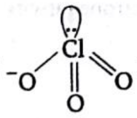
$\rightarrow sp^3d[s + p_x + p_y + p_z + d_{z^2}]$

(d) Square planar $\rightarrow sp^3d^2[s + p_x + p_y + p_z + d_{x^2-y^2} + d_{z^2}]$

19. (b)	BF_3	sp^2	Trigonal planar
	BrF_3	sp^3d	Bent 'T' shape
	$ICl_2^{\ominus}$	sp^3d	Linear
	$BeCl_2$	sp	Linear
	BCl_3	sp^2	Trigonal planar
	PCl_3	sp^3	Pyramidal
	NCl_3	sp^3	Pyramidal

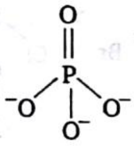
20. (d)

(a)

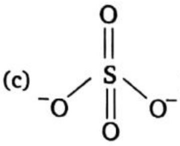


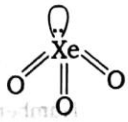
B.O. of Cl—O = 1.67

(b)



B.O. of P—O = 1.25

(c)  B.O. of S—O = 1.5

(d)  B.O. of Xe—O = 2.0

Bond order of O — O in $O_2 = 2.0$

21. (d) As size of sulphur is higher than that of oxygen atom, hence bond length of S—H bond is higher than that of O—H bond.

22. (c)

(a) $CH_2 = \underset{sp^3}{\overset{*}{C}H} - \underset{sp}{\overset{*}{C}} \equiv CH$

(b) $HC \equiv \underset{sp}{\overset{*}{C}} - \underset{sp}{\overset{*}{C}} \equiv CH$

(c) $H_2\underset{sp^3}{\overset{*}{C}} - \underset{sp^2}{\overset{*}{C}}H = CH_2$

(d) $H_2C = \underset{sp^2}{\overset{*}{C}H} - \underset{sp^2}{\overset{*}{C}H} = CH_2$

23. (d) Two different non-axial *d*-orbitals will lie in planes perpendicular to each other hence, such *d*-orbital will not form π-bond.

24. (c) C: $2s^2$ $2p^2$

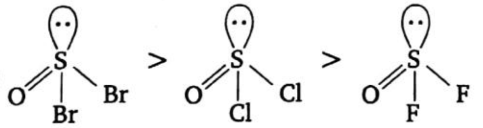
	$2s^2$	$2p^2$
C (In ground state)	[↑↓]	[↑|↑|]
		2*p*
C (In excited state)	[↑]	[↑|↑|↑]
	2*s*	2*p*

In the unhybridized state of carbon, 2*p* orbitals are 90° to one another and each one will overlap with 1*s* orbital of three hydrogen atoms, thus three C—H bonds are formed which are 90° to one another. For the fourth hydrogen atom, its 1*s* orbital may overlap with non-directional 2*s* orbital of the carbon and this σ-bond will be stronger than σC—H bonds formed by 2*p*—1*s* overlap. In such situation CH_4 molecule can never has tetrahedral geometry.

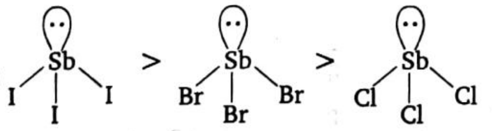
28. (b) d_{z^2} can not form π as well δ-bond but it can form σ-bond.

29. (c) Correct order of Lewis acidic character : $PF_5 > SiF_4 > SF_6$. Although, S has vaccant 3*d*-orbitals but it cannot accept co-ordinate bond from Lewis base due to steric crowding factor as S-atom is already bonded to six F-atoms.

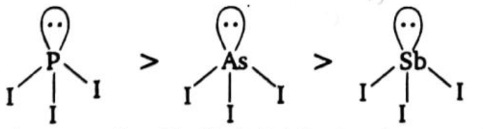
31. (d) Order of decreasing bond angle.

(a) 

On the basis of electronegativity of halogens

(b) 

On the basis of electronegativity of halogens

(c) 

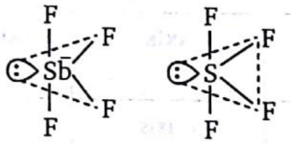
Involvement of *s*-orbital in hybridisation decreases downward in a group

Level 3

Passage-1

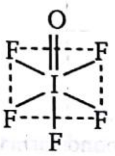
1. (d)

(a)



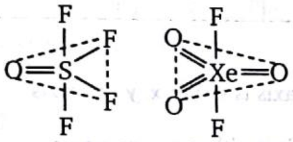
⇒ both have see-saw structure

(b)



⇒ Hyb : sp^3d^2

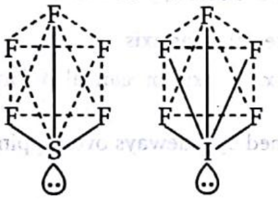
(c)



⇒ T.B.P. geometry

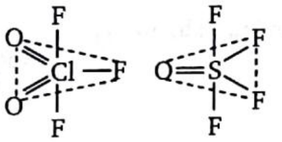
2. (d)

(a)



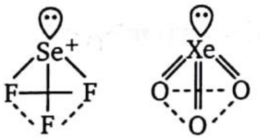
⇒ both have distorted square pyramidal structure

(b)



⇒ T.B.P. structure

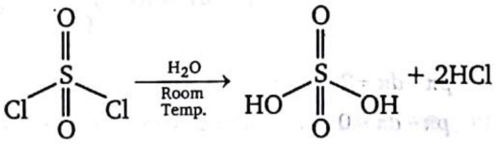
(c)



⇒ Triangular pyramid

3. (d)

⇒



Hyb : sp^3

(No. of $p\pi$-$d\pi$ bonds $=2$)

Passage-2

1. (d)

Option	Type of orbital combination	For π-bond		For σ-bond	
		Internuclear axis	Nodal plane	axis	Nodal plane
a	$d_{yz}+d_{yz}$	y-axis z-axis	xy xz	x-axis	xy and xz
b	$d_{xy}+d_{xy}$	x-axis y-axis	xz yz	z-axis	xz and yz
c	p_y+d_{xy}	x-axis	xz	No. δ-bond formation	

2. (d) (a) $\Rightarrow p_y+d_{x^2-y^2}$: can produce non-bonding if inter-nuclear axis is either x, y or z-axis

(b) $\Rightarrow p_z+d_{yz}$: can produce non-bonding if inter-nuclear axis is either x, y or z-axis

(c) $\Rightarrow s+d_{xz}$: will always form non-bonding irrespective of inter-nuclear axis

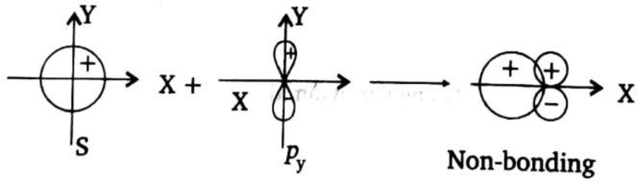
(d) $\Rightarrow d_{xy}+d_{xy}$: either form π-bond if inter-nuclear axis is x/y axis or can also form δ-bond if inter-nuclear axis is z-axis.

3. (c) Nodal plane of π-bond between C_3 and C_4 lies in yz-plane formed by sideways overlapping of p_x-orbitals.

Passage-10

1. (b) Bond dissociation energy : Cl—Cl > P—P > Si—Si

2. (a)



3. (c)

(a) SO_3	No. of $p\pi-p\pi=1$,	$p\pi-d\pi=2$
(b) NO_3^-	No. of $p\pi-p\pi=1$,	$p\pi-d\pi=0$
(c) SO_4^{2-}	No. of $p\pi-p\pi=0$,	$p\pi-d\pi=2$
(d) CO_3^{2-}	No. of $p\pi-p\pi=1$,	$p\pi-d\pi=0$

Passage-11

1. (d)

Code element	**Actual element**	
P	C	
Q	O	exhibits only covalency = 2;
R	Cl	minimum covalency = 1;
S	Al	maximum covalency = 7
T	S	
U	Si	

R and S will combine as SR_3 not as SR_5.

2. (c) Maximum electron affinity is of R. Maximum electronegativity is of Q

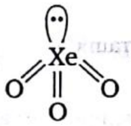
T and U belong to different groups.

3. (c) SR_3 : $AlCl_3$ UR_4 : $SiCl_4$ PQ_2 : CO_2 can act as Lewis acid.

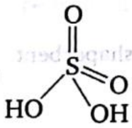
Lewis acidic character of $SiCl_4$ > $AlCl_3$

Passage-12

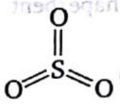
1. (c)

(a) 

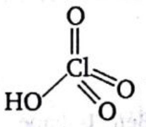
Three $(d\pi - p\pi)$ bonds

(b) 

Two $(d\pi - p\pi)$ bonds

(c) 

One $(p\pi - p\pi)$ and two $(d\pi - p\pi)$ bond

(d) 

Three $(d\pi - p\pi)$ bonds

2. (c)

(a) Involvement of hybridisation (NH_3, SO_2, SO_3, BF_3, PCl_3, IF_7)

(b) Hypervalent compounds (SO_2, SO_3, IF_7)

(c) Non-planar molecules (NH_3, PH_3, PCl_3, IF_7, P_4)

(d) SO_2 [one $(p\pi - p\pi)$ bond and one $(d\pi - p\pi)$ bond], SO_3 [one $(p\pi - p\pi)$ bond and two $(d\pi - p\pi)$ bonds]

ONE OR MORE ANSWERS IS/ARE CORRECT

4. (a, d)

Correct statement is :

(b) Number of $p\pi - d\pi$ bond(s) in SO_3 is two and in SO_2 is one

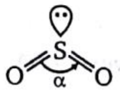
(c) Lewis basic order : $NCl_3 > NF_3$

10. (b, d)

Due to phenomenon of inert pair effect Pb^{2+} is more stable than Pb^{4+}.

12. (a, b, ,c)

AX_2: SO_2



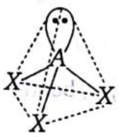
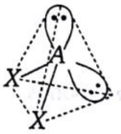
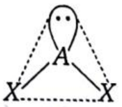
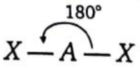
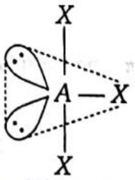
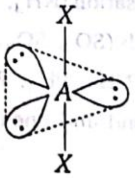
→ Hyb. of S : sp^2; shape : Bent

AY_2: SCl_2 → Hyb. of S : sp^3; shape : Bent

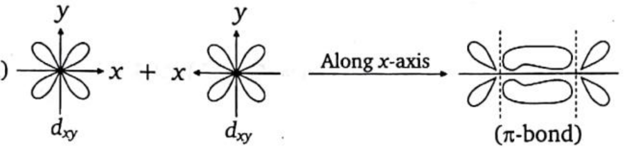
→ $\alpha > \beta$

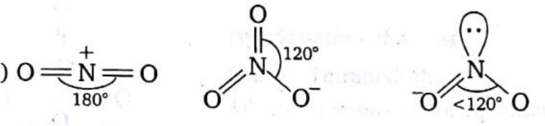
→ Both are planar

16. (a, c)

No.	Total no. of b.p. + l.p.	Hybridisation	Geometry	Shape
(i)	3 + 1	sp^3		Pyramidal
(ii)	2 + 2	sp^3		V-shape/bent
(iii)	2 + 1	sp^2		V-shape/bent
(iv)	2 + 0	sp		Linear
(v)	3 + 2	sp^3d		Bent T-shape
(vi)	2 + 3	sp^3d		Linear

17. (a, c)

(a)


(b)


B.O. = 2 B.O. = $4/3 = 1.33$ B.O. = $3/2 = 1.5$

(c) $NF_3 < NCl_3 < NBr_3 < NI_3$ (As E.N. value of C.A. ↓ bond angle and Lewis basic character ↑)

(d) $HF > HCl > HBr > HI$ (Dipole moment order)

$HF > HI > HBr > HCl$ (Boiling point order)

22. (a, c, d)

(a) $p_z + p_y \Rightarrow$ Non-bonding if internuclear axis is x-axis

(b) $p_y + d_{xz} \Rightarrow$ Form non-bonding if internuclear axis is x-axis

(c) $d_{xz} + d_{xz} \Rightarrow$ Can form δ-bond if internuclear axis is y-axis

(d) $p_z + d_{xz} \Rightarrow$ Can form π-bond, if internuclear axis is x-axis.

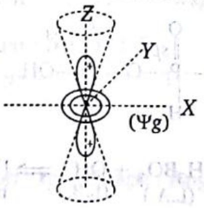
23. (a, c)

$s + p_z$: Non-bonding; $s + s$: σ-bond; $p_z + p_x$: Non-bonding; $d_{xy} + p_y$: π-bond

24. (a, b, ,c ,d)

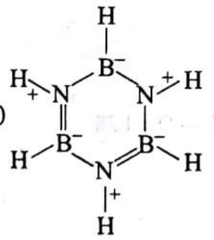
It has two angular nodes modified in shape of nodal cones.

One lobe is dumb-bell shape while the other is in the shape of circular ring (in XY plane)



MATCH THE COLUMN

1. (A)

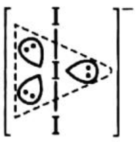


→ Planar as both B and N are sp^2-hybridized

→ $\mu_D = 0$ (non-polar)

→ has $2p_\pi - 2p_\pi$ back bonding between B—N bond.

→ has no co-ordinate bond

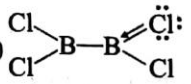
(B)


→ Planar structure

→ $\mu_D = 0$

→ has no back bond

$:\ddot{\underset{..}{I}}:-\ddot{\underset{..}{I}}: + :\ddot{\underset{..}{I}}: \rightleftharpoons :\ddot{\underset{..}{I}} - \ddot{\underset{..}{I}} \leftarrow \ddot{\underset{..}{I}}:$

(C)


→ Planar structure as both B-atoms are sp^2-hybridised

→ $\mu_D = 0$

→ has $2p_\pi$-$3p_\pi$ back bonding in B—Cl bond

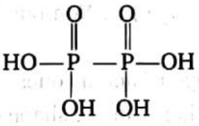
→ has no co-ordinate bond

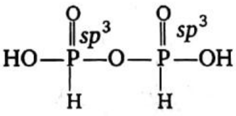
(D) $2p_\pi$-$3d_\pi$ back bonding

→ Non-planar

→ $\mu_D = 0$

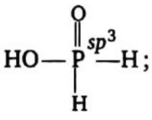
→ has no co-ordinate bond

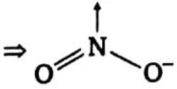
4. (A) Hypophosphoric Acid ($H_4P_2O_6$)

$$HO-\overset{\overset{O}{\|}}{\underset{\underset{OH}{|}}{P}}-\overset{\overset{O}{\|}}{\underset{\underset{OH}{|}}{P}}-OH$$
; Basicity = 4

(B) Pyrophosphoric Acid ($H_4P_2O_5$)

$$HO-\overset{\overset{O}{\|}\,sp^3}{\underset{\underset{H}{|}}{P}}-O-\overset{\overset{O}{\|}\,sp^3}{\underset{\underset{H}{|}}{P}}-OH$$
; Basicity = 2

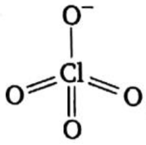
(C) Boric Acid (H_3BO_3)

$$\underset{\text{(L.A.)}}{H_3BO_3} + \underset{\text{(L.B.)}}{OH^-} \rightleftharpoons \underset{\text{borate ion}}{[B(OH)_4]^-}$$

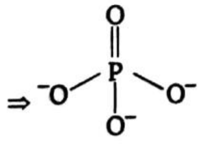
(D) Hypophosphorus acid (H_3PO_2)

$$HO-\overset{\overset{O}{\|}\,sp^3}{\underset{\underset{H}{|}}{P}}-H$$
; Basicity = 1

8. ⇒


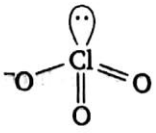
B.O. of N — O = 1.33

⇒


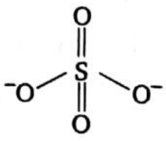
B.O. of Cl — O = 1.75

⇒


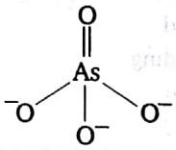
B.O.of P — O = 1.25

⇒


B.O. of Cl — O = 1.67

⇒ 

B.O.of S — O = 1.50

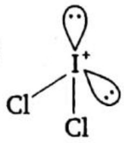
9. (a) 

Hybridisation of As : sp^3

Shape : Tetrahedron

All As—O bonds are of equal length due to resonance

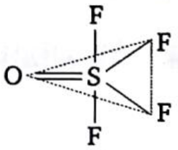
Number of $p\pi - d\pi$ bond = 1

(b) 

Hydridisation : sp^3

Shape : V-shape

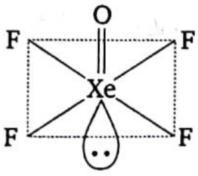
All I—Cl bonds are of equal length.

(c) 

Hybridisation of S : sp^3d $(sp_xp_y + p_zd_{z^2})$

Shape : T.B.P.

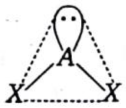
Number of $p\pi - d\pi$ bond = 1

(d) 

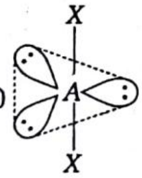
Hybridisation of Xe : sp^3d^2 $(\equiv sp_xp_yp_zd_{x^2-y^2}d_{z^2})$

Shape : Square pyramidal

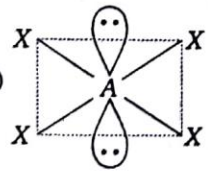
Number of $p\pi - d\pi$ bond = 1

10. (a) 

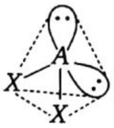
Hybridisation : sp^2; Shape : Angular; Polar; Planar

(b) 

Hybridisation : sp^3d; Shape : Linear; Non-polar; Planar

(c) 

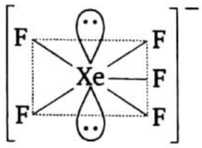
Hybridisation : sp^3d^2; Shape : Square planar; Non-polar; Planar

(d) 

Hybridisation : sp^3; Shape : Angular; Polar; Planar

11.

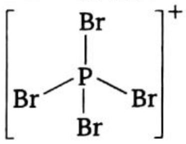
	Combining orbitals (internuclear axis)	**Type of bond formed**
P	$d_{yz}+p_y$, (z)	π-bond
Q	$s+p_x$, (y)	Non-bonding
R	$d_{yz}+d_{yz}$, (x)	δ-bond
S	$s+s$, (z)	σ-bond
T	$s+d_{xy}$, (y)	Non-bonding

12. (a) 

sp^3d^3-hybridisation $(s+p_x+p_y+p_z+d_{x^2-y^2}+d_{z^2}+d_{xy})$, d-orbital with zero nodal Plane (d_{z^2}) and non-axial d-orbital (d_{xy}) used in hybridisation.

Planar.

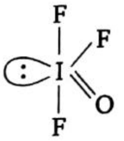
Bond angle, 72°

(b) 

Hybridisation sp^3d $(s+p_x+p_y+p_z+d_z)$

Non-planar species

Bond angle 109°28'

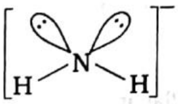
(c) 

Hybridisation sp^3d $(s+p_x+p_y+p_z+d_{z^2})$

d-orbital with zero nodal plane (d_{z^2}) used

Non-planar

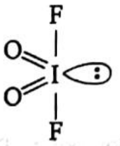
Bond angle < 90°

(d) 

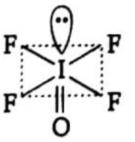
Hybridisation sp^3

Planar

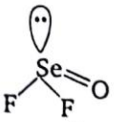
Bond angle < 109°28'

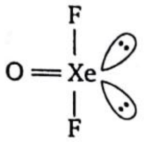
13. (a) $IO_2F_2^-$: 

See-saw, Non-planar

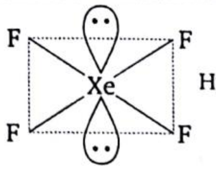
(b) IOF_4^- : 

Square pyramidal, non-planar

(c) $SeOF_2$:  Trigonal pyramidal, non-planar

(d) $XeOF_2$:  Bent-T-shape, Planar

ASSERTION-REASON TYPE QUESTIONS

12. 
Hybridisation of Xe : sp^3d^2, shape: square planar

SUBJECTIVE PROBLEMS

1.

		b.p.	l.p.
(A)	XeF_4	4	2
(B)	XeF_5^+	5	1
(C)	XeF_5^-	5	2
(D)	XeF_6	6	1
(E)	XeF_8^{2-}	8	1
		28	**7**

$\Rightarrow \frac{p}{q} = \frac{28}{7} = 04$

2. G-1 A(Li), B(Na), C(K), D(Rb), E(Cs)

G-2 F(Be), G(Mg), H(Ca), I(Sr), J(Ba)

G-13 K(B), L(Al), M(Ga), N(In), O(Tl)

G-15 P(N), Q(P), R(As), S(Sb), T(Bi)

G-17 U(F), V(Cl), W(Br), X(I), Y(At)

(i) $Tl^+ > Ca^{2+}$; Polarising power (T)

(ii) $Bi^{3+} > Sb^{3+} > As^{3+}$; Stability of cation (T)

(iii) $F^-(aq) > Cl^-(aq) > Br^-(aq) > I^-(aq)$; Size (T)

(iv) $BaCl_2 > SrCl_2 < MgCl_2 < AlCl_3$; Covalent nature (T)

(v) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$; Thermal stability (F)

(vi) $LiCl > NaCl > KCl > RbCl > CsCl$; Thermal stability (T)

(vii) $K_3N > Na_3N > Li_3N$; Lattice energy (F)

(viii) $BF_3 < BCl_3 < BBr_3 < BI_3$; Melting point (T)

$\Rightarrow |p-q|^2 |6-2|^2 = 16$

3. SO_2, HCHO

4. $P_1 = 3$, $P_2 = 5$, $Q_1 = 2$, $P_3 = 7$, $Q_2 = 3$

$$= \frac{5(7-3)}{3+2} = 4$$

7. $X = 5$ and $Y = 1$

so, $X - Y = 5 - 1 = 4$

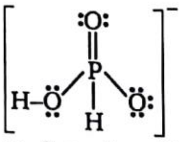
9. $X = 120$ (sp^2-hybridization)

$Y = 180$ (sp-hybridization)

$Z = 90$ (sp^3d^2-hybridization)

$$\frac{120+180+90}{10} = \frac{390}{10} = 39$$

15.



$x = 7, y = 1, z = 5$

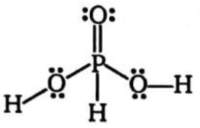
$7 + 1 - 5 \Rightarrow 3$

16. $p = 3$, $q = 5$, $r = 2$

$s = 6$, $t = 2$

$3 + 5 + 2 - 6 - 2 \Rightarrow 2$

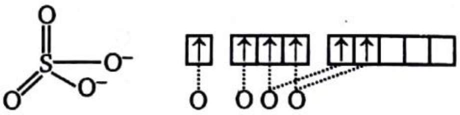
17.



$x = 6$ $y = 6$ $z = 1$

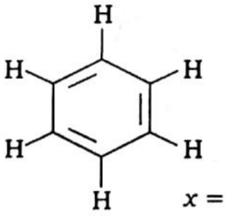
$\therefore\ y \times z - x = 6 \times 1 - 6 = 0$

18.

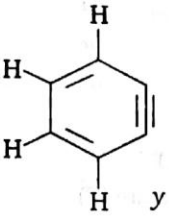


20. $x = 3$, $y = 1$, $z = 3$; $x + y - z = 3 + 1 - 3 = 1$

21.



$x = 12$



$y = 11$

$|x - y| = 1$

22. (i) $IF_5(sp^3d)$ (ii) $ClI_4^-(sp^3d^2)$ (iii) $XeO_2F_2(sp^3d)$ (iv) $NH_2^-(sp^3)$

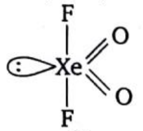
(v) $BCl_3(sp^2)$ (vi) $BeCl_2(sp)$ (vii) $AsCl_4^+(sp^3)$ (viii) $B(OH)_3(sp^2)$

(ix) $NO_2^-(sp^2)$ (x) $ClO_2^+(sp^2)$

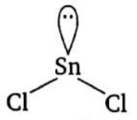
$x = (sp^3)2 + sp^3d(1) + sp^3d^2(2) = 5$

$y = 4, \quad z = 1; \quad 5 + 4 - 1 = 8$

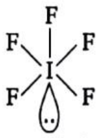
23. XeO_4, XeF_7^+



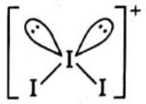
$\rightarrow sp^3d$
$\rightarrow$ polar



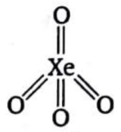
$\rightarrow sp^2$
$\rightarrow$ polar



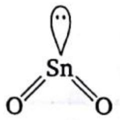
$\rightarrow sp^3d^2$
$\rightarrow$ polar



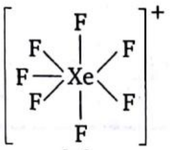
$\rightarrow sp^3$
$\rightarrow$ polar



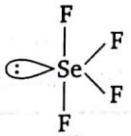
$\rightarrow sp^3$
$\rightarrow$ polar



$\rightarrow sp^2$
$\rightarrow$ polar



$\rightarrow sp^3d^3$
$\rightarrow$ non-polar



$\rightarrow sp^3d$
$\rightarrow$ polar

24.

Species	**Bond order**
NO_3^-	1.33
SO_4^{2-}	1.50
ClO_3^-	1.66
SO_3	2.00
PO_4^{3-}	1.25
XeO_3	2.00
CO_3^{2-}	1.33
SO_3^{2-}	1.33

$x = 4 \quad y = 4 \quad$ so, $\quad 4 - 4 = 0$

25. $3s$: 0 Nodal plane $\quad 4d_{z^2}$: 0 Nodal plane $\quad 4s$: 0 Nodal plane
$2p_x$: 1 Nodal plane $\quad 3d_{x^2-y^2}$: 2 Nodal plane $\quad 4p_z$: 1 Nodal plane
$4d_{xy}$: 2 Nodal plane $\quad 3p_y$: 1 Nodal plane
$3s$, $4d_{xy}$, $4d_{z^2}$, $3d_{x^2-y^2}$, $4s$ (Five)

26.
$PCl_5 \longrightarrow sp^3d$, non-planar
$ICl_2^- \longrightarrow sp^3d$, linear, planar
$NO_3^- \longrightarrow sp^2$, planar
$PCl_4^+ \longrightarrow sp^3$, tetrahedral, non-planar
$BrF_3 \longrightarrow sp^3d$, bent, T-shape, planar
$XeF_5^- \longrightarrow sp^3d^3$, pentagonal planar
$XeO_2F_2 \longrightarrow sp^3d$, see-saw, non-planar
$CH_3^+ \longrightarrow sp^2$, Trigonal planar

$a = 4, \quad b = 5, \quad c = 3 \qquad$ so, $\dfrac{a+b}{c} = 3$

27. Transformations (b), (c) and (d) involve change in hybridisation.

3

CHEMICAL BONDING (ADVANCED)

Level 1

First Introducing Question

1. On decreasing internuclear distance below, the optimum distance (where potential energy is minimum), there is steep increase in potential energy due to :
   (a) Increase in force of attraction between electrons and nucleus
   (b) Increase in stability of bonded atoms
   (c) Equal probability of finding bonding electrons near to either of nuclei
   (d) Increase in interelectronic and internuclear repulsions

Molecular Geometry and Shape

2. Identify the correct sequence of increasing number of π-bonds in the structure of the following molecules :
   (I) $H_2S_2O_6$ (II) $H_2S_2O_3$ (III) $H_2S_2O_5$
   (a) I, II and III (b) II, I and III
   (c) II, III and I (d) I, III and II
3. C_2H_2 is isostructural with :
   (a) H_2O_2 (b) NO_2
   (c) $SnCl_2$ (d) CO_2
4. The shapes of nitrite and nitrile respectively are :
   (a) Linear and angular (b) Angular and linear
   (c) Both angular (d) Both linear
5. Linear structure is assumed by :
   (I) NCO^- (II) CS_2 (III) $\overset{+}{N}O_2$ (IV) Solid BeH_2
   (a) all four (b) (II), (III) and (IV)
   (c) (I), (II) and (III) (d) (II) and (III)

6. Among the oxides of nitrogen, N_2O, NO and NO_2, molecules with unpaired electrons are :
(a) N_2O and NO (b) NO and NO_2
(c) N_2O and NO_2 (d) NO_2 and its dimer

7. Which of the following pair consists of only network solid ?
(a) SiO_2, P_4O_{10} (b) P_4O_{10}, SO_3
(c) P_4O_{10}, P_4O_6 (d) Diamond, SiO_2

8. Which of the following ions does not have S—S linkage?
(a) $S_2O_8^{2-}$ (b) $S_2O_6^{2-}$ (c) $S_2O_5^{2-}$ (d) $S_2O_3^{2-}$

9. Among $KO_2, KAlO_2, CaO_2$ and NO_2^+, unpaired electron is present in :
(a) NO_2^+ and CaO_2 (b) KO_2 and $KAlO_2$ (c) KO_2 only (d) CaO_2 only

10. Structure of S_2Cl_2 is analogous to :
(a) $SOCl_2$ (b) CO_2 (c) H_2S (d) H_2O_2

11. Number of P—H, P—O — P, P—O—H and P—O bonds in sodium dihydrogen pyrophosphate respectively are :
(a) 1, 1, 1, 2 (b) 0, 1, 2, 2 (c) 0, 1, 2, 4 (d) 2, 0, 0, 2

Hybridisation

12. Two hybrid orbitals have a bond angle of 120°. The percentage of *s*-character in the hybrid orbital is nearly:
(a) 25% (b) 33% (c) 50% (d) 66%

13. The state of hybridisation of central atom in dimer of BH_3 and BeH_2 is :
(a) sp^2, sp^2 (b) sp^3, sp^2 (c) sp^3, sp^3 (d) sp^2, sp^3

14. In NO_2 molecule N atom undergoes in :
(a) sp^3 hybridization (b) sp^2 hybridization
(c) sp hybridization (d) sp^2d hybridization

Bond Length

15. The strongest P—O bond is found in the molecule :
(a) F_3PO (b) Cl_3PO (c) Br_3PO (d) $(CH_3)_3PO$

16. O_2F_2 is an unstable yellow orange solid and H_2O_2 is a colourless liquid, both have O—O bond and O—O bond length in H_2O_2 and O_2F_2 respectively is :
(a) 1.22 Å, 1.48 Å (b) 1.48 Å, 1.22 Å
(c) 1.22 Å, 1.22 Å (d) 1.48 Å, 1.48 Å

17. The bond length of the S—O bond is maximum in which of the following compounds?
(a) $SOCl_2$ (b) $SOBr_2$
(c) SOF_2 (d) All have same length

Bond Angle

18. ∠ FAsF bond angle in AsF_3Cl_2 molecule is :
(a) 90° and 180° (b) 120° (c) 90° (d) 180°

19. Which of the following has largest bond angle ?
(a) H_2O (b) F_2O (c) Cl_2O (d) H_2S

Molecular Forces

20. The boiling points of noble gases are illustrative of the operation of forces of the type :

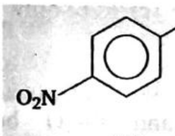
(a) ion-dipole (b) dipole-induced dipole
(c) ion-induced dipole (d) London dispersion forces

21. Among the following, which has the lowest enthalpy of fusion ?

(a) Fluorine (b) Hydrogen (c) Chlorine (d) Helium

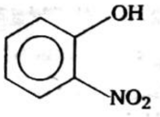
Hydrogen Bonding

22. Out of the two compounds shown below, the vapour pressure of *B* at a particular temperature is expected to be :



(*A*)

and



(*B*)

(a) higher than that of *A*
(b) lower than that of *A*
(c) same as that of *A*
(d) can be higher or lower depending upon the size of the vessel

23. The crystal lattice of ice is mostly formed by :

(a) ionic forces (b) covalent bonds
(c) intramolecular H-bonds (d) covalent as well as H-bonds

24. The boiling points of methanol, water and dimethyl ether are respectively 65° C, 100° C and 34.5° C. Which of the following best explains these wide variations in b.p.?

(a) The molecular mass increases from water (18) to methanol (32) to diethyl ether (74)
(b) The extent of H-bonding decreases from water to methanol while it is absent in ether
(c) The extent of intramolecular H-bonding decreases from ether to methanol to water
(d) The density of water is $1.00\ g\ mL^{-1}$, methanol $0.7914\ g\ mL^{-1}$ and that of diethyl ether is $0.7137\ g\ mL^{-1}$

25. In ice, the length of H-bonds :

(a) is less than that of covalent bonds
(b) is greater than that of covalent bonds
(c) is same as that of covalent bonds
(d) can be less greater or same as that of covalent bonds

26. The correct order of the strength of H-bonds is :

(a) $H\ldots F > H\ldots O > H\ldots N$ (b) $H\ldots N > H\ldots O > H\ldots F$
(c) $H\ldots O > H\ldots N > H\ldots F$ (d) $H\ldots F > H\ldots N > H\ldots O$

27. *o*-nitrophenol can be easily steam distilled whereas *p*-nitrophenol cannot be. This is because of :

(a) strong intermolecular hydrogen bonding in *o*-nitrophenol
(b) strong intramolecular hydrogen bonding in *o*-nitrophenol
(c) strong intramolecular hydrogen bonding in *p*-nitrophenol
(d) dipole moment of *p*-nitrophenol is larger than that of *o*-nitrophenol

28. What is not true about ice?
(a) It has open cage like structure
(b) It has less density than water
(c) Each O atom is surrounded by 4 H atoms
(d) Each O atom has four H-bonds around it

29. When ice melts to form liquid water at 0° C, there is a contraction in volume. This is due to :
(a) the molecules contracting in size
(b) a partial disruption of the hydrogen bonded network of ice on melting
(c) the absorption of heat during the melting process
(d) the dissolving of air into the water during the melting process

Fajan's Rule (Ionic Bond)

30. In an ionic compound A^+X^- the degree of covalent bonding is greatest when :
(a) A^+ and X^- ion are small
(b) A^+ is small and X^- is large
(c) A^+ and X^- ions are approximately of the same size
(d) X^- is small and A^+ is large

31. In which of the following species the bonds are non-directional?
(a) NCl_3 (b) RbCl (c) $BeCl_2$ (d) BCl_3

32. Which of the following when dissolved in water forms a solution which is non-conducting?
(a) Green vitriol
(b) Chile or Indian salt petre
(c) Alcohol
(d) Potash alum

33. Which of the following statements about LiCl and NaCl is wrong?
(a) LiCl has lower melting point than NaCl
(b) LiCl dissolves more in organic solvents whereas NaCl does not
(c) LiCl would ionise in water less than NaCl
(d) Fused LiCl would be less conducting than fused NaCl

34. Which of the following substances has the highest melting point?
(a) NaCl (b) KCl (c) MgO (d) BaO

35. The stability of ionic crystal principally depends on :
(a) high electron affinity of anion forming species
(b) the lattice energy of crystal
(c) low I.E. of cation forming species
(d) low heat of sublimation of cation forming solid

36. In which of the following solvents, KI has highest solubility?
(a) $C_6H_6(\in = 0)$
(b) $(CH_3)_2CO(\in = 2)$
(c) $CH_3OH(\in = 32)$
(d) $CCl_4(\in = 0)$

37. Amongst LiCl, $BeCl_2$, $MgCl_2$ and RbCl the compounds with greatest and least ionic character, respectively are :
(a) LiCl and RbCl
(b) RbCl and $BeCl_2$
(c) RbCl and $MgCl_2$
(d) $MgCl_2$ and $BeCl_2$

38. The compound with the highest degree of covalency is :
(a) NaCl (b) $MgCl_2$ (c) AgCl (d) CsCl

39. The salt having the least solubility in water is :
(a) $BaCl_2$ (b) $Ba(NO_3)_2$ (c) $MgSO_4$ (d) $BaSO_4$

40. The solubility of Na_2SO_4, $BeSO_4$, $MgSO_4$ and $BaSO_4$ in water follow the order :

(a) $BaSO_4 > BeSO_4 > MgSO_4 > Na_2SO_4$
(b) $Na_2SO_4 > BeSO_4 > MgSO_4 > BaSO_4$
(c) $BeSO_4 > MgSO_4 > BaSO_4 > Na_2SO_4$
(d) $MgSO_4 > BeSO_4 > Na_2SO_4 > BaSO_4$

41. Solubility of alkali metal fluorides increases down the group." Select correct explanation for given statement :

(a) Hydration energy increases and lattice energy decreases down the group
(b) Both energy decrease down the group but decrease in hydration energy is rapid
(c) Both energy decrease down the group but decrease in lattice energy is rapid
(d) Both energy increase down the group but increase in hydration energy is rapid

42. Covalency favoured in the following case :

(a) smaller cation
(b) larger anion
(c) large charge on cation and anions
(d) all of these

43. The melting point of RbBr is 682°C while that of NaF is 988°C. The principal reason for this fact is :

(a) the molar mass of NaF is smaller than that of RbBr
(b) the bond in RbBr has more covalent character than the bond in NaF
(c) the difference in electronegativity between Rb and Br is smaller than the difference between Na and F
(d) the internuclear distance, $r_c + r_a$ is greater for RbBr than for NaF

Back Bond

44. In which of the following compounds B—F bond length is shortest?

(a) BF_4^-
(b) $BF_3 \leftarrow NH_3$
(c) BF_3
(d) $BF_3 \leftarrow N(CH_3)_3$

Dipole Moment

45. Which of the following pair of molecules will have permanent dipole moment?

(a) NO_2 and CO_2
(b) NO_2 and O_3
(c) SiF_4 and CO_2
(d) SiF_4 and NO_2

46. The dipole moment of HCl is 1.03 D , if H—Cl bond distance is 1.26 Å, what is the percentage of ionic character in the H—Cl bond?

(a) 60%
(b) 39%
(c) 29%
(d) 17%

47. The dipole moment of *o*, *p* and *m*-dichlorobenzene will be in the order :

(a) $o > p > m$
(b) $p > o > m$
(c) $m > o > p$
(d) $o > m > p$

48. Which of the following molecules has highest dipole moment?

(a) BF_3
(b) NH_3
(c) NF_3
(d) B_2H_6

49. In terms of polar character, which of the following order is correct?

(a) $NH_3 < H_2O < HF < H_2S$
(b) $H_2S < NH_3 < H_2O < HF$
(c) $H_2O < NH_3 < H_2S < HF$
(d) $HF < H_2O < NH_3 < H_2S$

50. The correct order of dipole moment is :

(a) $CH_4 < NF_3 < NH_3 < H_2O$
(b) $NF_3 < CH_4 < NH_3 < H_2O$
(c) $NH_3 < NF_3 < CH_4 < H_2O$
(d) $H_2O < NH_3 < NF_3 < CH_4$

Resonance

51. The correct order of 'S—O' bond length is :

(a) $SO_3^{2-} > SO_4^{2-} > SO_3 > SO_2$
(b) $SO_3^{2-} > SO_4^{2-} > SO_2 > SO_3$
(c) $SO_4^{2-} > SO_3^{2-} > SO_2 > SO_3$
(d) $SO_4^{2-} > SO_3^{2-} > SO_3 > SO_2$

52. What is not true about resonance?

(a) The resonating structures are hypothetical
(b) The unpaired electrons in various resonating structures are same
(c) Hybrid structure is most energetic
(d) Hybrid structure is least energetic

53. Which of the following conditions is not correct for resonating structures?

(a) The contributing structures must have the same number of unpaired electrons
(b) The contributing structures should have almost similar energies
(c) The contributing structures should be so written that unlike charges reside on atoms that are far apart
(d) The positive charge should be present on the electropositive element and the negative charge on the electronegative element

54. A molecule may be represented by three structures having energies E_1, E_2 and E_3, respectively. The energies of these structures follow the order $E_3 < E_2 < E_1$, respectively. If the experimental bond energy of the molecule is E_0, the resonance energy is :

(a) $(E_1 + E_2 + E_3) - E_0$
(b) $E_0 - E_3$
(c) $E_0 - E_1$
(d) $E_0 - E_2$

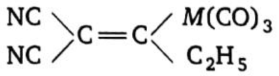
Co-ordinate Bond

55. A : tetracyanomethane B : carbondioxide
C : benzene D : 1, 3-buta-di-ene

Ratio of σ and π bonds is in order :

(a) $A = B < C < D$
(b) $A = B < D < C$
(c) $A = B = C = D$
(d) $C < D < A < B$

56. In a compound



the number of sigma and pi bonds respectively are :

(a) 19, 11 (b) 19, 5 (c) 13, 11 (d) 7, 3

57. Which of the following does not contain any co-ordinate bond?

(a) H_3O^+ (b) BF_4^- (c) HF_2^- (d) NH_4^+

58. Which of the following molecules does not have co-ordinate bonds?

(a) PH_4^+ (b) NO_2 (c) O_3 (d) CO_3^{2-}

L. Acid-Base

59. Which of the following halides is inert towards hydrolysis at room temperature?

(a) $SiCl_4$
(b) PCl_3
(c) NCl_3
(d) NF_3

60. Amongst the following trihalide, which one is least basic?
(a) NF_3 (b) NCl_3 (c) NBr_3 (d) NI_3

l Pair

61. Increasing order of stability of the +2 oxidation state of the ions ?
(a) $Ca^{2+} < Ba^{2+} < Sr^{2+}$ (b) $Pb^{2+} < Ge^{2+} < Sn^{2+}$
(c) $Ge^{2+} < Sn^{2+} < Pb^{2+}$ (d) $Cu^{2+} < Au^{2+} < Ag^{2+}$

Bridge Bond

62. The number of three centre two electron bonds in a molecule of diborane is :
(a) 0 (b) 2 (c) 4 (d) 6

63. In which of the following compounds octet is complete and incomplete for all atoms :

	Al_2Cl_6	$Al_2(CH_3)_6$	AlF_3	Dimer of $BeCl_2$	Dimer of BeH_2
(a)	IC	IC	IC	C	C
(b)	C	IC	IC	C	IC
(c)	C	IC	C	IC	IC
(d)	IC	C	IC	IC	IC

(**Note :** C for complete octet and IC for incomplete octet.)

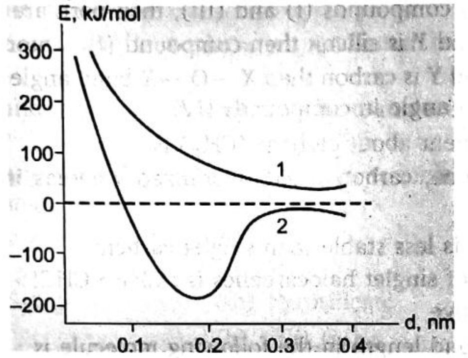
Metallic Bond

64. In which of the following metal to metal bond is present?
(a) Cupric chloride (b) Stannous chloride
(c) Mercurous chloride (d) Mercuric chloride

Level 2

First Introducing Question

1. Consider the given figure showing the formation of H_2^+ ion depending on internuclear distance *versus* potential energy of the system.



which is correct statement :

(a) Curve-1 represents the most stable state of the system for H_2^+ ion

(b) Curve-2 represents the most stable state of the system for H_2^+ ion

(c) Curve-1 indicates that the molecular hydrogen ion is formed

(d) Curve-2 represents the energy level of the antibonding region

Molecular Geometry and Shape

2. Molecule having non-polar as well as polar bonds but the molecule as a whole is polar :

(a) S_2F_2 (b) N_2O_4 (c) Si_2H_6 (d) I_2Cl_6

3. Choose the correct statement regarding $SeOCl_2$ molecule :

(a) It does not contain plane of symmetry

(b) '$Cl—\hat{Se}—Cl$' bond angle is greater than '$Cl—\hat{Se}—O$' bond angle

(c) Lone pair has greater than 33.3% *s*-character

(d) Central atom used one *d*-orbital in bonding

4. In which species, X—O bond order is 1.5 and contains $p\pi — d\pi$ bond(s).

(a) $IO_2F_2^-$ (b) $HCOO^-$ (c) SO_3^{2-} (d) XeO_2F_2

5. Which of the following species has polar and non-polar bonds but molecule as a whole is non-polar ?

(a) $S_2O_3^{2-}$ (b) $(SCN)_2$ (c) Be_2Cl_4 (d) Si_2H_6

6. The incorrect statement(s) regarding $\dot{C}X_3$ species is :

(a) If electronegativity of surrounding element 'X' is less than 2.5, then central carbon atom used almost 33% *s*-character in their hybrid bonding orbitals

(b) If electronegativity of surrounding element 'X' is greater than 2.5, then central carbon atom used almost 25% s-character in their hybrid bonding orbitals

(c) If 'X' is 'F', then species should be polar and pyramidal

(d) If 'X' is H, then species should be polar and planar

7. Consider following compounds :

(I) $H_3X—NCS$ (II) $H_3Y—NCS$ (III) $(H_3X)_2O$ (IV) $(H_3Y)_2O$

The incorrect statement regarding given compound is :

(a) IF Y is carbon in compounds (II) and (IV), then both are bent

(b) If X is silicon in compounds (I) and (III), then both are linear

(c) If X is carbon and Y is silicon then compound (I) is more basic than compound (II)

(d) If X is silicon and Y is carbon then $X—O—X$ bond angle compounds (III) is greater than $Y—O—Y$ bond angle in compounds (IV)

8. The incorrect statement about carbene (CH_2) is :

(a) In singlet carbene, carbon is sp^2-hybridized whereas in triplet carbene, carbon is sp-hybridized

(b) Triplet carbene is less stable than singlet carbene

(c) Stability order of singlet halocarbenes is : $CHF > CHCl > CHBr$

(d) None of the above

9. The lowest O—O bond length in the following molecule is :

(a) O_2F_2 (b) O_2 (c) H_2O_2 (d) O_3

10. Out of $CHCl_3$, CH_4 and SF_4 the molecules do not having regular geometry are :

(a) $CHCl_3$ only (b) $CHCl_3$ and SF_4 (c) CH_4 only (d) CH_4 and SF_4

11. When iodine is dissolved in aqueous potassium iodide, the shape of the species formed is :

(a) linear (b) angular (c) triangular (d) see-saw

12. Which of the following set of species have planar structures?

(a) $I_3^-, \dot{C}H_3, ClO_3^-, SiF_6^{2-}$ (b) $I_3^+, ICl_4^-, Al_2Cl_6, TeCl_4$

(c) $SCl_2, N_2O_5, SF_4, XeOF_4$ (d) $I_2Cl_6, XeF_2, BrF_4^-, XeF_5^-$

13. Which of the following compounds have the same no. of lone pairs with their central atom?

(I) XeF_5^- (II) BrF_3 (III) XeF_2 (IV) H_3S^+ (V) Triple Methylene

(a) IV and V (b) I and III (c) I and II (d) II, IV and V

14. Given the correct order of initials **T** or **F** for following statements. Use **T** if statements is true and **F** if it is false :

(I) $(CH_3)_2P(CF_3)_3$ is non-polar and $(CH_3)_3P(CF_3)_2$ is polar molecule

(II) $CH_3\hat{P}CH_3$ bond angles are equal in $(CH_3)_3P(CF_3)_2$ molecule

(III)PF_3 will be more soluble in polar solvent than SiF_4

(a) TTF (b) FFT (c) FFF (d) FTT

15. The correct sequence of polarity of the following molecule

(1) Benzene (2) Inorganic Benzene

(3) PCl_3F_2 (4) PCl_2F_3

	1	2	3	4
(a)	P	NP	NP	P
(b)	NP	NP	NP	P
(c)	NP	P	NP	P
(d)	NP	P	P	NP

(Where, P = polar, NP = non-polar)

16. Which among the following molecules is not perfect flat?

(a) $B_3N_3H_6$ (b) $C_3N_3(NH_2)_3$

(c) SO_3 (d) $C_3N_3(N_3)_3$

17. Which of the following structure(s) is/are non-planar?

(a) $Na_3B_3O_6$ (b) I_2Cl_6

(c) Sheet silicate (d) Inorganic graphite layer

18. Nodal planes of π-bond(s) in $CH_2{=}C{=}C{=}CH_2$ are located in :

(a) all are in molecular plane

(b) two in molecular plane and one in a plane perpendicular to molecular plane which contains C—C σ-bond

(c) one in molecular plane and two in plane perpendicular to molecular plane which contains C—C σ-bonds

(d) two in molecular plane and one in a plane perpendicular to molecular plane which bisects C—C σ-bonds at right angle

19. Which of the following have X—O—X linkage?
(where X is central atom) :

(i) $Cr_2O_7^{2-}$ (ii) $S_2O_3^{2-}$ (iii) Pyrosilicate (iv) Hyponitrous acid

(a) (i) (iii) (b) (iiii) (iv)

(c) (i) (iii) (iv) (d) (i) (ii)

20. Select the correct statement :

(a) HSO_5^- ion has one S—O—H linkage

(b) Number of B—O—B linkages in Borax is equal to number of P—O—P linkages in P_4O_{10}

(c) Hybridization of both sulphur in $H_2S_2O_5$ (pyrosulphurous acid) is same but oxidation state of both sulphur are different

(d) Tetra-polyphosphoric acid has four P—O—P and no P—P linkage

21. Oxidation state of 'S' in peroxodisulphuric acid and sodium tetrathionate :

(a) +6, +5, 0 (b) +6, +6, +6

(c) +6, +4, +2 (d) +6, +2, 0

22. Structure of $Na_2[B_4O_5(OH)_4]\cdot 8H_2O$ contains :

(a) two triangular and two tetrahedral units

(b) three triangular and one tetrahedral units

(c) all tetrahedral units

(d) all triangular units

23. Which of the following molecular species is not linear ?

(a) $(CN)_2$ (b) OCN^- (c) XeF_2 (d) S_3^{2-}

24. Incorrect match is :

	Electron geometry		**Possible molecular shape from respective electron geometry**
(a)	Tetrahedron	—	Bent
(b)	Trigonal bipyramidal	—	Triangular planar
(c)	Octahedron	—	Square pyramidal
(d)	Pentagonal bipyramidal	—	Pentagonal planar

Hybridisation

25. Consider the following reaction :

$MX_4 + X'_2 \longrightarrow MX_4X'_2$

If atomic number of M is 52 and X and X' are halogens and X' is more electronegative than X. Then choose correct statement regarding given information:

(a) Both X' atoms occupy axial positions which are formed by overlapping of p and d-orbitals only

(b) All $M — X$ bond lengths are identical in both MX_4 and $MX_4X'_2$ compounds

(c) Central atom 'M' does not use anyone valence non-axial set of d-orbital in hybridization of final product

(d) Hybridization of central atom 'M' remains same in both reactant and final product.

26. Select the incorrect match :

	Statement	Shape	Example
(a)	Bond pair has $> 75\%$ p-character		HF
(b)	Reduction in axial bond angle is more than that of in equatorial bond angle		SF_4
(c)	Two axial d-orbitals and one non-axial d-orbital are used in hybridization		XeF_5^-
(d)	Two p-orbitals are used in hybridization		$SnCl_2$

27. In which of the following species, d-orbitals having xz and yz two nodal planes involved in hybridization of central atom?

(a) $IO_2F_2^-$ (b) ClF_4^- (c) IF_7 (d) None of these

28. The correct order of increasing s-character (in percentage) in the hybrid orbitals of following molecules/ions is :

(I) CO_3^{2-} (II) XeF_4 (III) I_3^- (IV) NCl_3 (V) $BeCl_2$

(a) $II < III < IV < I < V$ (b) $II < IV < III < V < I$

(c) $III < II < I < V < IV$ (d) $II < IV < III < I < V$

29. The shape of MnO_4^- ion and the hybridisation of Mn in MnO_4^- is :

(a) tetrahedral, sp^3 (b) tetrahedral, d^3s

(c) square planar, dsp^2 (d) square planar, sp^3

Bond Length

30. Which one of the following molecule will have all equal $X—F$ bond length? (where X = central atom)

(a) $SOCl_2F_2$ (b) SeF_4 (c) PBr_2F_3 (d) IF_7

31. Consider the following information (X = F or Cl)

Molecule	P—X(axial) bond length	P—X(Equitorial) bond length
PF_5	a	b
PF_4CH_3	c	d
$PF_3(CH_3)_2$	e	f
PCl_5	g	h

According to given information choose the incorrect order of bond length :

(a) $g > a > d > b$ (b) $g > e > f > b$ (c) $f > d > a > b$ (d) $c > f > d > b$

32. In which of the following cases C—C bond length will be highest?

(a) $CH_3—CF_3$ (b) $FCH_2—CH_2F$ (c) $F_2CH—CHF_2$ (d) $CF_3—CF_3$

33. Select the incorrect statement about N_2F_4 and N_2H_4 :

(I) In N_2F_4, d-orbitals are contracted by electronegative fluorine atoms, but d-orbital contraction is not possible by H-atom in N_2H_4

(II) The N—N bond energy in N_2F_4 is more than N—N bond energy in N_2H_4

(III)The N—N bond length in N_2F_4 is more than that of in N_2H_4

(IV)The N—N bond length in N_2F_4 is less than that of in N_2H_4

Choose the correct code :

(a) I, II and III (b) I and III (c) II and IV (d) II and III

Bond Angle

34. The correct order of equatorial FSF bond angle in the following compound.

(I) SF_4 (II) OSF_4 (III) H_2CSF_4

(a) (III) > (II) > (I) (b) (I) > (III) > (II) (c) (I) > (II) > (III) (d) (II) > (III) > (I)

35. Incorrect order of bond angle is :

(a) $OCl_2 > SF_2 > AsH_3 > H_2Se$ (b) $NH_3 > PF_3 > PH_3 > H_2S$

(c) $XeO_4 > ClO_4^- > SO_4^{2-} > CF_4$ (d) $N(SiH_3)_3 > O(SiH_3)_2 > OMe_2$

36. Minimum F — S — F bond angle present in :

(a) SSF_2 (b) SF_6 (c) SF_2 (d) F_3SSF

37. The correct order of increasing bond angles is :

(a) $OF_2 < ClO_2 < H_2O < Cl_2O$ (b) $OF_2 < H_2O < Cl_2O < ClO_2$

(c) $OF_2 < H_2O < ClO_2 < Cl_2O$ (d) $ClO_2 < OF_2 < H_2O < Cl_2O$

38. The correct order of bond angles is :

(a) $NO_2^- > NO_2^+ > NO_2$ (b) $NO_2^+ > NO_2^- > NO_2$

(c) $NO_2 > NO_2^+ > NO_2^-$ (d) $NO_2^+ > NO_2 > NO_2^-$

39. Which one is correct for bond angle?

(a) $PF_3 > PCl_3$ (b) $OCl_2 = ClO_2$ (c) $NF_3 > NH_3$ (d) $PCl_3 > PF_3$

40. In molecules of the type AX_2L_n (where L represents lone pairs and n is its number) there exists a bond between element A and X. The $\angle XAX$ bond angle.

(a) Always decreases if n increases (b) Always increases if n increases

(c) Will be maximum for n=3 (d) generally decreases if n decreases

Molecular Forces

41. Which of the following solid has maximum melting point ?
(a) NaCl (b) Ice (c) Dry ice (d) SiO_2

42. The melting point of AlF_3 is 104°C and that of SiF_4 is – 77°C (it sublimes) because :
(a) there is a very large difference in the ionic character of the Al – F and Si – F bonds
(b) in AlF_3, Al^{3+} interacts very strongly with the neighbouring F^- ions to given a three dimensional structure but in SiF_4 no such interaction is possible
(c) the silicon ion in the tetrahedral SiF_4 molecule is not shielded effectively from the fluoride ions whereas in AlF_3, the Al^{3+} ion is shielded on all sides
(d) the attractive forces between the SiF_4 molecules are strong whereas those between the AlF_3 molecule are weak

43. The correct order of boiling point is :
(a) $T_2 < D_2 < H_2$
(b) *n* –pentane < neo-pentane
(c) Xe < Ar < He
(d) *m* –nitrophenol > *o* –nitrophenol

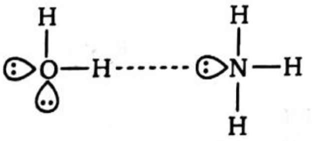
Hydrogen Bonding

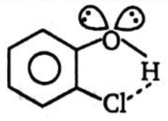
44. *Cis*-butene dioic acid $\xrightleftharpoons{K_{a_1}(-H^+)} X_1^- \xrightleftharpoons{K_{a_2}(-H^+)} X_2^{2-}$

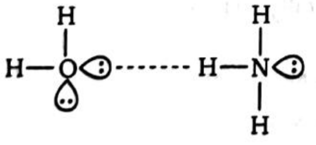
Trans-butene dioic acid $\xrightleftharpoons{K_{a_1}'(-H^+)} Y_1^- \xrightleftharpoons{K_{a_2}'(-H^+)} Y_2^{2-}$

The incorrect statement regarding above information is :
(a) X_2^{2-} species is more basic than Y_2^{2-} species
(b) X_1^- species is more basic than Y_1^- species
(c) K_{a_1} is greater than K'_{a_1}
(d) K'_{a_2} is greater than K_{a_2}

45. Which of the following is not a best representation of the H-bond?

(a) 

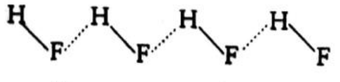
(b) 

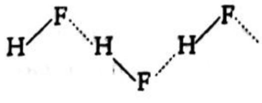
(c) 

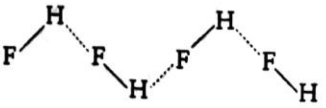
(d) None

46. The H-bonds in solid HF can be best represented as :

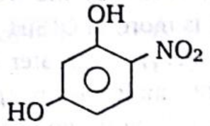
(a) H—F----H—F----H—F

(b) 

(c) 

(d) 

47. The type of molecular forces of attraction present in the following compound is :



(a) Intermolecular H-bonding (b) Intramolecular H-bonding
(c) van der Waals' force (d) All of these

48. Which of the following interaction lies in the range of 8 – 42 kJ/mol ?
(a) $H_2...H_2O$ (b) HCl...HCl
(c) $F^-...HF$ (d) $HCN...NH_3$

Fajan's Rule (Ionic Bond)

49. The incorrect order is :
(a) Covalent character : $PbCl_2 > CaCl_2 > SrCl_2 > BaCl_2$
(b) Thermal stability : $PbF_4 > PbCl_4 > PbBr_4 > PbI_4$
(c) Melting point : KF > KCl > KBr > KI
(d) Boiling point : $CHCl_3 > CH_3Cl > CCl_4$

50. If CdI_2 is pink in colour, the $CdCl_2$ will be '———' coloured.
(a) yellow (b) red (c) blue (d) cannot be predicted

51. Which order are correct?
(I) Thermal stability : $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$
(II) Basic nature : $ZnO > BeO > MgO > CaO$
(III) Solubility in water : $LiOH > NaOH > KOH > RbOH > CsOH$
(IV) Melting point : $NaCl > KCl > RbCl > CsCl > LiCl$
(a) (I), (IV) (b) (I), (II) and (IV) (c) (II), (III) (d) All correct

52. The correct solubility order is/are :
(I) $CaCO_3 > SrCO_3 > BaCO_3$ (II) $Li_2CO_3 < Na_2CO_3 < K_2CO_3$
(III) $K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$ (IV) $Na_2CO_3 > K_2CO_3 > Rb_2CO_3$
(a) II, IV (b) I, IV
(c) II, III,IV (d) I, II, III

53. On heating to 400-500°C, relatively unstable hydrides and carbonates decompose. Which of the following will decompose when heated to 400-500°C ?
(I) LiH (II) NaH (III) Li_2CO_3 (IV) Na_2CO_3
(a) II, III (b) I, II, III
(c) I, III (d) III, IV

Back Bond

54. Both $N(SiH_3)_3$ and $NH(SiH_3)_2$ compounds have trigonal planar skeleton. Incorrect statement about both compounds is :
(a) SiNSi bond angle in $NH(SiH_3)_2$ > SiNSi bond angle in $N(SiH_3)_3$
(b) N—Si bond length in $NH(SiH_3)_2 >$ N — Si bond length in $N(SiH_3)_3$
(c) N—Si bond length in $NH(SiH_3)_2 <$ N — Si bond length in $N(SiH_3)_3$
(d) Back bonding strength in $NH(SiH_3)_2$ > Back bonding strength in $N(SiH_3)_3$

55. The incorrect statement regarding $O(SiH_3)_2$ and OCl_2 molecule is/are :
(a) The strength of back bonding is more in $O(SiH_3)_2$ molecule than OCl_2 molecule
(b) Si — O — Si bond angle in $O(SiH_3)_2$ is greater than Cl — O — Cl bond angle in OCl_2
(c) The nature of back bond in both molecules is $2p_\pi$-$3d_\pi$
(d) Hybridisation of central O-atom in both molecules is same

56. Among following molecule N—Si bond length is shortest :
(a) $N(SiH_3)_3$ (b) $NH(SiH_3)_2$
(c) $NH_2(SiH_3)$ (d) All have equal N—Si bond length

57. Which of the following molecule has weakest $(p\pi - d\pi)$ back bonding ?
(a) OCl_2 (b) $N(SiH_3)_3$ (c) SiF_4 (d) $O(SiH_3)_2$

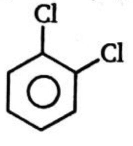
58. "Hybridisation of central atom does not always change due to back bonding". This statement is valid for which of the following compounds ?
(i) CCl_3^- (ii) CCl_2 (iii) $(SiH_3)_2O$ (iv) $N(SiH_3)_3$
(a) (i), (ii) (b) (i), (iii) (c) (ii), (iii) (d) All

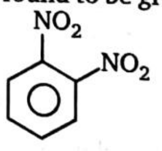
59. The geometry with respect to the central atom of the following molecules are :
$N(SiH_3)_3$; Me_3N; $(SiH_3)_3P$
(a) planar, pyramidal, planar
(b) planar, pyramidal, pyramidal
(c) pyramidal, pyramidal, pyramidal
(d) pyramidal, planar, pyramidal

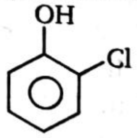
60. Incorrect statement regarding BF_2NH_2 molecule is :
(a) FBF bond angle < 120° (b) HNH bond angle > 109°28'
(c) Exhibits intermolecular H-bond (d) Hybridization of N-atom is sp^3

Dipole Moment

61. In which of the following molecule μ (observed) is found to be greater than μ(theoretical) :
(a) $CHCl_3$

(b)


(c)


(d)


62. Among the following, the molecule with highest dipole moment is :
(a) CH_3Cl (b) CH_2Cl_2
(c) $CHCl_3$ (d) CCl_4

63. Which of the following compounds has dipole moment approximately equal to that of chlorobenzene?
(a) *o*-dichlorobenzene (b) *m*-dichlorobenzene
(c) *p*-dichlorobenzene (d) *p*-chloronitrobenzene

Co-ordinate Bond

64. Which of the following bonds have lowest bond energy?
(a) C—C (b) N—N (c) H—H (d) O—O

65. The bond having the minimum bond energy is :
(a) C — C (b) O — O (c) S — S (d) P — P

L. Acid-Base

66. The correct increasing order of extent of hydrolysis is :

(a) $CCl_4 < MgCl_2 < AlCl_3 < SiCl_4 < PCl_5$ (b) $CCl_4 < AlCl_3 < MgCl_2 < PCl_5 < SiCl_4$

(c) $CCl_4 < SiCl_4 < PCl_5 < AlCl_3 < MgCl_2$ (d) $CCl_4 < PCl_5 < SiCl_4 < AlCl_3 < MgCl_2$

67. Inorganic benzene reacts with HCl to form a compound $B_3N_3H_9Cl_3$. The protonation occurs at :

(a) B-atom
(b) N-atom
(c) First at B-atom then rearranges into N-atom
(d) First at N-atom then rearranges into B-atom

68. Select correct statement about hydrolysis of BCl_3 and NCl_3 :

(a) NCl_3 is hydrolysed and gives HOCl but BCl_3 is not hydrolysed
(b) Both NCl_3 and BCl_3 on hydrolysis gives HCl
(c) NCl_3 on hydrolysis gives HOCl but BCl_3 gives HCl
(d) Both NCl_3 and BCl_3 on hydrolysis gives HOCl

Molecular Orbital Theory

69. The incorrect statement regarding molecular orbital(s) is :

(a) If there is a nodal plane perpendicular to the internuclear axis and lying between the nuclei of bonded atoms then corresponding orbitals is antibonding M.O.

(b) If a nodal plane lies in the inter-nuclear axis, then corresponding orbitals is pi(π) bonding M.O.

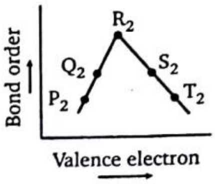
(c) The σ-bonding molecular orbital does not contain nodal planes containing the internuclear axis

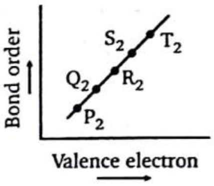
(d) The δ-bonding molecular orbital possesses three nodal planes containing the internuclear axis.

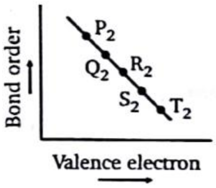
70. Which of the following species absorb maximum energy in its HOMO-LUMO electronic transition?

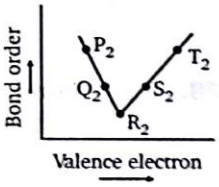
(a) O_2 (b) N_2^- (c) C_2 (d) N_2

71. If P to T are second period p-block elements then which of the following graph show correct relation between valence electrons in P_2 to T_2 (corresponding molecules) and their bond order is :

(a)


(b)


(c)


(d)


72. Which of the following facts given is not correct ?

(I) Bond length order : $H_2^- = H_2^+ > H_2$

(II) O_2^+, NO, N_2^- have same bond order of $2\frac{1}{2}$

(III) Bond order can assume any value including zero upto four

(IV) NO_3^- and BO_3^- have same bond order for X — O bond (where X is central atom)

(a) I, II & III (b) I & IV (c) II & IV (d) I & II

73. N_2 and O_2 are converted to monocations N_2^+ and O_2^+ respectively, which is wrong statement :

(a) In N_2^+, the N—N bond weakens (b) In O_2^+, the O—O bond order increases

(c) In O_2^+, the paramagnetism decreases (d) N_2^+ becomes diamagnetic

74. In which of the following transformations, the bond order has increased and the magnetic behaviour has changed?

(a) $C_2^+ \rightarrow C_2$ (b) $NO^+ \rightarrow NO$ (c) $O_2 \rightarrow O_2^+$ (d) $N_2 \rightarrow N_2^+$

75. H.O.M.O. (Highest Occupied Molecular Orbital) of CO molecular is :

(a) Non-bonding M.O. with slight antibonding character

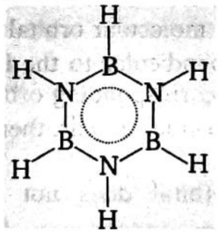
(b) Non-bonding M.O. with slight bonding character

(c) Pure non-bonding M.O.

(d) None of the above

Molecular Structure

76. The structure of $B_3N_3H_6$ is as follows :



How may derivative structures of $B_3N_3H_4X_2$ can be derived from the basic structure, by the replacement of two hydrogen atoms?

(a) 2 (b) 3 (c) 4 (d) 5

Valence Bond Theory

77. Correctly match is :

(a) $d_{x^2-y^2}$ atomic orbital — One nodal plane

(b) p_y atomic orbital — Two nodal planes

(c) σ_{p_x} — ψ (gerade)

(d) $p^*_{p_y}$ — ψ (ungerade)

78. Select correct statement(s) :

(a) Acidic strength of HBr > HCl but reverse is true for their reducing property

(b) Basic strength of $PH_3 > AsH_3$ but reverse is true for their bond angle

(c) Dipole moment of $CH_3Cl > CH_3F$ but reverse is true for their $H\hat{C}H$ bond angle

(d) K_{a_1} of fumaric acid is higher than maleic acid but reverse is true for their K_{a_2}

Level 3

PASSAGE 1

Colour of compounds occurs due to phenomenon of polarisation, charge transfer, *d-d* transition and H.O.M.O.-L.U.M.O. transition. Most of the transition metal complex compound are coloured either due to *d-d* electron transition or charge transfer and ionic compounds are coloured due to polarisation of anion.

1. Which of the following is correct about $\underset{\text{(I)}}{KFe^{II}[Fe(CN)_6]}$ and $\underset{\text{(II)}}{KFe^{III}[Fe(CN)_6]}$ complex compounds ?

(a) Both are blue coloured compound because colour arises due to *d-d* electron transition in Fe cation present outside the complex ion.

(b) Both are blue coloured compound because colour arises due to transfer of electron between Fe^{II} and Fe^{III} cation

(c) Both are blue coloured compound because in complexes Fe^{II} cation shows same *d-d* transition band

(d) Complex (I) has blue colour while complex (II) has brown colour.

2. If MCl_2 salt is white, then comment on colour of its iodide salt.

(a) Coloured
(b) White
(c) May be white or coloured
(d) Black

3. Choose incorrect statement.

(a) Halogens are coloured due to HOMO-LUMO transition

(b) During charge transfer, oxidation state of atoms changes

(c) Higher the polarisation, more is colour intensity

(d) Complex compound having no unpaired electron can not undergo *d-d* transition and therefore it is colourless

PASSAGE 2

Hydrogen bond is the term given to the relatively weak secondary interaction between a hydrogen atom bound to an electronegative atom and another atom which is also generally electronegative and which has one or more lone pairs and can thus acts as a base. We can give the following generalized representation of a hydrogen bond.

$$\overset{\delta-}{X}-\overset{\delta+}{H}...Y$$

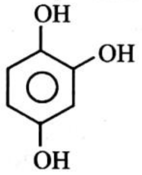
Bond dissociation energy of H-bond ranges from 8 to 42 kJ/mol, and the most commonly encountered hydrogen bonds are O—H...O, N—H...O and F—H...F.

1. Among molecules of HCl, which of the following forces are present.
   (a) Interaction between two HCl molecules is found to be greater than 8 kJ/mol
   (b) Weak dipole-dipole interactions
   (c) Weak ion-dipole interactions
   (d) All of the above
2. Which of the following interaction has energy between 8-42 kJ/ mol ?
   (a) $Na^+:CCl_4$ (b) $CHCl_3:Br^-$ (c) $C_6H_6:CCl_4$ (d) $H_2O:HCN$

PASSAGE 3

The intermolecular forces of attraction (*i.e.*, H-bonding and van der Waals' forces) exist among polar and non-polar species which affect melting point, boiling point, solubility and viscosity of covalent compounds :

1. Melting and boiling point of halogens increase down the group due to :
   (a) Increase in London dispersion forces (b) Increase in extent of polarity
   (c) Increase in molecular mass (d) Both (a) and (b)
2. The type of molecular force of attraction present in the following compound is :



   (a) Intermolecular H-bonding (b) Intramolecular H-bonding
   (c) van der Waals' force (d) All of these
3. Select the incorrect order of boiling point between the following compounds :
   (a) $N_3H < CH_3N_3$ (b) $Me_2SO_4 < H_2SO_4$
   (c) $Me_3BO_3 < B(OH)_3$ (d) $BF_3 < BI_3$

PASSAGE 4

There are five species *P*, *Q*, *R*, *S* and *T*. Spectroscopical analysis shows that *P*, *Q* and *R* are homonuclear diatomic species and have their bond order 2.5, 1.5 and 2.5 respectively and rest two species *S* and *T* are heteronuclear diatomic species and have bond order 3 and 2 respectively. All homonuclear diatomic species are paramagnetic and all heteronuclear diatomic species are diamagnetic in nature. *P*, *R*, *S* and *T* are monovalent positive ion and *Q* is monovalent negative ion :

1. According to given information the incorrect match is :
   (a) $P = N_2^+$ (b) $R = O_2^+$ (c) $S = CO^+$ (d) $T = CN^+$

2. The correct statement is :

(a) If P is having 13 electrons then removal of one electron retains its magnetic behaviour

(b) If Q is having 17 electrons then addition of one electron retains its magnetic behaviour

(c) If R is having 15 electrons then addition of one e^- retains its magnetic behaviour

(d) If T is having 12 electrons then addition of one e^- retains its magnetic behaviour

3. The incorrect statement is :

(a) If R has 15 electrons then bond order of R is greater than its parent molecule

(b) If Q has 17 electrons then bond order of Q is less than its parent molecule

(c) If P has 13 electrons then bond order of P is greater than its parent molecule

(d) On addition of two electrons in P(having 13 electrons) the bond order remains same

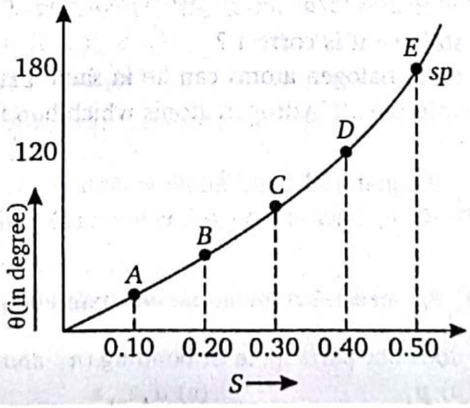
PASSAGE 5

Compound, MX_n type ($n = 2$ or 3 or 4)	Value of $\cos\theta$ (θ = bond angle between equivalent hybrid orbitals)
P	-0.241
Q	-0.292
R	-0.5
S	-0.325
T	-0.469

In all expected compounds each central atom only uses its s and p-orbitals in hybridization. The relationship between bond angle 'θ' and decimal fraction of s and p character present in the equivalent hybrid orbitals is given by :

$\cos\theta = \dfrac{S}{S-1} = \dfrac{P-1}{P}$, S = decimal fraction of s-character in the equivalent hybrid orbital

P = decimal fraction of p-character in the equivalent hybrid orbital.



1. The correct order of % *p*-character in bond pairs of central atoms in the following compounds is :
   (a) $P > T > S > Q > R$ (b) $S > R > T > P > Q$
   (c) $P > Q > S > R > T$ (d) $P > Q > S > T > R$
2. If the value of *n* is 2 for compound *T*, then number of lone pair present at central atom of compound *T* will be :
   (a) 0 (b) 1 (c) 2 (d) 3
3. The incorrect statement is :
   (a) The ratio of % p-character *to* % *s*-character is less than four, for the bond pair of central atom of compound *S*
   (b) Central atom uses three hybrid orbitals to form compound *R*
   (c) Central atom uses four hybrid orbitals to form compound *S*
   (d) There are three compounds present between point *C* to *E*, according to % *s*-character in bond pair of central atom

PASSAGE 6

The concept of redistribution of energy in different orbitals of an atom associated with different energies to give new orbitals of equal (or sometimes it may be non-equal) energy oriented in space in definite directions is called hybridisation and formed new orbitals are called hybrid orbitals. The bonds formed by such orbitals are called hybrid bonds. The process of mixing of orbitals itself requires some energy. Thus, some additional energy, is needed for the hybridisation (mixing) of atomic orbitals.

1. Select from each set the molecule or ion having the smallest bond angle :
   (i) H_2Se, H_2Te and PH_3
   (ii) NO_2^- and NH_2^-
   (iii) POF_3 and $POCl_3$ ($X—P—X$ angle)
   (iv) OSF_2Cl_2 and $SF_2(CH_3)_2$(F — S — F angle)
   (a) H_2Se, NH_2^-, POF_3 and OSF_2Cl_2 (b) H_2Te, NO_2^-, POF_3 and $SF_2(CH_3)_2$
   (c) $PH_3, NH_2^-, POCl_3$ and $SF_2(CH_3)_2$ (d) H_2Te, NH_2^-, POF_3 and $SF_2(CH_3)_2$
2. Which of the following statement is correct ?
   (a) In BrF_3, maximum three halogen atoms can lie in same plane
   (b) In $CH_2SF_2(CH_3)_2$ molecule all hydrogen atoms which bonded to $s - sp^2$ overlapping, lie in equatorial plane
   (c) In $OSCl_4$, Cl — S — Cl equatorial bond angle is greater than 120°
   (d) Molecules IOF_5 and XeO_2F_4 have similar shape but have different number of lone pairs in whole molecule
3. In neutral molecule $XeO_{n_1}F_{n_2}$, central atom has no lone pair and ratio of $\frac{n_2}{n_1}$ is two, then which of the following orbital does not participate in bonding (n_1 and n_2 are natural numbers) :
   (a) d_{z^2} (b) p_z (c) $d_{x^2-y^2}$ (d) None of these

PASSAGE 7

Drago suggested an emprical rule which is compatible with the energetics of hybridization. It states that if the central atom is in the third row or below in the periodic table, the lone pair will occupy a stereochemically inactive *s*-orbital, and the bonding will be through *p*-orbitals and bond angles will be nearly 90° if the electronegativity of the surrounding atom is ≤ 2.5.

1. In which of the following molecule central atom has higher % *s*-character in its bond pair :
(a) AsH_3 (b) GeH_4 (c) P_4 (d) H_2Se

2. Correct order of bond angle is :
(a) $PH_4^+ > OF_2 > SF_2 > SbH_3 > H_2Te$
(b) $OF_2 > SF_2 > PH_4^+ > SbH_3 > H_2Te$
(c) $PH_4^+ > SF_2 > OF_2 > SbH_3 > H_2Te$
(d) $SF_2 > OF_2 > PH_4^+ > SbH_3 > H_2Te$

PASSAGE 8

According to hybridisation theory, the % *s*-character in *sp*, sp^2 and sp^3-hybrid orbitals is 50, 33.3 and 25 respectively, but this is not true for all the species. When θ is the bond angle between equivalent hybrid orbitals then % *s* and *p*-character in hybrid orbital (when only *s*- and *p*-orbitals are involved in hybridisation) can be calculated by the following formula :

$$\cos\theta = \frac{S}{S-1} = \frac{P-1}{P}$$

1. Two elements *X* and *Y* combined together to form a covalent compound. If % *p*-character is found to be 80% in a hybrid orbital then the hybridised state of central atom *X* for the orbital is:
(a) sp^2 (b) sp^3 (c) sp^4 (d) sp^5

2. Smallest $O\hat{S}O$ bond angle is found in :
(a) SO_2F_2 (b) SO_2Cl_2 (c) $SO_2(CF_3)_2$ (d) $SO_2(CH_3)_2$

3. Correct order of P—P bond length in the following compound is :
(a) $P_2F_4 < P_2(CH_3)_4 < P_2(CF_3)_4 < P_2H_4$
(b) $P_2F_4 < P_2(CF_3)_4 < P_2(CH_3)_4 < P_2H_4$
(c) $P_2F_4 < P_2H_4 < P_2(CH_3)_4 < P_2(CF_3)_4$
(d) $P_2F_4 < P_2(CH_3)_4 < P_2H_4 < P_2(CF_3)_4$

PASSAGE 9

PCl_5 is an example of a molecule having sp^3d-hybridisation. Three out of the five orbitals involved in sp_xp_y-hybridization while remaining two have $p_zd_{z^2}$-hybridization. If P-atom is attached to substituents differ in electronegativity, as in PCl_xF_{5-x}, then it has been experimentally observed that the more electronegative substituent occupies the axial position of t.b.p geometry.

1. The correct statement is :
   (a) in CH_2F_2 the F—C—F bond angle is larger 109° 28'
   (b) in CH_2F_2 the C—F bond has more than 25% *s*-character
   (c) in CH_2F_2 the H—C—H bond angle is larger than 109° 28'
   (d) in CH_2F_2 the C—H bond has less than 25% *s*-character
2. The incorrect statement regarding PCl_2F_3 molecule will be :
   (a) given compound is polar
   (b) both axial position occupied by F-atoms
   (c) both Cl atoms present in equatorial position
   (d) one Cl atom present at axial and other Cl atom is present at equatorial position of geometry
3. The highest H — C — H bond angle present in :
   (a) CH_2F_2 (b) CH_4 (c) CH_3Cl (d) CH_3F

PASSAGE 10

The first compound of the noble gases was made in 1962. Bartlett and Lohman had previously used the highly oxidizing compound platinum hexafluoride to oxidize dioxygen.

$$O_2 + PtF_6 \longrightarrow O_2^+[PtF_6]^-$$

The first ionization energy for $O_2 \rightarrow O_2$ is 1165 kJ mol^{-1}, which is almost the same as the value of 1170 kJ mol^{-1} for $Xe \rightarrow Xe^+$. It was predicated that xenon should react with PtF_6. Experiments showed that when deep red PtF_6 vapour was mixed with an equal volume of Xe, the gases combined immediately at room temperature to produce a solid.

$$Xe + PtF_6 \longrightarrow Xe[PtF_6]$$

1. IUPAC name of first xenon-compound synthesized by scientist Bartlett is :
   (a) xenonhexafluoroplatinate (IV) (b) xenonhexafluoroplatinate (V)
   (c) hexafluoroplatinum (V) xenon (d) xenoniumhexafluoroplatinum (V)
2. Noble gases are water insoluble, however their insolubility in water decreases down the group due to increases in :
   (a) dipole-dipole attraction
   (b) dipole-induced dipole attraction
   (c) instantaneous dipole-induced dipole attraction
   (d) none of these
3. Which of the following species is not having perfect octahedron structure?
   (a) XeF_6 (b) SiF_6^{2-}
   (c) PCl_6^- (d) XeO_6^{4-}

PASSAGE 11

According to MOT, two atomic orbitals overlap resulting in the formation of molecular orbitals. Number of atomic orbitals overlapping together is equal to the molecular orbital formed. The two atomic orbital thus formed by LCAO (linear combination of atomic orbital) in the same phase or in the different phase are known as bonding and antibonding molecular orbitals respectively. The energy of bonding molecular orbital is lower than that of the pure atomic orbital by an amount Δ. This known as the stabilization energy. The energy of antibonding molecular orbital is increased by Δ′ (destabilisation energy).

1. The bond order of N_2^- is equal to that of :
(a) O_2 (b) O_2^{2-}
(c) O_2^+ (d) None

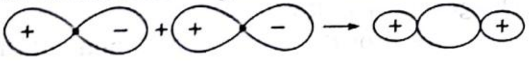
2. Which among the following pairs contain both paramagnetic species.
(a) O_2^{2-} and N_2^- (b) O_2^- and N_2 (c) O_2 and N_2 (d) O_2 and N_2^-

3. Which of the following statement(s) is true :
(a) Higher the bond order lesser the bond length
(b) Higher the bond order greater the bond length
(c) Higher the bond order lesser the bond energy
(d) Higher the bond order lesser the number of bonds

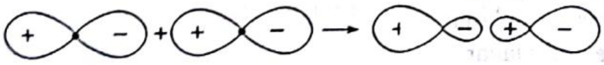
4. Which of the following pairs of molecule can exist ?
(a) He_2 and Be_2 (b) O_2^{2-} and Na_2 (c) O_2^{2-} and H_2^{2-} (d) Be_2 and Mg_2

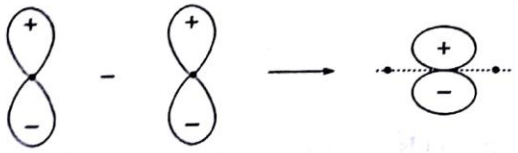
5. How many nodal plane is present in $\sigma_{(s \text{ and } p)}$ bonding molecular orbital?
(a) zero (b) 1 (c) 2 (d) 3

6. Which of the following combination of orbitals is correct?

(a) 

(b) 

(c) 

(d) 

7. Which of the following statements is not correct regarding bonding molecular orbitals?
(a) Bonding molecular orbitals possess less energy than the atomic orbitals from which they are formed
(b) Bonding molecular orbitals have low electron density between the two nuclei

(c) Electron in bonding molecular contributes to the attraction between atoms
(d) They are formed when the lobes of the combining atomic orbitals have the same sign

8. If x-axis is the molecular axis, then π-molecular orbitals are formed by the overlap of :
(a) $s + p_z$ (b) $p_x + p_y$ (c) $p_z + p_z$ (d) $p_x + p_x$

PASSAGE 12

Polar covalent molecules exhibit dipole moment. Dipole moment is equal to the product of charge separation, q and the bond length d for the bond. Unit of dipole moment is debye. One debye is equal to 10^{-18} esu cm.

Dipole moments is a vector quantity. It has both magnitude and direction. Hence, dipole moment of a molecule depends upon the relative orientation of the bond dipoles, but not on the polarity of bonds alone. A symmetrical structure shows zero dipole moment. Thus, dipole moment helps to predict the geometry of a molecules. Dipole moment values can be used to distinguish between *cis*-and *trans*-isomers; *ortho*-, *meta*- and *para*-forms of a substance, etc.

1. Which is a polar molecule?
(a) XeF_4 (b) BF_3
(c) I_2Cl_6 (d) PCl_2F_3

2. A diatomic molecule has a dipole moment of 1.2 D. If the bond length is 1.0×10^{-8} cm, what fraction of charge does exist each atom?
(a) 0.1 (b) 0.2 (c) 0.25 (d) 0.3

3. Arrange the following compounds in increasing order of dipole moments, toluene (I) *o*-dichlorobenzene (II), *m*-dichlorobenzene (III) and *p*-dichlorobenzene (IV) :
(a) IV < I < II < III (b) I < IV < II < III
(c) IV < I < III < II (d) IV < II < I < III

4. μ of the AX_4 type of molecule is zero. The geometry of it can be :
(a) tetrahedral (b) square planar (c) A or B (d) none of these

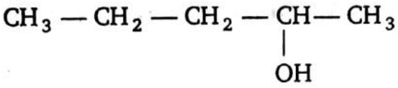
5. Which of the following statement is correct regarding $C_2H_2F_2$ molecule?
(a) One isomer is polar, one is non-polar
(b) Two isomers are polar, one is non-polar
(c) Two isomers are planar, one is non-planar
(d) Two isomers are only possible and planar

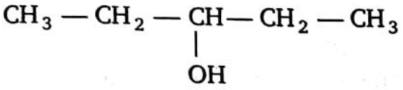
PASSAGE 13

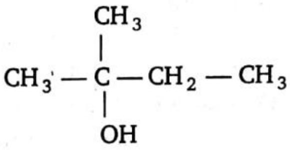
In general boiling point of covalent compounds is affected due to increasing molecular weight and hydrogen bonding. Thus it is observed that the boiling point of octanol is greater that water while that of methanol is lesser than water. The other properties which are considerably affected due to hydrogen bond formation are acidic nature, melting point, anamalous behaviour of water below 4°C., It is therefore concluded that hydrogen bonding plays a vital role in explaning many observable facts.

1. Which among the following has maximum boiling point ?

(a) $CH_3-CH_2-(CH_2)_2-CH_2OH$

(b) 
$CH_3-CH_2-CH_2-\underset{\substack{|\\ OH}}{CH}-CH_3$

(c) 
$CH_3-CH_2-\underset{\substack{|\\ OH}}{CH}-CH_2-CH_3$

(d) 
$CH_3-\overset{\substack{CH_3\\ |}}{\underset{\substack{|\\ OH}}{C}}-CH_2-CH_3$

2. Which of the following statements is true ?
(a) the lattice structure of ice involves true covalent bond
(b) the lattice structure of ice is the result of dipole-dipole interaction
(c) the lattice structure of ice is the result of intra and inter-molecular hydrogen bond formation
(d) the lattice structure of ice is only due to inter-molecular hydrogen bonding

3. K_{a_2} of Maleic acid is lesser than K_{a_2} of fumaric acid due to :
(a) intramolecular hydrogen bonding in the formed after one proton removal in fumaric acid
(b) intermolecular hydrogen bonding in the ion formed after one proton removal in maleic acid
(c) intramolecular hydrogen bonding in the ion formed after one proton removal in maleic acid
(d) intermolecular hydrogen bonding in the ion formed after one proton removal in fumaric acid

PASSAGE 14

The molecule in which an atom is associated with more than 8 electrons is known as hypervalent molecule and less than 8 electrons is known as hypovalent molecule. All hypervalent molecules must have *pπ-dπ* bonding but the molecules having back bonding need not to have always *pπ-dπ* bonding.

1. Which of the molecule is not hypovalent but complete its octet :
(a) $AlCl_3$
(b) $AlBr_2$
(c) AlF_3
(d) BF_3

2. Which of the following molecule is having complete octet :
(a) $BeCl_2$ (dimer)
(b) BeH_2 (dimer)
(c) $BeH_2(s)$
(d) $BeCl_2(s)$

3. Which of the following molecule is not having *pπ-dπ* bonding :
(a) SO_2
(b) P_4O_{10}
(c) PF_3
(d) $B_3N_3H_6$

ONE OR MORE ANSWERS IS/ARE CORRECT

1. Which is correct statement ?

(a) LiCl is more soluble in polar solvent (water) than NaCl

(b) K_{a_2} fumaric acid is more than K_{a_2} of maleic acid

(c) The O—O bond length in $O_2[AsF_4]$ is shorter than KO_2

(d) In $CF_2{=}C{=}CF_2$ molecule all the four fluorine atoms are in the same plane

2. Select correct statement(s) :

(a) Thermodynamic stability of graphite > diamond, but reverse order is true for their kinetic stability

(b) Melting point of NaCl > LiCl, but reverse order is true for their thermal stability

(c) Ionisation energy of $N_2 > O_2$, but reverse order of ionisation energy is true for their corresponding atoms

(d) Lewis acidic strength of $BeI_2 > BeF_2$, but reverse order is true for their melting point

3. Select correct statements regarding σ and π-bonds :

(a) σ-bond lies on the line joining the nuclei of bonded atoms

(b) π-electron cloud lies on either side to the line joining the nuclei of bonded atoms

(c) $(2p\pi - 3d\pi)$ Pi-bond is stronger than $(2p\pi - 3p\pi)$ Pi-bond

(d) σ-bond has primary effect to decide direction of covalent bond, which π-bond has no primary effect in direction of bond.

4. Which of the following molecular species is/are having π_{2p} as H.O.M.O. (highest occupied molecular orbital):

(a) N_2^- (b) O_2^{2+} (c) NO^+ (d) B_2^+

5. Select correct order between given compounds.

(a) $COCl_2 > COF_2$: XCX bond angle

(b) $NO_2F > NO_2Cl$: ONO bond angle

(c) $SO_2F_2 < SOF_2$: FSF bond angle

(d) $N_2F_2 < N_2(CH_3)_2$: N—N bond length

6. Select the correct statement(s) regarding BF_2NH_2 molecule :

(a) FBF bond angle < 120° (b) HNH bond angle > 109°28'

(c) HNH bond angle < 109°28' (d) FBF bond angle > 120°

7. Correct statement(s) about dipole moment of R_3NO and R_3PO is/are :

(a) dipole moment of R_3NO > dipole moment of R_3PO

(b) dipole moment of R_3NO < dipole moment of R_3PO

(c) Experimental dipole moment of R_3PO > theoretical dipole moment of R_3PO

(d) Experimental dipole moment of R_3PO < theoretical dipole moment of R_3PO

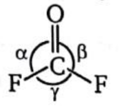
8. In which of the following compound, observed bond angle is found to be greater than expected, but not due to back bonding.

(a) $N(SiH_3)_3$ (b) $N(CH_3)_3$ (c) $O(CH_3)_2$ (d) $O(SiH_3)_2$

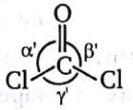
9. Two compounds PX_2Y_3 and PX_3Y_2. (Where P = Phosphorous atom and X, Y = monovalent atoms). If all 'X' atoms are replaced by 'Z' atoms and electronegativity order is $X > Y > Z$. Then incorrect statement(s) is/are :

(a) The dipole moment of product obtained from PX_2Y_3 is non-zero
(b) The dipole moment of product obtained from PX_2Y_3 is zero
(c) The dipole moment of product obtained from PX_3Y_2 is zero
(d) The dipole moment of product obtained from PX_3Y_2 is non-zero

10. Correct order of bond angles in the given compounds is/are :



and



(a) $\gamma < \gamma'$ (b) $\gamma < \beta = \alpha$ (c) $\alpha > \alpha'$ (d) $\beta > \beta'$

11. The correct statement(s) is/are :
(a) Boiling point of *m*-hydroxybenzaldehyde is greater than *o*-hydroxybenzaldehyde
(b) Boiling point of $CHCl_3$ is higher than CCl_4
(c) Melting point of $BeCl_2$ is higher than BeF_2
(d) Boiling point of HF is greater than CH_3F

12. Consider the following reactions

$$CHF_3 \xrightarrow{K_a} CF_3^- + H^+$$

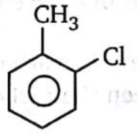
$$CHCl_3 \xrightarrow{K'_a} CCl_3^- + H^+$$

Then regarding given reactions which of the following statement(s) is/are correct :
(a) $K_a > K'_a$
(b) CHF_3 act as a stronger bronsted acid than $CHCl_3$
(c) CCl_3^- is more stable than CF_3^-
(d) CCl_3^- is weaker lewis base than CF_3^-

13. In which of the following molecule $\mu_{exp.}$ (observed dipole moment) is found to be greater than $\mu_{th.}$ (expected dipole moment) ?

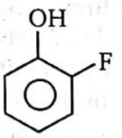
(a) $POCl_3$

(b)



(c) HNC

(d)



14. Correct statement(s) regarding $As(CH_3)F_2Cl_2$ molecule is/are :
(a) Maximum three halogen atoms can lie in same plane
(b) Both axial and equatorial plane may have equal number of atoms
(c) As—Cl bond length is longer than As—F bond length
(d) Maximum five atoms can lie in equatorial plane

15. Which of the following species is/are having 'N—N' bond order = 2?
(a) N_3^- (b) N_2F_2 (c) N_2O_4 (d) N_2O

16. Which of the following statements is correct ?
(a) ClF_3 molecule is bent 'T' shape
(b) In SF_4 molecule, F—S—F equatorial bond angle is 103° due to *lp-lp* repulsion
(c) In $[ICl_4]^-$ molecular ion, Cl—I—Cl bond angle is 90°
(d) In OBr_2, the bond angle is less than OCl_2

17. Which of the following species is/are not know ?
(a) FeI_3 (b) SH_6 (c) PbI_4 (d) PI_5

18. Select correct order between following compounds:
(a) $NH_3 > NF_3$: Bond angle
(b) $NH_3 > NF_3$: Dipole moment
(c) $NH_3 > NF_3$: % *s*-Character of lone pair
(d) $NH_3 > NF_3$: Reactivity towards Lewis acid

19. Which of the following is (are) V-shaped ?
(a) S_3^{2-} (b) I_3^- (c) N_3^- (d) I_3^+

20. Select correct order between given compounds:
(a) $COCl_2 > COF_2$: $X\hat{C}X$ bond angle
(b) $NO_2F > NO_2Cl$: $O\hat{N}O$ bond angle
(c) $SO_2F_2 < SOF_2$: $F\hat{S}F$ bond angle
(d) $N_2F_2 < N_2(CH_3)_2$: N — N bond length

21. Which of the following equilibria would have highest and lowest value of K_p at a common temperature ?
(a) $BeCO_3 \rightleftharpoons BeO + CO_2$ (b) $CaCO_3 \rightleftharpoons CaO + CO_2$
(c) $SrCO_3 \rightleftharpoons SrO + CO_2$ (d) $BaCO_3 \rightleftharpoons BaO + CO_2$

22. Which of the following process is/are associated with change of hybridization of the underlined compound?
(a) $\underline{Al(OH)_3}$ ppt. dissolved in NaOH (b) $\underline{B_2H_6}$ is dissolved in THF
(c) $\underline{SiF_4}$ vapour is passed through liq. HF (d) Solidification $\underline{PCl_5}$ vapour

23. Which of the following are true ?
(a) van der Waals forces are responsible for the formation of molecular crystals
(b) Branching lower the boiling points of isomeric organic compounds due to decrease in van der Waals forces
(c) In graphite, van der Waals forces act between the carbon layers
(d) In diamond, van der Waals forces act between the carbon layers

24. Which of the following statement is incorrect :
(a) O_2 is paramagnetic, O_3 is also paramagnetic
(b) O_2 is paramagnetic, O_3 is diamagnetic
(c) B_2 is paramagnetic, C_2 is also paramagnetic
(d) Different observation is found in their bond length when $NO \rightarrow NO^+$ and $CO \rightarrow CO^+$

25. Which of the following statements are not correct?
(a) All C—O bonds in CO_3^{2-} are equal but not in H_2CO_3
(b) All C—O bonds in HCO_2^- are equal but not in HCO_2H
(c) C—O bond length in HCO_2^- is longer than C—O bond length in CO_3^{2-}
(d) C—O bond length in HCO_2^- and C—O bond length in CO_3^{2-} are equal

26. In the structure of H_2CSF_4, which of the following statement is/are correct?
(a) Two C—H bonds are in the same plane of axial S—F bonds
(b) Two C—H bonds are in the same plane of equitorial S—F bonds

(c) Total six atoms are in the same plane
(d) Equitorial S—F plane is perpendicular to the nodal plane of π-bond

27. In which compound vacant hybride orbital take part in bonding :
(a) B_2H_6 (b) Al_2Cl_6 (c) C_2H_5Cl (d) H_3BO_3

28. Which of the following is true for N_2O ?
(a) Its molecule is linear
(b) Symmetric N — O — N is a favoured structure as compared to N — N — O skeleton
(c) Bond orders are fractional for N — N and N — O bonds
(d) It is a neutral oxide

29. Silane is more reactive than CH_4 towards Nu^- substitution due to :
(a) larger size of Si compared to C which facilitate the attack by nucleophile
(b) Polarity of Si—H bond is opposite to that of C—H bond
(c) Availability of vacant $3d$ orbitals in case of Si to form the reaction intermediate easily for nucleophilic attack
(d) Si—H bond energy is lower than that of C—H bond

30. Which of the following statements is/are not correct for following compounds?
(I) $SCl_2(OCH_3)_2$ and (II) $SF_2(OCH_3)_2$
(a) —OCH_3 groups in both cases occupy the same position
(b) Cl-atoms occupy equitorial position in case of (I) and F-atoms occupy equitorial position in case of (II)
(c) Cl-atoms occupy axial position in case of (I) & F-atoms occupy equitorial position in case of (II)
(d) Cl and F-atoms occupy either axial or equitorial position in case of (I) and (II) respectively

31. If N_B is the number of bonding electrons and N_A is the number of antibonding electrons of a molecule. Then choose the incorrect statement(s) for the relationship, $N_B > N_A$:
(a) Molecule may be stable or unstable
(b) Molecule may have any integral, fractional or zero value of bond order
(c) Molecule is only paramagnetic species
(d) Molecule does not exist

32. Stepwise hydrolysis of P_4O_{10} takes place via formation of :
(a) tetrametaphosphoric acid (b) tetrapolyphosphoric acid
(c) pyrophosphoric acid (d) orthophosphoric acid

33. Select the correct statement(s) about the compound $NO[BF_4]$:
(a) If has 5σ and 2π bond
(b) Nitrogen-oxygen bond length is higher than nitric oxide (NO)
(c) It is a diamagnetic species
(d) B—F bond length in this compound is lower than in BF_3

34. Which of the following molecules has as O—O bond?
(a) $H_2S_2O_8$ (b) $H_2S_2O_7$ (c) H_2SO_5 (d) $H_2S_2O_6$

35. Which of the following species is paramagnetic :
(a) CN^- (b) NO (c) O_2^{2-} (d) O_2

36. CO_2 molecule is not isostructural with :
(a) $HgCl_2$ (b) $SnCl_2$ (c) C_2H_2 (d) NO_2

37. Which of the following have a linear structure?
(a) $HgCl_2$ (b) $SnCl_2$ (c) ICl_2^- (d) CS_2

38. Which of the following compounds is/are non-polar?
(a) NO_2 (b) B_2H_6 (c) PF_3Cl_2 (d) $B_3N_3H_6$

39. Non-polar molecules are :
(a) CH_4 (b) C_2F_2 (c) C_2F_4 (d) OF_2

40. Which of the following molecular species is/are having π_{2p} as HOMO (highest occupied molecular orbital) ?
(a) N_2^- (b) O_2^{2+} (c) NO^+ (d) B_2^+

41. Correct order of B.pt. is/ are:
(a) $H_2 < He$ (b) $H_2 < D_2$ (c) $H_2O < D_2O$ (d) $NH_3 < SbH_3$

42. Incorrect order between following compounds is/are:
(a) $O(CH_3)_2 < O(SiH_3)_2$: number of sp^3-hybrid atoms
(b) $O(CH_3)_2 < O(SiH_3)_2$: Bond angle w.r.t. common atom
(c) $O(CH_3)_2 < O(SiH_3)_2$: % *s*-character of hybrid orbital on central atom
(d) $O(CH_3)_2 < O(SiH_3)_2$: reactivity towards Lewis acid

MATCH THE COLUMN

Column-I and Column-II contains four entries each. Entries of Column-I are to be matched with some entries of Column-II. One or more than one entries of Column-I may have the matching with the same entries of Column-II.

1.

Column-I	Column-II
(A) $O(SiH_3)_2$	(P) Hybridization of central atom does not change due to back bonding
(B) Singlet CCl_2	(Q) Bond angle of central atom increases due to combined effect of back bonding and steric factor
(C) H_4SiO_4	(R) Anyone of t_{2g} *d*-orbital is involved in back bonding
(D) $B(NMe_2)_3$	(S) Electron density on central atom decreases due to back bonding
	(T) Electron density on central atom increases due to back bonding

2.

Column-I	**Column-II**
(A) CO, CN^-, NO^+, O_2^{2+}	(P) All are paramagnetic
(B) N_2^+, O_2^+, O_2^-, NO	(Q) All are diamagnetic
(C) NO^-, N_2^{2+}, C_2, B_2^{2-}	(R) All have intermixing of *s* and *p*-orbitals
(D) CN, C_2^+, B_2^+, N_2^-	(S) All have same bond order
	(T) All have fractional bond order

3.

Column-I (Reactions)	**Column-II (Characteristics of final products)**
(A) Formation of cation and anion by self ionization of iodine	(P) Lone pair(s) is/are present at central atom
(B) Attack of hydroxide ion on boric acid	(Q) *d*-orbital(s) involved in hybridization of central atom of either of product
(C) $Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4 \downarrow$ (white ppt.)	(R) *d*-orbital(s) not involved in hybridization of central atom of either of product
(D) $MgSO_4 \xrightarrow{T>800^\circ C} MgO + SO_2 + \frac{1}{2}O_2$	(S) $d\pi - p\pi$ bond(s)
	(T) Planar covalent species is formed

4.

Column-I (Compounds)	**Column-II (Characteristics)**
(A) H_4SiO_4	(P) Back bond
(B) H_2SeO_4	(Q) Intermolecular hydrogen bond
(C) H_3BO_3	(R) Hypovalent compound
(D) H_2NBF_2	(S) Proton donor acid
	(T) Hypervalent compound

5.

Column-I (Characteristics)	**Column-II (Species)**
(A) The distribution of *s*-character in hybrid orbitals of central atom is not equal and all bond lengths (CA—X) are equivalent	(P) $(CH_3)_2O$
(B) The distribution of *s*-character in hybrid orbitals of central atom is equal and all bond lengths (CA—*X*) are equivalent	(Q) NH_3

(C) The distribution of *s*-character in hybrid orbitals of central atom is not equal and bond angle (*X*—CA—*X*) is greater than 109°28'	(R) PBr_4^+
(D) The distribution of s-character in hybrid orbitals of central atom is equal and bond angle (*X*—CA—*X*) is either equal or less than 109°28'	(S) H_2O
	(T) XeO_6^{4-}

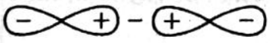
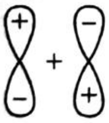
6.

Column-I	Column-II
(A) NH_2BF_2	(P) Six-atoms are in same plane
(B) Be_2Cl_4	(Q) Polar ($\mu \neq 0$)
(C) CH_2SF_4	(R) Non-planar
(D) IF_7	(S) All 'CA—*X*' (*X*= halogen) bond lengths are identical
	(T) All surrounding atoms contain non-bonding electron pair (lone pair)

7.

Column-I	Column-II
(A) $Re_2Cl_8^{2-}$	(P) $p\pi$ - $p\pi$ bonding
(B) NO_3^-	(Q) $p\pi$ - $d\pi$ bonding
(C) SO_4^{2-}	(R) $d\pi$ - $d\pi$ bonding
(D) SO_3	(S) δ-bonding

8.

Column-I	Column-II
(A) 	(P) Resulting H. O. M. O. of O_2 molecule
(B) 	(Q) Resulting H. O. M. O. of C_2 molecule
(C) 	(R) Resulting molecular orbital having one nodal plane
	(S) Resulting M. O. having lower energy than participating atomic orbitals

9.

Column-I (Species)	Column-II (Characteristics)
(A) XeF_5^-	(P) Non-polar and planar
(B) MnO_4^-	(Q) Species having equal bond angle and bond length
(C) $\dot{C}H_3$	(R) Both axial *d*-orbitals are involved in hybridisation

(D) I_2Cl_6	(S) All non-axial *d*-orbitals are involved in hybridisation

10.

Column-I (Axial/sideways combination of appropriate/ inappropriate pure orbitals)	**Column-II (Types of molecular orbital)**
(A) $p + p$ pure orbitals	(P) σ - bonding molecular orbital
(B) $s + p$ pure orbitals	(Q) π - anti-bonding molecular orbital
(C) (non-axial) $d + p$ pure orbitals	(R) σ - anti-bonding molecular orbital
(D) (axial) $d + p$ pure orbitals	(S) π - bonding molecular orbital
	(T) Non- bonding molecular orbital

11.

Column-I (Oxyacids)	**Column-II (Oxidation state of S-atom)**
(A) $H_2S_4O_6$	(P) +6
(B) $H_2S_2O_3$	(Q) +5
(C) H_2SO_5	(R) 0
(D) $H_2S_2O_5$	(S) −2
	(T) +3

12.

Column-I	**Column-II**
(A) NH_4Cl	(P) Hydrogen bond
(B) $CuSO_4 \cdot 5H_2O$	(Q) Co-ordinate bond
(C) HNC	(R) Ionic bond
(D) Liquid H_2O_2	(S) Covalent bond

13.

Column-I	**Column-II**
(A) $B_3N_3H_6$	(P) Planar geometry
(B) S_2Cl_2	(Q) Non-planar geometry
(C) B_2H_6	(R) No lone pair
(D) I_2Cl_6	(S) Non-polar molecule

14.

Column-I (Pair of species)	**Column-II (Identical Property in pairs of species)**
(A) PCl_3F_2, PCl_2F_3	(P) Hybridisation of central atom
(B) BF_3 and BCl_3	(Q) Shape of molecule/ion
(C) CO_2 and CN_2^{-2}	(R) μ (dipole moment)
(D) C_6H_6 and $B_3N_3H_6$	(S) Total number of electrons

15.

Column-I (Decreasing order)	**Column-II (Physical properties)**
(A) NH_3, SbH_3, AsH_3, PH_3	(P) Bond dipole moment
(B) HI, HBr, HCl, HF	(Q) Reducing property
(C) $SnH_4, GeH_4, SiH_4, CH_4$	(R) Enthalpy of fusion
(D) H_2O, H_2Te, H_2Se, H_2S	(S) Boiling point

16.

Column-I (Species)	**Column-II (Bond angle)**
(A) NO_2^+	(P) 180°
(B) NO_2^-	(Q) 120°
(C) NO_2	(R) 134°
(D) NO_3^-	(S) 115°
	(T) 109°

ASSERTION-REASON TYPE QUESTIONS

These questions consist of two statements each, printed as assertion and reason, while answering these questions you are required to choose any one of the following responses.

(A) If assertion is true but the reason is false
(B) If assertion is false but reason is true
(C) If both assertion and reason are true and the reason is the correct explanation of assertion
(D) If both assertion and reason are true but reason is not the correct explanation of assertion

1. Assertion : C_3O_2 is non-planar molecule.
Reason : Terminal π-bonds of the molecule are lying in different planes.

2. Assertion : If $d_{x^2-y^2}$ and p_y-orbital come close together along z-axis, then they can form π-bond by sideways overlapping.
Reason : Both orbitals do not have electron density along z-axis.

3. Assertion : BF_3 undergoes in partial hydrolysis.
Reason : Due to strong back bondig in BF_3 only two fluoride groups have come out on nucleophilic attack by H_2O.

4. Assertion : The central carbon atom in $F_2C=C=CF_2$ and both carbon atoms in $F_2B-C\equiv C-BF_2$ are *sp*-hybridized.
Reason : Both molecules are planar.

5. Assertion : Formation of PH_4^+ ion is relatively difficult in comparison to NH_4^+ ion.
Reason : Lone pair of phosphorus atom in PH_3 resides in stereochemically inactive pure *s*-orbital.

6. Assertion : Bond dissociation energy of $B-F$ bond in BF_3 molecule is lower than $C-F$ bond in CF_4 molecule.
Reason : Atomic size of B-atom is larger than that of C-atom.

7. **Assertion** : PF_3 is stronger Lewis base than PH_3.

Reason : l.p. of P-atom in PF_3 molecule is present in sp^3-hybrid orbital, whereas l.p. of P-atom in PH_3 is present in almost pure s-orbital.

8. **Assertion** : NiO is less basic than CaO.

Reason : Ni^{2+} is pseudo noble gas configuration cation whereas Ca^{2+} is noble gas configuration cation.

9. **Assertion** : When two gaseous OF molecules are allowed to cool, then they undergo dimerisation through O-atom.

Reason : Dimer-form of OF molecule (*i.e.*, O_2F_2) is having one peroxy linkage in its structure.

10. **Assertion** : Bond dissociation energy of N—F bond in NF_3 molecule is lower than that of in NCl_3 molecule.

Reason : Interelectronic repulsion exists between small size N and F atoms in N—F bond of NF_3 molecule.

11. **Assertion** : If $d_{x^2-y^2}$ and p_y orbitals come close together along z-axis, they can form π-bond by sideways overlapping.

Reason : Both orbitals do not have electron density along z-axis.

12. **Assertion** : HOF bond angle is higher than HOCl.

Reason : Oxygen is more electronegative than chlorine.

13. **Assertion** : NaCl is more ionic than NaI.

Reason : Chlorine is more electronegative than iodine.

14. **Assertion** : PbI_4 doesn't exist and converts into PbI_2 and I_2 spontaneously at room temperature but $PbCl_4$ needs heating to convert into $PbCl_2$ and Cl_2.

Reason : Pb^{2+} is more stable than Pb^{4+} due to inert pair effect.

15. **Assertion** : Dipole moment of NF_3 is less than that of NH_3.

Reason : Polarity of N—F bond is less than that of N—H bond.

16. **Assertion** : Solubility of *n*-alcohol in water decreases with increase in molecular weight.

Reason : The hydrophobic nature of alkyl chain increase.

17. **Assertion** : The unpaired electron of $\dot{C}H_3$ free radical occupies *p*-orbital.

Reason : $\dot{C}H_3$ possesses sp^2 hybridization.

18. **Assertion** : Nitrogen is inactive at room temperature but becomes reactive at elevated temperature (on heating or in the presence of catalyst).

Reason : In nitrogen molecule, there is delocalization of electrons.

19. **Assertion** : The *p*-isomer of dichlorobenzene has higher melting point than *o*- and *m*-isomer.

Reason : *p*- isomer is symmetrical and thus shows more closely packed structure.

20. **Assertion** : Na_2SO_4 is soluble in water while $BaSO_4$ is water insoluble.

Reason : Lattice energy of $BaSO_4$ exceeds its hydration energy.

21. **Assertion** : N_2 and NO^+ both are diamagnetic substances.

Reason : NO^+ is isoelectronic with N_2.

22. Assertion : Bond order can assume any value including zero.
Reason : Higher the bond order, shorter is the bond length and greater is the bond energy.

23. Assertion : C_3O_2 has linear structures.
Reason : Each C atom in C_3O_2 is *sp*-hybridised.

24. Assertion : H bonding occurs in H_2O due to larger size of O-atom.
Reason : The size of O- atom is larger than H atom.

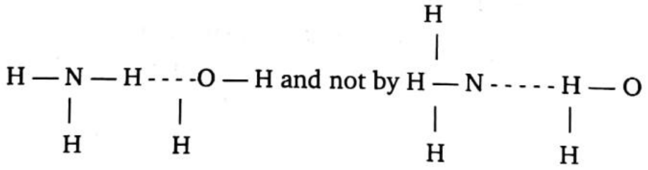
25. Assertion : $(CH_3)_3N$ geometry is pyramidal but in case $(SiH_3)_3N$ it is planar.
Reason : The maximum covalency of Si is six but that of C is four.

26. Assertion : Superoxides of alkali metals are paramagnetic.
Reason : Superoxides contain the ion O_2^- which has one unpaired electron in its anti-bonding molecular orbital.

27. Assertion : The HF_2^- ion exists in the solid state & also in liquid state but not in aqueous state.
Reason : The magnitude of hydrogen bonds among HF molecules is weaker than that in between HF and H_2O.

28. Assertion : If $d_{x^2-y^2}$ and p_y-orbitals come close together along *z*-axis, then they can form π -bond by sideways overlapping.
Reason : Both orbitals do not have electron density along *z*-axis.

29. Assertion : The H-bond present in NH_3 dissolved in water is best represented by :



$$\mathrm{H-\underset{\displaystyle H}{\underset{|}{N}}-H\cdots\cdots\underset{\displaystyle H}{\underset{|}{O}}-H} \text{ and not by } \mathrm{H-\overset{\displaystyle H}{\overset{|}{\underset{\displaystyle H}{\underset{|}{N}}}}\cdots\cdots\underset{\displaystyle H}{\underset{|}{H}}-O}$$

Reason : The O—H bond polarity is more compared to that of N—H bond.

SUBJECTIVE PROBLEMS

1. There are two groups of compounds *A* and *B*. Group *A* contains three compounds Px_4, Qy_3, Rz_2. Group *B* also contains three compounds Sx_4, Ty_3, Uz_2. Hybridization of each central atom of group *A* compounds is same as that of iodine in $IBrCl^-$ while in group *B* compounds it is same as that of iodine in $IBrCl^+$. Substituents *X*, *Y* and *Z* exhibit covalency of one in ground state. Then find the value of *x/y*.

   Where, *x* and *y* are total number of lone pairs present at central atoms of compounds of group *A* and *B* respectively.

2. Consider the following three compounds (i) AX_{2n}^{n-}, (ii) AX_{3n} and (iii) AX_{4n}^{n+}, where central atom *A* is 15th group element and their maximum covalency is 3*n*. If total number of proton in surrounding atom *X* is *n* and value of *n* is one, then calculate value of "$x^3 + y^2 + z$". (Where *x*, *y* and *z* are total number of lone pair at central atom in compound (i), (ii) and (iii) respectively.

3. Consider the following combination of atomic orbitals :

Combinding orbitals (internuclear axis)	Combinding orbitals (Internuclear axis)
(i) $s+p_x(x)$	(ii) $d_{xy}+d_{xy}(x)$
(iii) $d_{yz}+p_z(z)$	(vi) $s+s(z)$
(v) $d_{yz}+d_{yz}(x)$	(iv) $p_y+p_y(y)$
(vii) $d_{z^2}+d_{z^2}(z)$	(viii) $d_{xy}+d_{xy}(z)$
(ix) $p_x+p_x(y)$	(x) $s+p_z(x)$

Then calculate value of "a^2+b^2+2cd". (where $a=\sigma$ M.O.; $b=\pi$ M.O.; $c=\delta$ M.O.; d = non-bonding M.O.)

4. Consider the following six changes

(i) $NO \longrightarrow NO^+$ (ii) $O_2^- \longrightarrow O_2^{2-}$ (iii) $O_2 \longrightarrow O_2^+$ (iv) $NO^+ \longrightarrow NO^-$

(v) $NO^+ \longrightarrow NO^{2+}$ (vi) $CO \longrightarrow CO^+$

Then calculate value of "c^3-b^2-a", where a, b and c are total number of transformations in which magnetic property will be changed, bond order increases and bond order decreases respectively.

5. When B_2H_6 is allowed to react with following Lewis bases, then how many given Lewis bases form adduct through symmetrical cleavage of B_2H_6?

NH_3, $MeNH_2$, Pyridine, CO, T.H.F., PH_3, PF_3, Me_3N, Me_2NH

6. Consider the following elements *A*, *B*, *C* and *D* and their outer electronic configurations are $ns^2np^1, ns^2np^3, ns^2np^4$ and ns^2np^5 respectively. Element *E* also has same outer electronic configuration like *D* but shows only single oxidation state (–1). If element *A*, *B*, *C* and *D* belong to same period as that of sodium. Consider the following compounds.

(i) CE_4 (ii) BD_2E_3 (iii) DE_3 (iv) CE_2

(v) BD_3E_2 (vi) C_2E_2 (vii) DE (viii) A_2D_6

Then calculate the value of "$x \div y$", (where x and y are total number of polar and non-polar compounds).

7. Consider following four compounds :

(a) C_xO_y (b) C_xO_{y+1}

(c) $C_{x+2}O_{y+1}$ and (d) $C_{z+11}O_{y+8}$

If "$x=y=1$", then calculate the value of $|p-q|$, where p and q are total number of sp^2 and sp-hybridized carbon atoms respectively in given four compounds :

8. Total number of species among following which can use any one t_{2g} d-orbital in back bonding.

H_4SiO_4, H_2NBF_2, $O(SiH_3)_2$, $\overset{\uparrow\downarrow}{C}Cl_2$, $N(SiH_3)_3$, $(BN)_x$, R_3PO, P_4O_{10}, CCl_3^-

9. Calculate expression $(x+y+z)$ for diatomic molecules.

Where x = Total number of singly occupied molecular orbital (SOMO) in O_2

y = Total number of singly occupied molecular orbital (SOMO) in B_2

z = Total number of singly occupied molecular orbital (SOMO) in NO

10. If Hund rule violats, then find the total number of species among following which will be diamagnetic :

B_2, O_2, N_2^-, C_2, NO, OF, N_2^{2-}, BN

11. Consider the following table

Compounds (*X* are monovalent surrounding atoms)		**Central atoms(*A* to *D*) belong to group**	**Characteristics of compounds**	**Number of lone pair(s) at central atom**
(i)	AX_{n_1}	16	Planar and polar	m_1
(ii)	BX_{n_2}	15	Trigonal pyramidal	m_2
(iii)	CX_{n_3}	14	Zero dipole moment	m_3
(iv)	DX_{n_4}	13	All $X — D — X$ bond angle are 120°	m_4

Than calculate value of expression $\left|\dfrac{n_1+n_2+n_3+n_4}{m_1+m_2+m_3+m_4}\right|^2$

12. Total number of species among following, in which bond angle is equal to or less than 109°28' and also they act as lewis base :

NH_3, NMe_3, $O(SiH_3)_2$, ICl_4^-, XeO_3, BF_2Cl, SiF_4, AsH_3, SO_2F_2

13. Total number of unpaired electron(s) present in both cationic and anionic part of compound $O_2[PtF_6]$.

14. Total number of species which has/have symmetrical electronic distribution in their HOMO and also paramagnetic.

N_2^+, O_2^{2-}, C_2, O_2, B_2, C_2^{2-}, N_2^{2-}

15. Total number of molecules, in which each covalent bond is comprised of effective back bond.
BF_3, $N(SiH_3)_3$, PF_3, POF_3, $B(OH)_3$, $O(SiH_3)_2$, $NH(SiH_3)_2$, BFH_2, $BF_2(NH_2)$

16. Total number of angle in $SeCl_4$ which are less than 90°.

17. Consider the following species

$O(Me)_2$, $N(SiH_3)_3$, CO, $O(SiH_3)_2$, CCl_2(Singlet), CCl_3^-, H_4SiO_4, OCl_2, MeNCS

Then calculate total number of species which have $(p_\pi - p_\pi)$ back bond or $(p_\pi - d_\pi)$ back bond.

18. Total number of molecules which can form H-bond among themselves.
SiH_3OH, HCN, $B(OMe)_3$, $NHMe_2$, CH_3CONH_2, HCHO, HCOOH, NH_2OH, H_4SiO_4

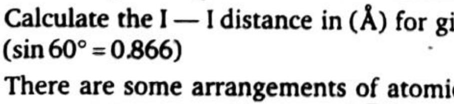
19. Consider two covalent compounds AL_{n_1} and BL_{n_2}, if central atom (A) of first compounds has total six electron pairs and central atom (B) of second compound contains total five electron pairs in its valence shell and both compounds are planar and non-polar then calculate value of expression $(n_1 - n_2)^2$.

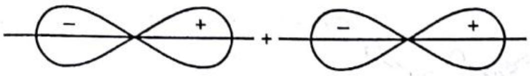
[where n_1 and n_2 are number of monovalent surrounding atom (L)]

20. Calculate the I — I distance in (Å) for given compound H_2CCl_2 if C — I bond length is 2.35 Å. ($\sin 60° = 0.866$)

21. There are some arrangements of atomic orbitals which are given below :

(i)



(ii)


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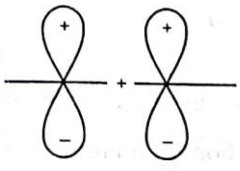

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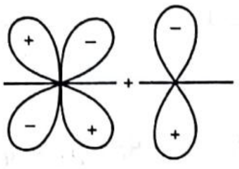

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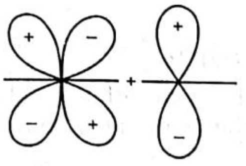
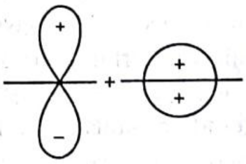


(vi)


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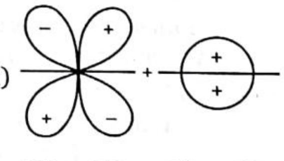
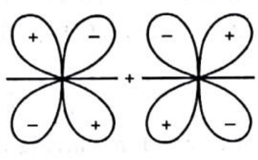
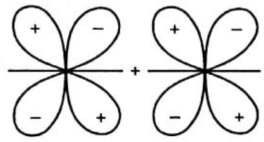


(viii)


(ix)


Then calculate the value of "$Q \times R - P$" where, P, Q and R are no. of arrangements which give bonding molecular orbitals (positive overlap), antibonding molecular orbitals (negative overlap) and non-bonding molecular orbitals (zero overlap) respectively.

22. Number of hybrid orbital C atoms which have 33% p character in $C(CN)_4$.

23. Max. no. of equal P — O bonds in $P_2O_7^{4-}$ ion is :

24. Consider the following species :

(i) CH_3^+ (ii) $(CH_3)_3Al$ (iii) HCHO (iv) CH_4

(v) $(C_2H_5)_3N$ (vi) $TiCl_4$ (vii) CO_2 (viii) $SiCl_4$

(ix) BF_3

Then find out total number of species which can act as Lewis acid.

25. Calculate value of $|x - y|$, here x and y are the total number of bonds in benzene and benzyne respectively which are formed by overlapping of hybridized orbitals.

26. Consider the following compounds:

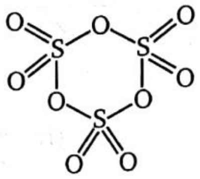
(i) IF_5 (ii) ClI_4^- (iii) XeO_2F_2 (iv) NH_2^-

(v) BCl_3 (vi) $BeCl_2$ (vii) $AsCl_4^+$ (viii) $B(OH)_3$

(ix) NO_2^- (x) ClO_2^+

Then, calculate value of "$x + y - z$", here x, y and z are total number of compounds in given compounds in which central atom used their all three p-orbitals, only two p-orbitals and only one p-orbital in hybridisation respectively :

27. Consider the following molecule



Calculate value of $p \div q$, here p and q are total number of $d\pi$-$p\pi$ bonds and total number of sp^3 hybridised atoms respectively in given molecule.

28. Consider the following orbitals (i) $3p_x$ (ii) $4d_{z^2}$ (iii) $3d_{x^2-y^2}$ (iv) $3d_{yz}$
Then, calculate value of "$x + y - z$" here x is total number of gerade orbital and y is total number of ungerade orbitals and z is total number of axial orbitals in given above orbitals.

29. Consider the following oxyanions :
$PO_4^{3-}, P_2O_6^{4-}, SO_4^{2-}, MnO_4^{-}, CrO_4^{2-}, S_2O_5^{2-}, S_2O_7^{2-}$
and find the value of $R + Q - P$
Where
P = Number of oxy anions having three equivalent X—O bonds per central atom
Q = Number of oxy anions having two equivalent X—O bonds per central atom
R = Number of oxy anions having four equivalent X—O bonds per central atom

30. Consider the following three compounds (i) AX_{2n}^{n-}, (ii) AX_{3n} and (iii) AX_{4n}^{n+}, where central atom A is 15th group element and their maximum covalency is $3n$. If total number of proton in surrounding atom X is n and value of n is one, then calculate value of "$x^3 + y^2 + z$". (Where x, y and z are total number of lone pair at central atom in compound (i), (ii) and (iii) respectively).

31. Consider the following compounds and Calculate value of $\left(\dfrac{P^2 - Q^2}{R + S}\right)$.

(i) BrF (ii) ICl (iii) BrF_3 (iv) BrF_5
(v) ICl_3 (vi) IF_3 (vii) IF_5 (viii) IF_7,

Where P : Total number of polar compounds,
Q : Total number of planar compounds
R : Total number of non-polar compounds
S : Total number of non-planar compounds

32. Consider the following compounds
(1) H_3CF (2) H_2CF_2 (3) CH_4
(4) H_3CCF_3 (5) $CH_3\overset{+}{C}H_2$ (6) C_2H_4
and calculate value of $Y \div X$, (Where X is the total number of compounds which have H—C—H bond angles equal to 109°28′ and Y is the total number of compounds which have H—C—H bond angles greater than 109°28′ and less than 120°)

33. There are some species given below.

(i) O_2^+ (ii) CO (iii) B_2 (iv) O_2^-
(v) NO^+ (vi) He_2^+ (vii) C_2^{2+} (viii) CN^-
(ix) N_2^-

Total number of species which have their fractional bond order.

34. Following compounds *A* and *B* have similar structure with delocalization of π-electron system.

(A) $(PNCl_2)_{x/2}$ (B) $(CH)_x$

If value of *x* is 6, then calculate value of "$P \div Q$", where '*P*' is total no. of σ -bonds in compound *A* and *B* and '*Q*' is total no. of π bond in compound *A* and *B*.

35. The hybridization of central atoms of compounds *A*,*B*,*C* and *D* are sp^3d, sp^3, sp^2 and *sp* respectively. If compounds *A* and *D* have same shape like I_3^- and compounds *B* and *C* have same shape like water molecule. Then calculate value of "$P + Q + R + S$", where *P*,*Q*,*R* and *S* are number of lone pairs on central atoms of compounds *A*,*B*,*C* and *D* respectively.

36. In compound PCl_xF_{5-x}, possible values of *x* are 0 to 5, then calculate value of $x_1 + x_2 + x_3$ (where x_1, x_2 and x_3...... are possible values of *x*, with zero dipole moment for given compound).

ANSWERS

Level 1

1. (d)	**2.** (c)	**3.** (d)	**4.** (b)	**5.** (c)	**6.** (b)	**7.** (d)	**8.** (a)	**9.** (c)	**10.** (d)
11. (c)	**12.** (b)	**13.** (b)	**14.** (b)	**15.** (a)	**16.** (b)	**17.** (b)	**18.** (a)	**19.** (c)	**20.** (d)
21. (d)	**22.** (a)	**23.** (d)	**24.** (b)	**25.** (b)	**26.** (a)	**27.** (b)	**28.** (d)	**29.** (b)	**30.** (b)
31. (b)	**32.** (c)	**33.** (c)	**34.** (c)	**35.** (b)	**36.** (c)	**37.** (b)	**38.** (c)	**39.** (d)	**40.** (b)
41. (c)	**42.** (d)	**43.** (d)	**44.** (c)	**45.** (b)	**46.** (d)	**47.** (d)	**48.** (b)	**49.** (b)	**50.** (a)
51. (b)	**52.** (c)	**53.** (c)	**54.** (b)	**55.** (a)	**56.** (a)	**57.** (c)	**58.** (d)	**59.** (d)	**60.** (a)
61. (c)	**62.** (b)	**63.** (c)	**64.** (c)						

Level 2

1. (b)	**2.** (a)	**3.** (d)	**4.** (a)	**5.** (d)	**6.** (d)	**7.** (b)	**8.** (b)	**9.** (b)	**10.** (b)
11. (a)	**12.** (d)	**13.** (c)	**14.** (d)	**15.** (b)	**16.** (b)	**17.** (c)	**18.** (b)	**19.** (a)	**20.** (c)
21. (a)	**22.** (a)	**23.** (d)	**24.** (b)	**25.** (c)	**26.** (b)	**27.** (c)	**28.** (a)	**29.** (b)	**30.** (a)
31. (c)	**32.** (b)	**33.** (b)	**34.** (d)	**35.** (c,d)	**36.** (d)	**37.** (b)	**38.** (d)	**39.** (d)	**40.** (c)
41. (d)	**42.** (b)	**43.** (d)	**44.** (b)	**45.** (c)	**46.** (c)	**47.** (d)	**48.** (d)	**49.** (d)	**50.** (d)
51. (a)	**52.** (d)	**53.** (a)	**54.** (b)	**55.** (d)	**56.** (c)	**57.** (a)	**58.** (a)	**59.** (b)	**60.** (d)
61. (d)	**62.** (a)	**63.** (b)	**64.** (d)	**65.** (b)	**66.** (a)	**67.** (b)	**68.** (c)	**69.** (d)	**70.** (d)
71. (a)	**72.** (b)	**73.** (d)	**74.** (a)	**75.** (a)	**76.** (c)	**77.** (c)	**78.** (c)		

Level 3

Passage-1	**1.** (b)	**2.** (c)	**3.** (d)					
Passage-2	**1.** (b)	**2.** (d)						
Passage-3	**1.** (d)	**2.** (d)	**3.** (a)					
Passage-4	**1.** (c)	**2.** (c)	**3.** (c)					
Passage-5	**1.** (d)	**2.** (b)	**3.** (d)					
Passage-6	**1.** (d)	**2.** (d)	**3.** (d)					
Passage-7	**1.** (b)	**2.** (a)						
Passage-8	**1.** (c)	**2.** (d)	**3.** (b)					
Passage-9	**1.** (c)	**2.** (d)	**3.** (a)					
Passage-10	**1.** (b)	**2.** (b)	**3.** (a)					
Passage-11	**1.** (c)	**2.** (d)	**3.** (a)	**4.** (b)	**5.** (a)	**6.** (c)	**7.** (b)	**8.** (c)

Passage–12 1. (d) 2. (c) 3. (c) 4. (c) 5. (b)
Passage–13 1. (a) 2. (d) 3. (c)
Passage–14 1. (c) 2. (d) 3. (d)

One or More Answers is/are correct

1. (a,b,c) **2.** (a,b,d) **3.** (a,b,c,d) **4.** (b,c,d) **5.** (a,b,d) **6.** (a,b)
7. (a,d) **8.** (b,c) **9.** (b,d) **10.** (a,b,c,d) **11.** (a,b,d) **12.** (c,d)
13. (a,b,c,d) **14.** (a,b,c,d) **15.** (a,b) **16.** (a,c) **17.** (a,b,c) **18.** (a,b,d)
19. (a,d) **20.** (a,b,d) **21.** (a,d) **22.** (a,c,d) **23.** (a,b,c) **24.** (a,c,d)
25. (c,d) **26.** (a,c,d) **27.** (a,b) **28.** (a,c,d) **29.** (a,b,c,d) **30.** (a,b,c,d)
31. (b,c,d) **32.** (a,b,c,d) **33.** (a,c) **34.** (a,c) **35.** (b,d) **36.** (b,d)
37. (a,c,d) **38.** (b,d) **39.** (a,b,c) **40.** (b,c,d) **41.** (b,c,d) **42.** (a,d)

Match the Column

1. A→ Q, R, S; B→ P, Q, T; C→ P, R, T; D→ P, T
2. A→ Q, S; B→ P, T; C→ R, S; D→ P, R, T
3. A→ P, Q, R, T; B→ R; C→ R, S; D→ P, R, S, T
4. A→ P, Q, S; B→ Q, S, T; C→ P, Q, R; D→ P, Q, R
5. A→ P, Q, S; B→ R, T; C→ P; D→ R, T
6. A→ Q, R, S; B→ P, T; C→ P, Q, R; D→ P, R, T
7. A→ R, S; B→ P; C→ Q; D→ P, Q
8. A→ R; B→ S; C→ P
9. A→ P, Q, R; B→ Q, S; C→ P, Q; D→ P, R
10. A→ P, Q, R, S, T; B→ P, R, T; C→ Q, S, T; D→ P, R, T
11. A→ Q, R; B→ P, S; C→ P; D→ Q, T
12. A→ Q, R, S; B→ P, Q, R, S; C→P, S; D→ P, S
13. A→ P, R, S; B→ Q; C→ Q, R, S; D→ P, S
14. A→ P,Q; B→ P, Q, R; C→ P, Q, R, S; D→ P, Q, R, S
15. A→ P, R; B→ Q; C→ P, Q,R,S; D→ P, R, S
16. A→ P; B→ S; C→ R; D→ Q

Assertion-Reason Type Questions

1. (B) **2.** (B) **3.** (A) **4.** (A) **5.** (C) **6.** (B) **7.** (B) **8.** (A) **9.** (A) **10.** (B)
11. (B) **12.** (B) **13.** (D) **14.** (D) **15.** (A) **16.** (C) **17.** (C) **18.** (A) **19.** (C) **20.** (C)
21. (D) **22.** (D) **23.** (C) **24.** (B) **25.** (A) **26.** (C) **27.** (C) **28.** (B) **29.** (B)

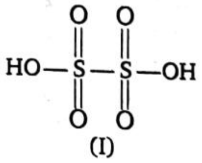
Subjective Problems

1. 2 **2.** 9 **3.** 28 **4.** 13 **5.** 6 **6.** 3 **7.** 7
8. 6 **9.** 5 **10.** 5 **11.** 16 **12.** 4 **13.** 2 **14.** 4
15. 3 **16.** 4 **17.** 7 **18.** 7 **19.** 4 **20.** 4 **21.** 2
22. 0 **23.** 6 **24.** 7 **25.** 1 **26.** 8 **27.** 1 **28.** 1
29. 2 **30.** 9 **31.** 6 **32.** 5 **33.** 4 **34.** 4 **35.** 6
36. 8

Hints and Solutions

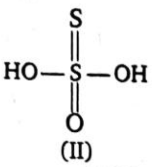
Level 1

2. (c)



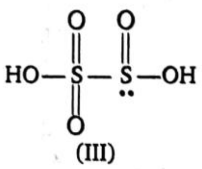
$HO-S(=O)_2-S(=O)_2-OH$

(I)



$HO-S(=S)(=O)-OH$

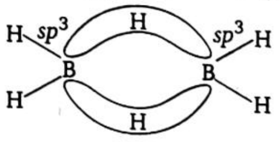
(II)



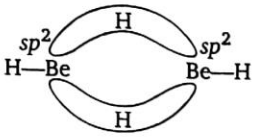
$HO-S(=O)_2-\ddot{S}-OH$

(III)

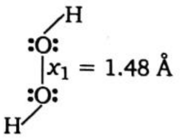
13. (b) $2BH_3 \rightarrow B_2H_6$

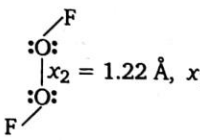


$2BeH_2 \rightarrow Be_2H_4$



16. (b)

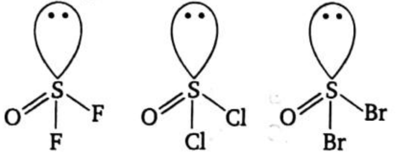




$x_1 > x_2$

According to Bent's Rule in O_2F_2, there is more *p*-character in O—F bond in comparison to O—H bond in H_2O_2; hence *s*-character in O—O bond is greater in O_2F_2.

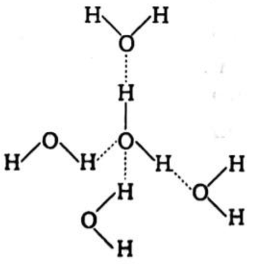
17. (b)



According to Bent's Rule

22. (a) Compound (B) exhibits intramolecular H-bonding has more vapour pressure than compound (A) involved in intermolecular H-bonding.

28. (d)



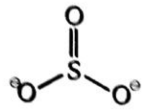
41. (c) Although both hydration and lattice energies of alkali metal fluorides decrease down the group and hydration energy dominates over lattice energy, therefore, solubility increases down the group.

44. (c) Only in BF_3 $p\pi$-$p\pi$ back bonding is possible due to which B—F bond length is shortest. In other compounds, p-orbital at boron is not vacant hence, $p\pi$-$p\pi$ back bonding is not possible.

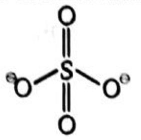
Water molecules are hexagonally closed packed in ice with the help of H-bonds, hence due to existance of voids/interstitial spaces it has cage like structure with less density than water.

49. (b) As electronegativity difference of bond increases, polar character also increases.

51. (b)



$\text{B.O.} = \frac{4}{3} = 1.33$

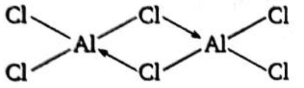


$\text{B.O.} = \frac{6}{4} = 1.5$

$$\left[\text{B.L.} \propto \frac{1}{\text{B.O.}}\right]$$

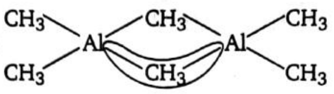
$$\therefore \quad SO_3^{2-} > SO_4^{2-} > \underbrace{SO_2 > SO_3}_{\text{Bent's Rule}}$$

63. (c) (i)



(complete octet)

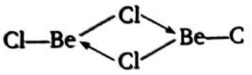
(ii)



(3c-2e) bond
(incomplete octet)

(iii) AlF_3 (ionic compound) $\longrightarrow$ Al^{3+} $2s^22p^6$ (octet complete) + $3F^-$ $2s^22p^6$ (octet complete)

(iv)



(Incomplete octet)

(Incomplete octet)

(v)

(Incomplete octet)

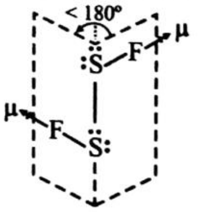
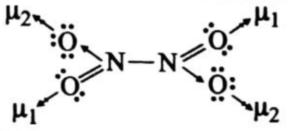
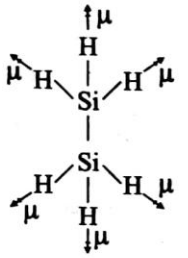
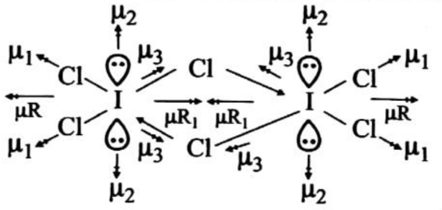
$(3c - 2e^-)$ bond

64. (c) Cl—Hg—Hg—Cl

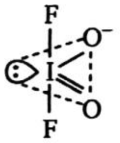
Mercurous ion is represented as Hg_2^{2+} it is evidenced by the fact that its $\mu = 0$, *i.e.*, it is diamagnetic. It is possible only when there is presence of a metal-metal bond.

Level 2

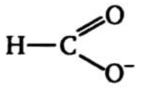
2. (a)

	Non-polar bond : S—S Polar bond : S—F $\mu_D \neq 0$
	Non-polar bond : N—N Polar bond : N—O $\mu_D = 0$
	Non-polar bond : Si—Si Polar bond : Si—H $\mu_D = 0$
	Non-polar bond : Absent Polar bond : I—Cl $\mu_D = 0$

4. (a)

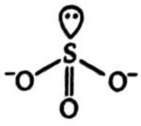


p_π-p_π bond(s) = 0
p_π-d_π bond(s) = 1
Bond order of (I—O) = 1.5



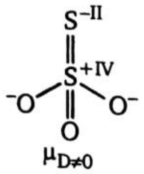
p_π-p_π bond(s) = 1
p_π-d_π bond(s) = 0
Bond order of (C—O) = 1.5

p_π-p_π bond(s) = 0
p_π-d_π bond(s) = 1
Bond order of (S—O) = 1.33

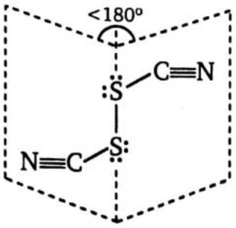


p_π-p_π bond(s) = 0
p_π-d_π bond(s) = 2
Bond order of (Xe—O) = 2.0

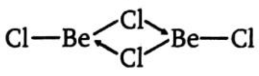
5. (d)



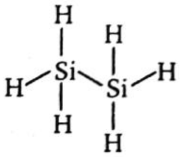
$\mu_{D\neq0}$



$\mu_{D\neq0}$

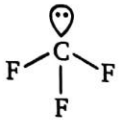


$\mu_{D=0}$
But has no non-polar bond



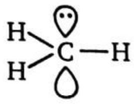
$\mu_{D=0}$

6. (d) ⇒



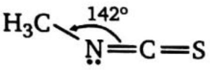
Hyb. of carbon : sp^3, hence % s-character in C—F bond ≈ 25%
→ Non-planar
→ Polar

⇒

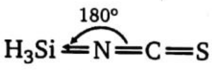


Hyb. of carbon : sp^2, hence % s-character in C—H bond ≈ 33%
→ Planar
→ Non-polar

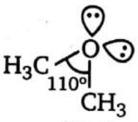
7. (b)



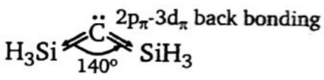
Bent



Linear



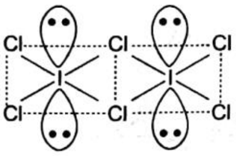
Bent



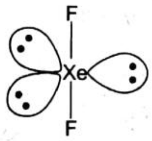
Bent

8. (b) Triplet carbene is more stable than singlet carbene.

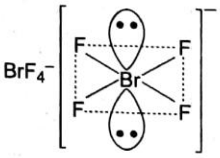
12. (d)



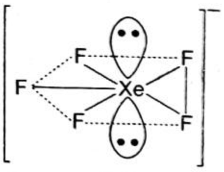
sp^3d^2
Planar



sp^3d
Linear: It is planar as three points are in same plane



sp^3d^2
square planar

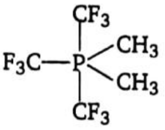


sp^3d^3
pentagonal planar

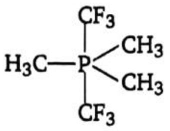
13. (c)

XeF_5^-	: 2 lone pairs	; pentagonal planar
BrF_3	: 2 lone pairs	; Bent-T-shape
XeF_2	: 3 lone pairs	; Linear
H_3S^+	: 1 lone pairs	; Pyramidal
$\overset{\uparrow\uparrow}{C}H_2$	: 2 unpaired $\bar{e}s$ (No lone pair)	; Linear

14. (d) (I)

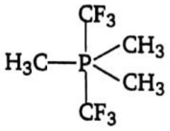


$\mu \neq 0$



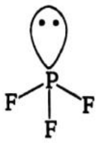
$\mu = 0$

(II)



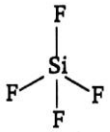
$CH_3\hat{P}CH_3$ bond angles are equal

(III)



$\mu \neq 0$

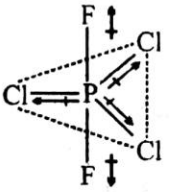
(Polar)



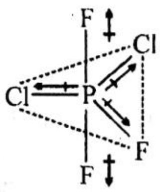
$\mu = 0$

(No Polar)

15. (b)



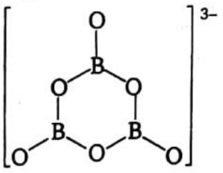
$\mu=0$



$\mu \neq 0$

In sheet silicates although one SiO_4^{4-} tetrahedron is linked to other three tetrahedrons but the layer/sheet obtained is not planar, as fourth oxygen atom is projecting away from sheet.

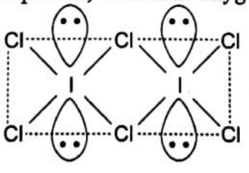
17. (c)



Planar

B : sp^2

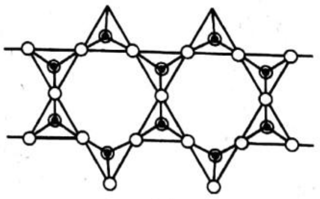
(a)



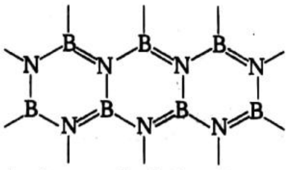
Planar

I : sp^3d^2

(b)



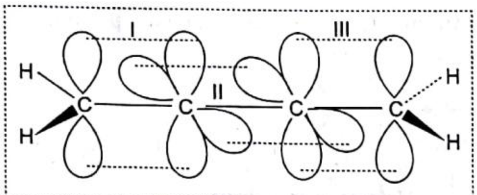
(c)



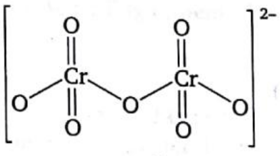
each layer is planar as both B and N are sp^2 hybridized

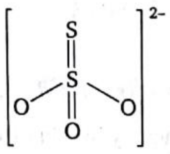
(d)

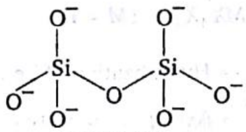
18. (b)

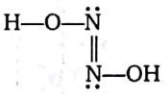


19. (a)

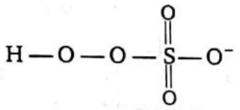

$Cr_2O_7{}^{2-}$


$S_2O_3{}^{2-}$


Pyrosilicate

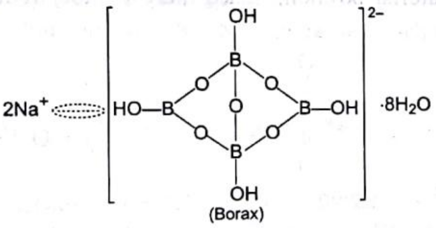

Hyponitrous acid

20. (c)

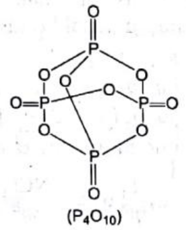

$$H-O-O-\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}-O^-$$

(HSO_5^-)

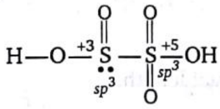
No. of B—O—B linkages = 5; No. of P—O—P linkages = 6



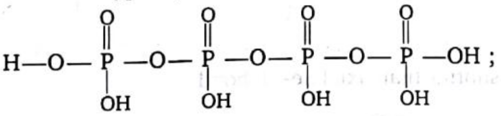
(Borax)


(P_4O_{10})

Pyrosulphurous Acid :


$$H-O\overset{+3}{-}\underset{\underset{sp^3}{\cdot\cdot}}{\overset{\overset{O}{\|}}{S}}-\underset{\underset{O}{\|}}{\overset{\overset{O}{\|}}{S}}\overset{+5}{\underset{sp^3}{-}}OH$$

Tetra Polyphosphoric Acid : $(H_6P_4O_{13})$


$$H-O-\underset{\underset{OH}{|}}{\overset{\overset{O}{\|}}{P}}-O-\underset{\underset{OH}{|}}{\overset{\overset{O}{\|}}{P}}-O-\underset{\underset{OH}{|}}{\overset{\overset{O}{\|}}{P}}-O-\underset{\underset{OH}{|}}{\overset{\overset{O}{\|}}{P}}-OH\ ;$$

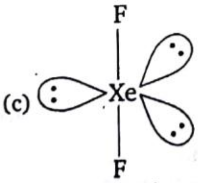
No. of P—O—P linkages = 3

23. (d)

(a) $N\equiv C-C\equiv N$ (Linear)

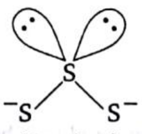
(b) $^-O-C\equiv N$ (Linear)

(c)



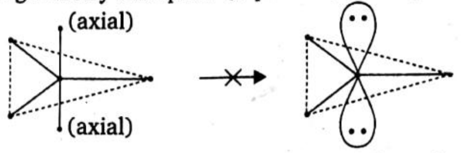
(Linear)

(d)



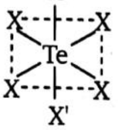
(Bent shape)

24. (b) In trigonal bipyramidal geometry lone pairs (if present) never placed at axial positions.



(Trigonal bipyramidal geometry) (Trigonal planer shape is not possible)

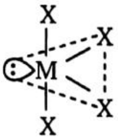
25. (c) $MX_2 + X'_2 \longrightarrow MX_4X'_2$ $(M = \text{Te})$



→ Hybridization of Te : $sp^3d^2(sp_xp_yp_zd_{x^2-y^2}d_{z^2})$

→ Axial positions are formed by hybrid orbitals.

→ All M—X bond lengths are identical.



→ Hybridization of Te : $sp^3d(\equiv sp_xp_y + p_zd_{z^2})$

→ All M — X bond lengths are not identical

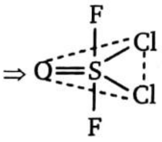
26. (b) In see-saw structure, as lone pair lies in equatorial position, hence there is more reduction in equatorial bonds than in axial bonds.

27. (c) $IO_2F_2^-$: Hyb. sp^3d, $[\equiv sp_xp_yp_zd_{z^2}]$
ClF_4^-: Hyb. sp^3d^2 $[\equiv sp_xp_yp_zd_{x^2-y^2}d_{z^2}]$
IF_7: Hyb. sp^3d^3. $[sp_xp_yp_zd_{x^2-y^2}d_{xy}d_{z^2}]$
d_{xy}: orbital has two nodal planes xz and yz

28. (a)

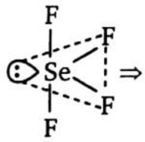
CO_3^-	XeF_4	I_3^-	NCl_3	$BeCl_2$
sp^2	sp^3d^2	sp^3d	sp^3	sp

30. (a) ⇒



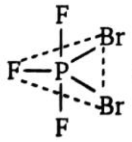
: both S—F bonds are of equal length.

⇒



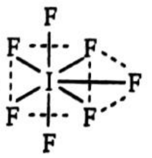
⇒ Equatorial Se—F bond is shorter than axial Se—F bond

⇒



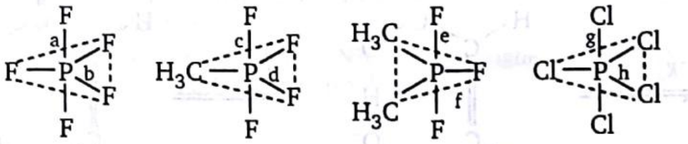
⇒ Equatorial P—F bond is shorter than axial P—F bond

⇒



⇒ **Equatorial I—F bond is longer than axial I—F bond.**

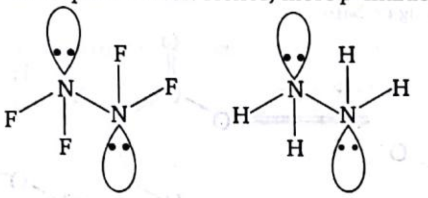
31. (c) $a = 1.577Å$ $b = 1.534Å$ $c = 1.612Å$ $d = 1.543Å$ $e = 1.643Å$
$f = 1.553Å$ $g = 2.19Å$ $h = 2.04Å$



→ According to Bent's Rule : $f > d > b$ and
$h > f$ as $r_{Cl} > r_F$
$g > e$ as $r_{Cl} > r_F$

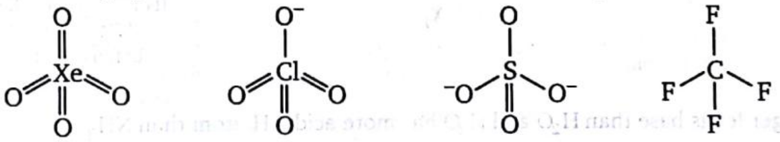
32. (b) According to Bent's Rule more electronegative substituents attached to hybrid orbital that contains more p-character. Hence, more p-character, longer will be bond length.

33. (b)



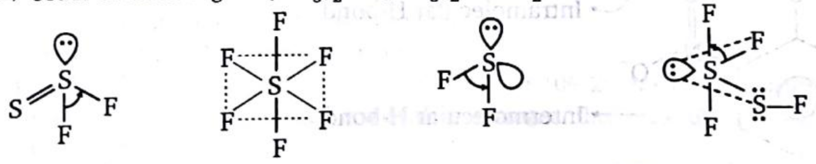
It can be explained on the basis of Bent's rule. In N_2F_4, N—N bond has more s-character hence bond length decreases.
While in N_2H_4, N—N bond has less s-character (*i.e.*, more p-character), hence bond lengths

35. (c, d)



∠OXeO = 109°28' ∠OClO = 109°28' ∠OSO = 109°28' ∠FCF = 109°28'
⇒ Order of bond angle $O(SiH_3)_2 > N(SiH_3)_2 > OMe_2$

36. (d)



∠FSF < 109°28' ∠FSF < 90° ∠FSF < 109°28' ∠FSF < 90°

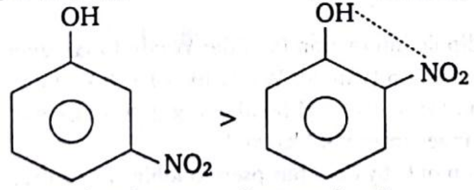
43. (d)

(a) $T_2 > D_2 > H_2$ [BP ∝ mol.wt.]

(b) n-pentane > neo-pentane [BP ∝ VWf ∝ contact area ∝ $\frac{1}{\text{Branching}}$]

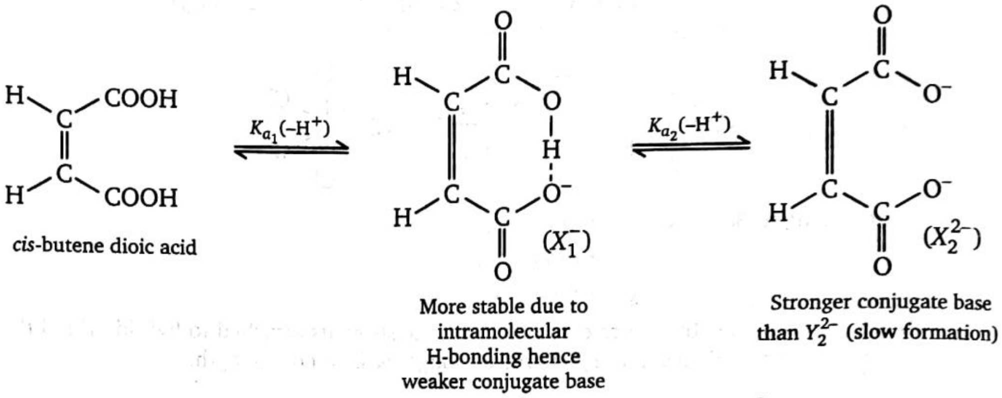
(c) Xe > Ar > He [BP ∝ mol.wt.]

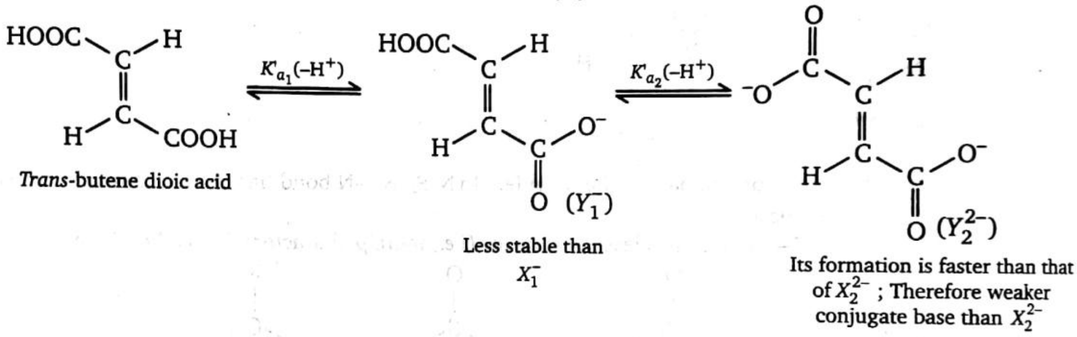
(d)



Intermolecular H-bonding Intramolecular H-bonding

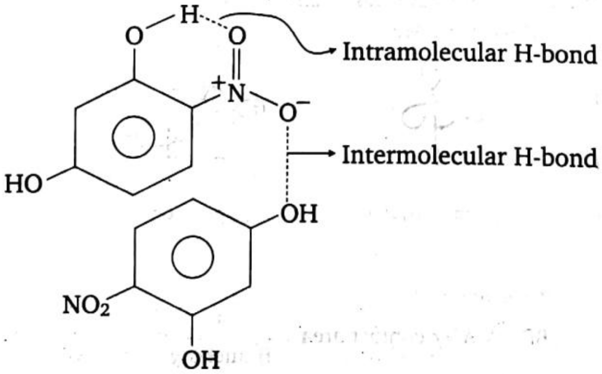
44. (b)





45. (c) NH_3 is stronger lewis base than H_2O and H_2O has more acidic H-atom than NH_3.

47. (d)



48. (d)

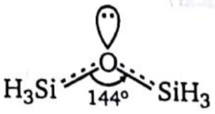
(a) $H_2.....H_2O$	Dipole-induced dipole interaction (van der Waals' force) energy < 8 kJ/mol
(b) H—Cl.....H—Cl	Dipole-dipole interaction (van der Waals' force) < 8 kJ/mol
(c) $F^-.....HF$	Ion-dipole H-bond (very strong H-bond energy) > 42 kJ/mol
(d) $HCN.....NH_3$	H-bond energy ranges from 8-42 kJ/mol

50. (d) In CdI_2, Pink colour is due to polarization of I^- by Cd^{2+} has pseudonoble gas configuration. In $CdCl_2$, extent of polarization of Cl^- by Cd^{2+} is relatively less, hence specific colour cannot be predicted.

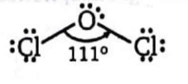
54. (b) → In $NH(SiH_3)_2$ electron density or lone pair at N-atom is involved in back bonding only with two empty 3*d*-orbitals of two silicon atoms while in $N(SiH_3)_3$ it is involved with three empty 3*d*-orbitals of three silicon atoms.

→ Strength of back bonding in $NH(SiH_3)_2$ is higher than in $N(SiH_3)_3$ hence N—Si bond length in $NH(SiH_3)_2$ is less than that of in $N(SiH_3)_3$.

55. (d)

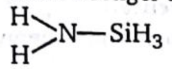


Hybridisation of O-atom : sp^2 due to more extent of $(2p_\pi\text{-}3d_\pi)$ back bonding



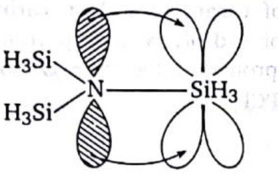
Hybridisation of O-atom remains sp^3, because of less effective $(2p_\pi\text{-}3d_\pi)$ back bonding due to *d*-orbital resonance

56. (c) More stronger the back bond, smaller will be the bond length.

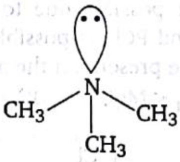


[Strongest back bond
∴ Smallest bond length]

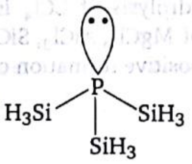
59. (b)



due pπ-pπ back bonding
Hybridisation of Nitrogen : sp^2
planar shape

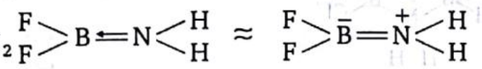


Hybridisation : sp^2
pyramidal shape



No back bonding
pyramidal shape

60. (d) BF_2NH_2



$$\begin{matrix}F\\F\end{matrix}\!>\!B \leftarrow N\!<\!\begin{matrix}H\\H\end{matrix} \approx \begin{matrix}F\\F\end{matrix}\!>\!\bar{B}=\overset{+}{N}\!<\!\begin{matrix}H\\H\end{matrix}$$

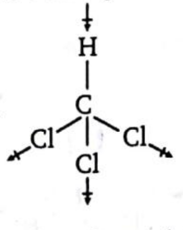
* Both boron and nitrogen are sp^2-hybridised.

* FBF bond angle < 120° (VSPER theory)

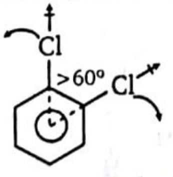
* HNH bond angle is less than 120° but greater than 109°28' due to back bonding.

* Due to presence of H-atom attached to nitrogen this molecule can exhibits intermolecular H-bonding.

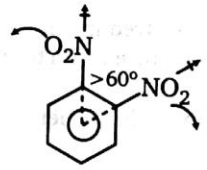
61. (d) →



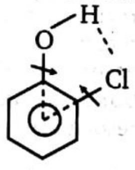
Due to steric repulsion among Cl-atoms observed ∠Cl C Cl is found to be greater than expected.



Bond angle between both C—Cl bonds is greater than 60° due to steric repulsion between both Cl-atoms, hence μ_D(observed) < μ_D (Theoretical)



Observed bond angle between both C—NO_2 bonds is found to be greater than 60° due to steric repulsion, between NO_2 groups, hence μ_D(observed) < μ_D(Theoretical)



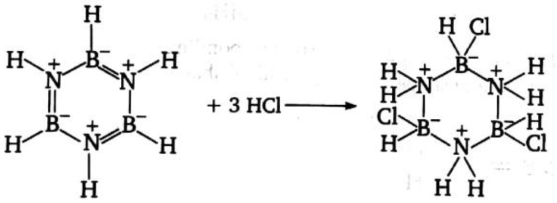
Observed bond angle between C—O and C—Cl bond is found to be less than 60° due to intramolecular H-bonding present in it, hence, μ_D(observed) > μ_D(Theoretical)

65. (b) Due to inter electronic repulation between lone pairs on both oxygen atoms bond energy of O—O bond is less.

66. (a) Aqueous hydrolysis of CCl_4 is not possible due to absence of vacant orbital on carbon, while hydrolysis of $MgCl_2$, $AlCl_3$, $SiCl_4$ and PCl_5 is possible. Extent of hydrolysis is proportional to the amount of positive formation charge present on the atomic site prone to attack of H_2O molecules.

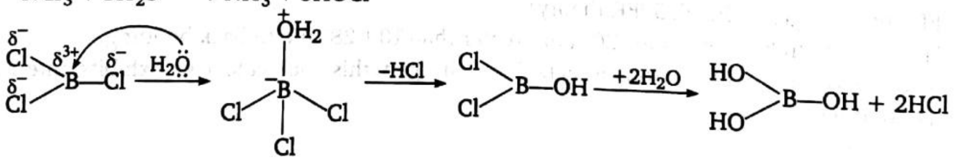
$$CCl_4 < MgCl_2 < AlCl_3 < SiCl_4 < PCl_5$$

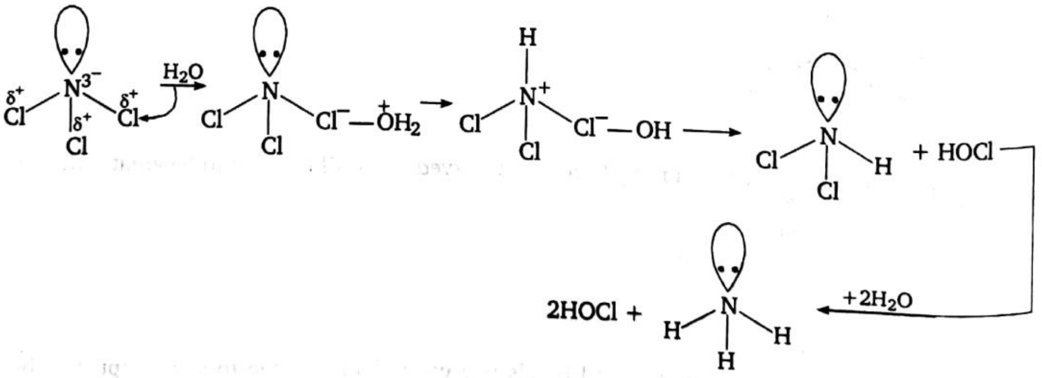
67. (b)



68. (c) $BCl_3 + 3H_2O \longrightarrow H_3BO_3 + 3HCl$

$NCl_3 + 3H_2O \longrightarrow NH_3 + 3HOCl$





71. (d)

Species :	P_2: (B_2)	Q_2:(C_2)	R_2: (N_2)	S_2(O_2)	T_2: (F_2)
Bond order	1.0	2.0	3.0	2.0	1.0
Total No. of valence e¯s	6	8	10	12	14

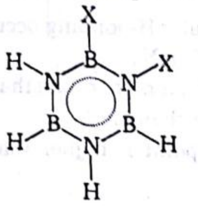
74. (a)

(a) $\underset{\substack{\text{BO = 1.5}\\ \text{Paramagnetic}}}{C_2^+} \longrightarrow \underset{\substack{\text{BO = 2}\\ \text{Diamagnetic}}}{C_2}$ (b) $\underset{\substack{\text{BO = 3}\\ \text{Diamagnetic}}}{NO^+} \longrightarrow \underset{\substack{\text{BO = 2.5}\\ \text{Paramagnetic}}}{NO}$

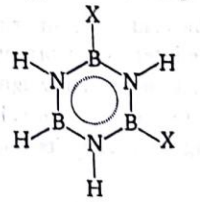
(c) $\underset{\substack{\text{BO = 2}\\ \text{Paramagnetic}}}{O_2} \longrightarrow \underset{\substack{\text{BO = 2.5}\\ \text{Paramagnetic}}}{O_2^+}$ (d) $\underset{\substack{\text{BO = 3}\\ \text{Diamagnetic}}}{N_2} \longrightarrow \underset{\substack{\text{BO = 2.5}\\ \text{Paramagnetic}}}{N_2^+}$

75 (a) According to coulsion model, H.O.M.O. (Highest Occupied Molecular Orbital) of CO molecule is non-bonding M.O. with slight antibonding character.

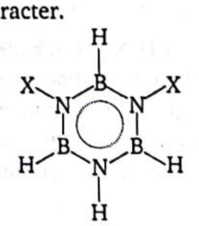
76. (c)



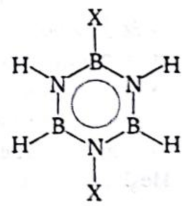
ortho-form



meta-form



meta-form

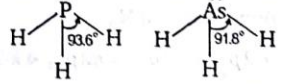


para-form

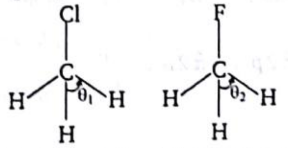
77. (c) σ-bonding molecular orbital is gerade due to having center of symmetry.

78. (c) (a)Acidic strength of HBr > HCl and their reducing properties are also in same order

(b)Basic strength of $PH_3 > AsH_3$, their bond angles are also in same order



(c) $\theta_2 > \theta_1$ because C—H bond has more *s*-character in CH_3F than in CH_3Cl.



(d) K_{a_1} of maleic acid is higher than K_{a_1} of fumaric acid but reverse is true for their K_{a_2}

Level 3

Passage-2

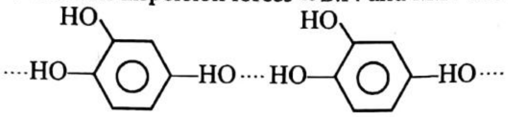
1. (b) $\overset{\delta+}{H}—\overset{\delta-}{Cl}\overset{E}{\cdots}\overset{\delta+}{H}—\overset{\delta-}{Cl}$. The bond energy ($E$) between two H—Cl molecules, caused by dipole-dipole interaction is not found to be in the range of unsymmetrical H-bond energy, rather it is less than 8 kJ/mol, hence this interaction is called weak dipole-dipole interaction.

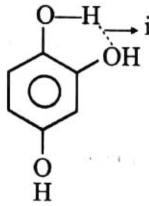
2. (d) Na^+:CCl_4 : ion-induced dipole < 8 kJ/mol
$CHCl_3$: Br : Weaker ion-dipole < 8 kJ/mol
C_6H_6:CCl_4 : London dispersion forces < 8 kJ/mol
H_2O : HCN : Unsymmetrical H-bond : 8-42 kJ/mol

Passage-3

1. (d) → Halogens are non-polar species, hence London dispersion forces act among them and these forces are directly proportional to molecular weight.

→ London dispersion forces ∝ B.P. and M.P. in such non-polar species.

2. (d)  → Intermolecular H-bonding



3. (a) → Boiling point of $HN_3 > CH_3N_3$ as in hydrazoic acid (HN_3) intermolecular H-bonding occurs and its bond energy is higher than weak dipole-dipole interactions present in CH_3N_3.

→ Boiling point of BI_3 is greater than that of BF_3 as molecular weight of BI_3 is higher than that of BF_3.

→ Due to intermolecular H-bonding in H_2SO_4 its boiling point is higher than Me_2SO_4.

→ Similarly due to intermolecular H-bonding in $B(OH)_3$ its boiling point is higher than that of Me_3BO_3.

Passage-4

1. (c) **P** : $\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \pi 2p_{x^2} < \pi 2p_{y^2} < \sigma 2p_{z^1}$

→ by removing one $\bar{e}$, *P* becomes diamagnetic from paramagnetic.

→ Bond order of P(*i.e.*, N_2^+) < Bond order of N_2

Q : $\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \sigma 2p_{z^2} < \pi 2p_{x^2} = \pi 2p_{y^2} < \overset{*}{\pi} 2p_{y^2} = \overset{*}{\pi} 2p_{y^1}$

→ by adding one $\bar{e}$, *Q* become diamagnetic from paramagnetic

Bond order of Q(*i.e.*, O_2^-) < bond order of O_2

R : $\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \sigma 2p_{z^2} < \pi 2p_{x^2} = \pi 2p_{x^2} < \overset{*}{\pi} 2p_{y^1} = \overset{*}{\pi} 2p_{y^0}$

→ by adding one $\bar{e}$, *R* retains its paramagnetic behaviour

T : $\sigma 1s^2 < \overset{*}{\sigma} 1s^2 < \sigma 2s^2 < \overset{*}{\sigma} 2s^2 < \pi 2p_{x^2} = \pi 2p_{y^2}$

→ by adding one $\bar{e}$, *T* becomes paramagnetic from diamagnetic

Passage-5

3. (d)

Compound, MX_n type (n = 2 or 3 or 4)	**Value of cos θ (θ = bond angle between equivalent hybrid orbitals)**
P	–0.241 ⟶ close to sp^3
Q	–0.292 ⟶ close to sp^3
R	–0.5 ⟶ sp^2
S	–0.325 ⟶ sp^3
T	–0.469 ⟶ close to sp^2

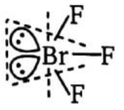
Passage-6

1. (d) Order of bond angle :

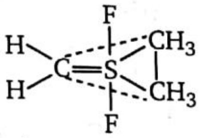
(i) $PH_3 > H_2Se > H_2Te$ (ii) $NO_2^- > NH_2^-$

(iii) $POCl_3 > POF_3(X—P—X$ angle) (iv) $OSF_2Cl_2 > SF_2(CH_3)_2(\angle F—S—F)$

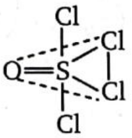
2. (d)

(a) 

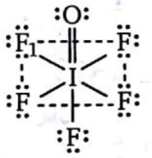
⇒ Maximum number of atoms that can lie in a plane = 4

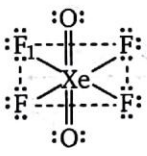
(b) 

⇒ Hydrogen atoms bonded by $1s-sp^2$ overlapping lie in axial plane.

(c) 

⇒ ∠Cl—S—Cl is less than 120°, due to shifting of *s*-character in S = O bond.

(d) 



No. of lone pairs = 17 No. of lone pairs = 16

3. (d) For $XeO_2F_4, = \frac{n_2}{n_1} = 1$

Hyb. of Xe : $sp^3d^2[sp_xp_yp_zd_{x^2-y^2}d_{z^2}]$

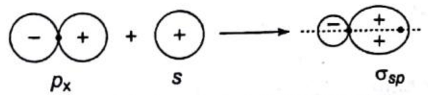
Passage-7

1. (b) In AsH_3, P_4 and $H_2Se \rightarrow$ No Hybridisation [Acc. to Drago's rule]
$GeH_4 \rightarrow sp^3$-hybridisation [% s = 25%] maximum.

2. (a) $PH_4^{\oplus} \rightarrow sp^3[109°28']$
$OF_2 \rightarrow sp^3$ [B.A. $< 109°28'$]
$SF_2 \rightarrow sp^3$[B. A.$<<$ $109°28'$]
$SbH_3 \rightarrow$ No hybridisation [B.A. $\approx 90°$]
Order of B.A. : $PH_4^{\oplus} > OF_2 > SF_2 > SbH_3 > H_2Te$

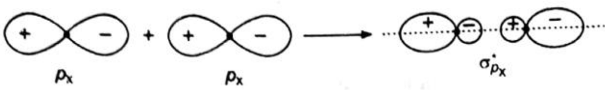
Passage-11

3. (a) Bond order ∝ Bond energy $\propto \frac{1}{\text{Bond length}}$

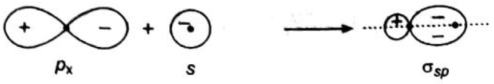
5. (a) 

(No nodal plane between both nuclei)

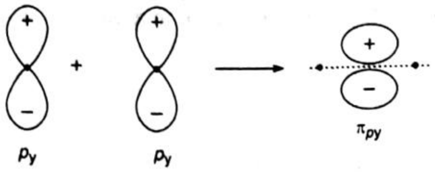
6. (c) (a)



(b)

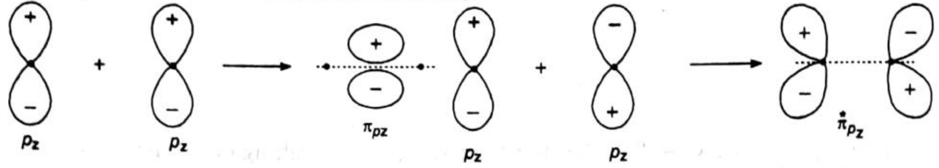


(d)



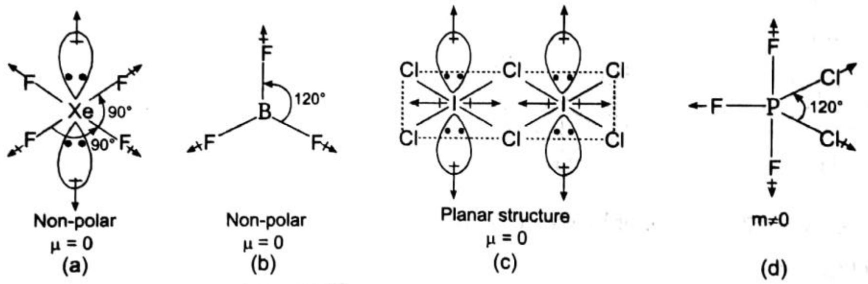
7. (b) bonding M.O. has maximum electron density between two nuclei

8. (c)



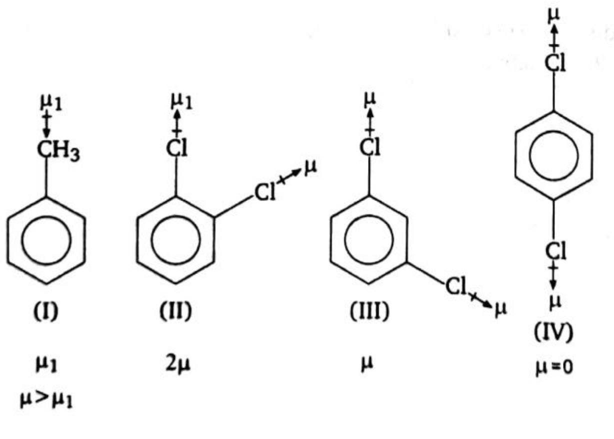
Passage-12

1. (d)

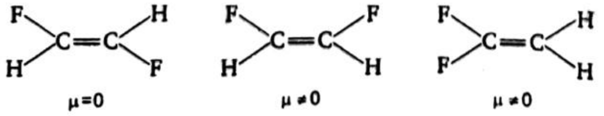


2. (c) Fraction of charge $= \dfrac{1.2\times10^{-18}}{4.8\times10^{-10}\times10^{-8}} = 0.25$

3. (c)



5. (b)

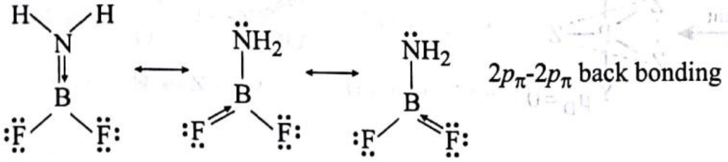


Passage-14

1. (c) AlF_3 is ionic compound, hence Al^{3+} and F^- both have complete octet, rest compounds do not complete, their octet.

ONE OR MORE ANSWERS IS/ARE CORRECT

6. (a, b)

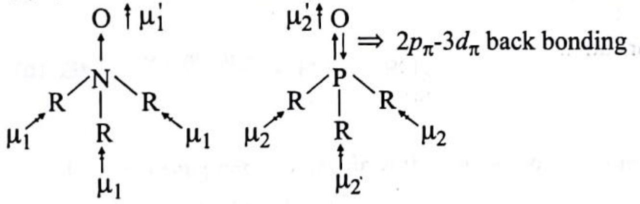


According to Bent's rule there is more *p*-character in B—F bond than in B—N bond; hence FBF is less than 120°

As size of —NH_2 group is larger than F-atom hence repulsion between —NH_2 group and F-atoms is higher than between two F-atoms.

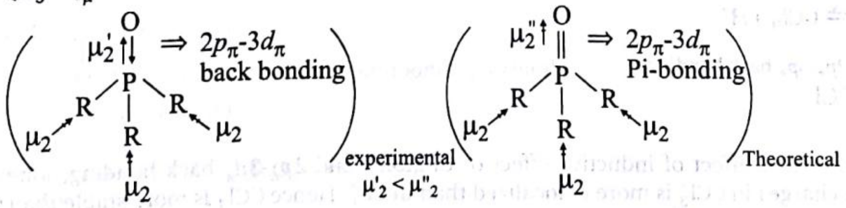
As lone pair of N-atom in NH_2 group participate in back bonding hence H—N—H is greater than 109°28', as hybridization of N is changing from sp^3 towards close to sp^2

7. (a, d)



$\mu_1 > \mu_2 \Rightarrow$ due to higher difference in electronegativity of N and C than between P and C

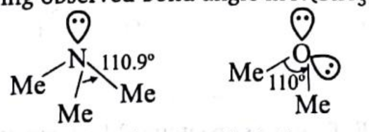
$\mu_1' > \mu_2' \Rightarrow$ because $2p_\pi - 3d_\pi$ back bonding in the P—O bond decreases its dipole moment hence $(R_3NO)_\mu > (R_3PO)_\mu$



Hence, experimental dipole moment of R_3PO < theoretical dipole moment of R_3PO.

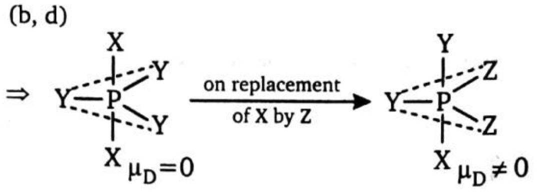
8. (b, c)

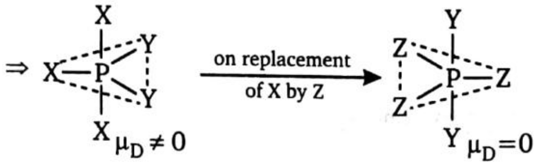
Due to $2p_\pi \cdot 3d_\pi$ back bonding observed bond angle in $N(SiH_3)_3$ and $O(SiH_3)_2$ is higher than expected



both have no back bonding but higher bond angle is due to steric repulsions between methyl groups.

9. (b, d)





10. (a, b, c, d)

According to Bent's rule, there is less *s*-character in C—F bonds in COF_2 than in C—Cl bonds in case o $COCl_2$ hence $\gamma' > \gamma$ and ∠FCF is less than 120°.

$\Rightarrow \alpha = \beta$ as both C—F bonds are equivalent similarly $\alpha' = \beta'$ as both C—Cl bonds are equivalent $\alpha = \beta > \gamma$

$\alpha > \alpha'$

$\beta > \beta'$

11. (a, b, d)

[Melting point of a covalent compound having bond between metal and non-metal]

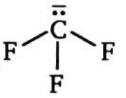
$$\propto \frac{1}{\text{Polarization}}$$

Hence, melting point of $BeF_2 > BeCl_2$

12. (c, d)

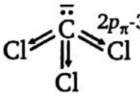
$K_a' > K_a$

$CHF_3 \overset{K_a}{\rightleftharpoons} CF_3^- + H^+$



Stabilized by inductive effect of F-atoms

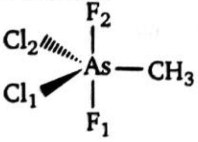
$CHCl_3 \overset{K_a'}{\rightleftharpoons} CCl_3^- + H^+$



$2p_\pi$-$3p_\pi$ back bonding

Due to combined effect of inductive effect of Cl-atoms and $2p_\pi$-$3d_\pi$ back bonding, lone pair at C-atom (negative charge) in CCl_3^- is more delocalized than in CF_3^-. Hence CCl_3^- is more stable than CF_3^- and CCl_3^- is weaker lewis base than CF_3^-.

14. (a, b, c, d)



(a) The plane which passes from (Cl_1, F_1, F_2 and As) contains 3-halogen atoms.

(b) Axial plane → maximum atom = 5[F_1, F_2, As, C, H]

equatorial plane → maximum atom = 5[Cl_1, Cl_2, As, C, H]

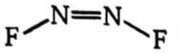
(c) $(\text{B.L.})_{\text{As—Cl}} > (\text{B.L.})_{\text{As—F}}$ As size of Cl-atom >> F-atom.

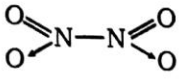
(d) Equatorial plane → maximum atoms = $5[\text{Cl}_1, \text{Cl}_2, \text{As, C, H}]$

15. (a, b)

(a) $N_3^{\ominus}$,

$$\overset{\ominus}{N} = \overset{\oplus}{N} = \overset{\ominus}{N} \leftrightarrow \overset{\ominus}{N}{}^{2}—\overset{\oplus}{N} \equiv N \leftrightarrow N \equiv \overset{\oplus}{N}—\overset{2-}{N} \text{ (B. O. = 2)}$$

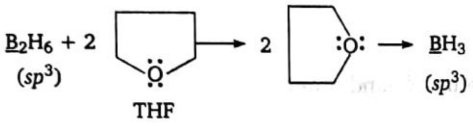
(b) N_2F_2,  $(\text{B.O.})_{\text{N—N}} = 2$

(c) N_2O_4,  $(\text{B.O.})_{\text{N—N}} = 1$

(d) N_2O, $N \equiv N \rightarrow O$ $(\text{B.O.})_{\text{N—N}} \approx 3$

22. (a, c, d)

(a) $\underline{\text{Al}}(\text{OH})_3 + \text{NaOH} \longrightarrow \text{Na}[\underline{\text{Al}}(\text{OH})_4]$
(sp^2) (sp^3)

(b) 

$\underline{B}_2H_6 + 2$ THF $\longrightarrow 2$ THF:$\rightarrow \underline{B}H_3$
(sp^3) (sp^3)

(c) $\underline{\text{Si}}\text{F}_4 + 2\text{HF} \longrightarrow \text{H}_2\underline{\text{Si}}\text{F}_6$
sp^3d (sp^3d^2)

(d) $2\underline{\text{P}}\text{Cl}_5 \xrightarrow{\text{solidification}} \underline{\text{P}}\text{Cl}_4^{\oplus} + \underline{\text{P}}\text{Cl}_6^{\ominus}$
(sp^3d) (sp^3) (sp^3d^2)

24. (a, c, d)

O_2 = Paramagnetic molecule with 2 unpaired electrons in antibonding *p*-orbital

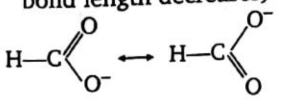
O_3 = diamagnetic molecule

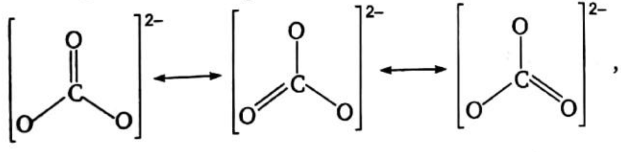
B_2 = Paramagnetic with 2 unpaired electron in bonding π-orbitals

C_2 = Diamagnetic molecule

$\text{NO} \longrightarrow \overset{\oplus}{\text{N}}\text{O}$ (Electron removes from antibonding orbital bond length decreases)

$\text{CO} \longrightarrow \text{C}\overset{\oplus}{\text{O}}$ (Electron removes from antibonding orbital bond length decreases)

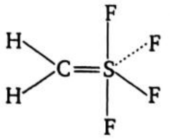
25. (c,d)  $\text{B.O.} = \frac{2+1}{2} = 1.5$



$$\text{B.O.} = \frac{2+1+1}{3} = \frac{4}{3} = 1.33$$

C—O bond length in HCOO^- is less than C—O bond length in CO_3^{2-}

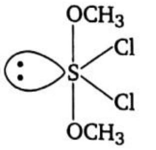
26. (a,c,d)



Hydrogen atoms are in a vertical plane with axial fluorine atoms π-bond involving a p-orbital of carbon atom must lie in equatorial plane of the molecule.
Six atoms, *i.e.*, 2 H-atoms, C, S and both axial F-atoms lie in one plane.

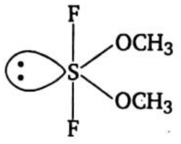
29. (a,b,c,d) $\overset{\delta+}{\text{Si}}-\overset{\delta-}{\text{H}}$ $\quad$ $\overset{\delta-}{\text{C}}-\overset{\delta+}{\text{H}}$

30. (a,b,c,d)



$SCl_2(OCH_3)_2$

(I)



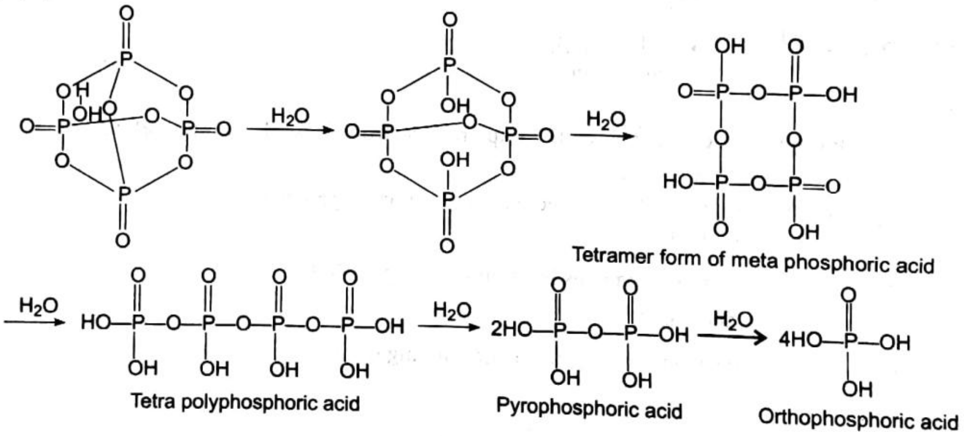
$SF_2(OCH_3)_2$

(II)

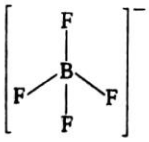
31. (b,c,d)

Molecule may have only integral/fractional value of bond order
Molecule may or not be paramagnetic
Molecule will exist

32. (a, b, c, d)



33. (a,c) $NO^+[BF_4]^-$



No. of σ bonds in $[BF_4]^- = 4$

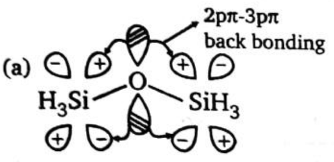
$\Rightarrow$ B.O. of $NO^+ = 3.0$, *i.e.*, one sigma bond and two π bonds
$\therefore$ No. of π bonds = 2
No. of σ bonds = 5
$\Rightarrow$ B.O. of $NO^+ = 3.0$
and B.O. of NO = 2.5

⇒ NO^+ is diamagnetic and BF_4^- is also diamagnetic

⇒ B—F bonds are longer in BF_4^- than in BF_3 due to absence of $p\pi$-$p\pi$ back bonding in $[BF_4]$

MATCH THE COLUMN

1. (a)



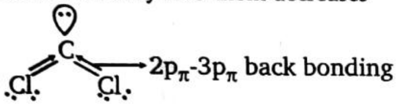
→ Si—O—Si ≈ 144°

→ Hybridization of O-atom changed to sp^2

→ In $2p_\pi$ - $3d_\pi$ back bonding non-axial d-orbital of t_{2g} is used

→ Electron density at O-atom decreases

(b)

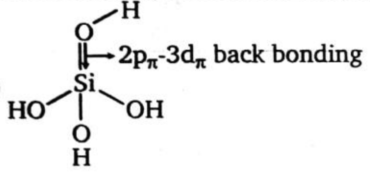


→ ∠Cl — O — Cl increases due to back bonding and steric repulsion between both Cl-atoms

→ Hybridization of C remains sp^2

→ Electron density increases at central C-atom.

(c)

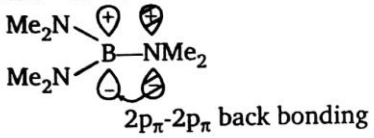


→ Electron density at Si-atom increases due to $2p_\pi - 3d_\pi$ back bonding

→ Non-axial d-orbital of t_{2g} set of orbitals is involved in back bonding

→ All O—Si—O remains at 109°28' because all four substituents are same

(d)



→ Hybridization of central does not change

→ Electron density at B-atom increases

→ All N—B—N remain same as all three substituents are same.

2. M.O. configuration for molecules having total number electron less or equal to 14.

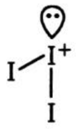
$$\sigma 1s < \overset{*}{\sigma} 1s < \sigma 2s < \overset{*}{\sigma} 2s < \underset{\pi 2p_y}{\pi 2p_x} < \sigma 2p_z < \underset{\overset{*}{\pi} 2p_x}{\overset{*}{\pi} 2p_x} < \overset{*}{\sigma} 2p_z$$

For molecules having total number of e^-s greater than 14

$$\sigma 1s < \overset{*}{\sigma} 1s < \sigma 2s < \overset{*}{\sigma} 2s < \sigma 2p_z < \underset{\pi 2p_y}{\pi 2p_x} < \underset{\overset{*}{\pi} 2p_y}{\overset{*}{\pi} 2p_x} < \overset{*}{\sigma} 2p_z$$

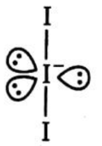
S. No.	species	Total No. of e^-s	No. of unpaired e^-s and lieff unpaired e^-s and lieff	Mixing of *s* and *p*-orbitals	Bond order
a	CO	14	diamagnetic	Yes	3.0
	CN^-	14	diamagnetic	Yes	3.0
	NO^+	14	diamagnetic	Yes	3.0
	O_2^{2+}	14	diamagnetic	No	3.0
b	N_2^+	13	paramagnetic	Yes	2.5
	O_2^+	15	paramagnetic	No	2.5
	O_2^-	17	paramagnetic	No	1.5
	NO	15	paramagnetic	Yes	2.5
c	NO^-	16	paramagnetic	Yes	2.0
	N_2^{2+}	13	diamagnetic	Yes	2.0
	C_2	12	diamagnetic	Yes	2.0
	B_2^{2-}	12		Yes	2.0
d	CN	13	paramagnetic	Yes	2.5
	C_2^+	11	paramagnetic	Yes	1.5
	B_2^+	9	diamagnetic	Yes	0.5
	N_2^-	15	diamagnetic	Yes	2.5

3. (a) $3I_2 \rightarrow I_3^+ + I_3^-$



(I_3^+)

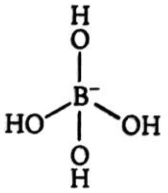
Hybridization : *sp*³
planar



(I_3^-)

Hybridization : *sp*³*d*
planar

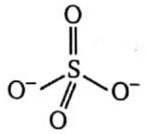
(b) $B(OH)_3 + OH^- \rightarrow B(OH)_4^-$



→ **Hybridization of B** : *sp*³

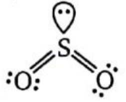
→ **Non-planar**

(c) $Ba^{2+}SO_4^{2-}$:



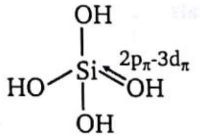
; Hybridization of S : sp^3
Non-planar
$p\pi$-$d\pi$ bonds = 2

(d) MgO ⇒ Ionic; SO_2: covalent



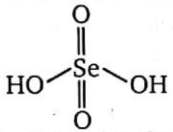
Hybridization of S : sp^2,
Planar
$p\pi$-$d\pi$ bonds = 1

4. ⇒



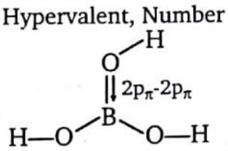
→ $2p_\pi$-$3d_\pi$ back bond
→ Can exhibit intermolecular H-bonding as H-atom is bonded to O-atom.
→ Proton donor acid; basicity = 4

⇒



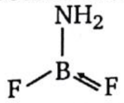
→ back bond is absent
→ can form intermolecular H-bond as H-atom is directly bonded to O-atom
→ Proton donor acid, basicity = 2
→ Hypervalent, Number of e^-s at Se = 12

⇒



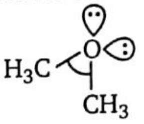
→ $2p_\pi$-$2p_\pi$ back bond is present
→ Hypovalent, as number of e^-s at B-atom = 6
→ Does not furnish H^+

⇒

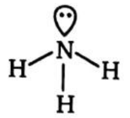


→ $2p_\pi$-$2p_\pi$ back bond is present
→ Can form intermolecular H-bonding as H-atom is directly bonded to N-atom
Hypovalent number of e^-sat B-atom = 6
→ Does not furnish H^+

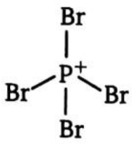
5. (a)



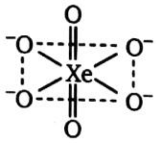
→ Unequal distribution of s-character in hybrid orbitals
→ ∠C—O—C > 109°28'
→ Both O—C bonds are equivalent

(b) 

→ Unequal distribution of s-character in hybrid orbitals
→ ∠HNH < 109°28'
→ All three N—H bonds are equivalent

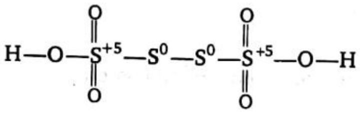
(c) 

→ Equal distribution of s-character in hybrid orbitals
→ ∠Br — P — Br = 109°28'
→ All P—Br bonds are equivalent

(d) 

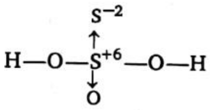
→ Equal distribution of s-character in all hybrid orbitals
→ ∠O—Xe—O = 90°
→ All Xe—O bonds are equivalent

11. h S_4O_6 :



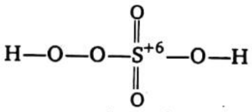
$$\mathrm{H{-}O{-}}\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}{}^{+5}{-}S^{0}{-}S^{0}{-}\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}{}^{+5}\mathrm{{-}O{-}H}$$

$H_2S_2O_3$:



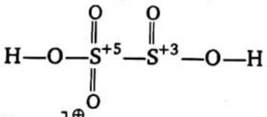
$$\mathrm{H{-}O{-}}\overset{\overset{S^{-2}}{\uparrow}}{\underset{\underset{O}{\downarrow}}{S}}{}^{+6}\mathrm{{-}O{-}H}$$

H_2SO_5 :



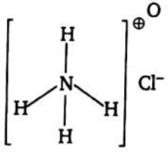
$$\mathrm{H{-}O{-}O{-}}\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}{}^{+6}\mathrm{{-}O{-}H}$$

$H_2S_2O_5$:

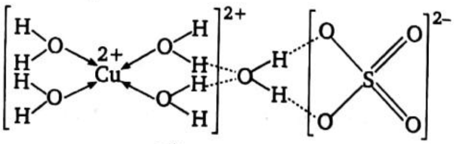


$$\mathrm{H{-}O{-}}\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}{}^{+5}{-}\overset{\overset{O}{\|}}{S}{}^{+3}\mathrm{{-}O{-}H}$$

12. (A) NH_4Cl

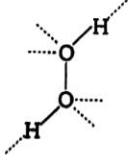


(B) $CuSO_4.5H_2O$

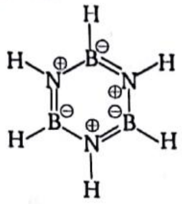


(C) HNC $\mathrm{H{-}N}\overset{\rightarrow}{\equiv}\mathrm{C}$

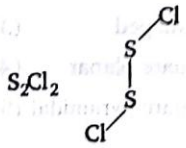
(D) Liquid H_2O_2



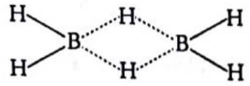
13. (A) $B_3H_3H_6$



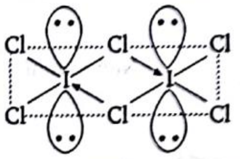
(B) S_2Cl_2



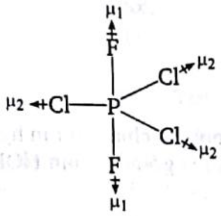
(C) B_2H_6



(D) I_2Cl_6



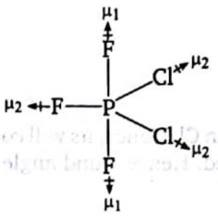
14. (A)



$\mu = 0$

sp^3d hybridisation

Trigonal bipyramidal

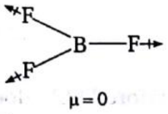


$\mu \neq 0$

sp^3d hybridisation

Trigonal bipyramidal

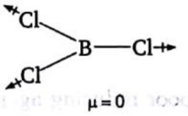
(B)



$\mu = 0$

sp^2 hybridisation

Trigonal planar



$\mu = 0$

sp^2 hybridisation

Trigonal planar

$\overset{\leftrightarrow}{}\ \ \overset{\leftrightarrow}{}$
$C:O=C=O$

sp hybridisation

linear

$\mu = 0$

No. of $e^-s = 22$

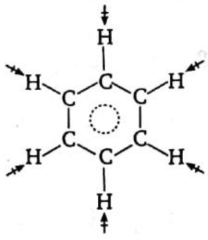
$\overset{\leftrightarrow}{}\ \ \overset{\leftrightarrow}{}$
$[:\ddot{N}=C=\ddot{N}:]^{2-}$

sp hybridisation

linear

$\mu = 0$

No. of $e^-s = 22$

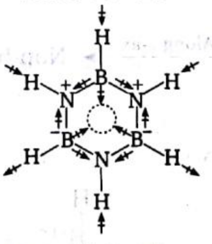


sp^2

planar

$\mu = 0$

No. of $e^-s = 42$



B: sp^2 N: sp^2

planar

$\mu = 0$

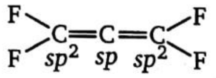
No. of $e^-s = 42$

15.

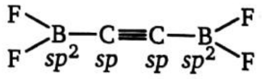
$NH_2^{\ominus}$	Hybridisation sp^3	V-shaped	$(2\text{-}bp, 2\text{-}lp)$
$XeOF_2$	sp^3d	T-shaped	$(3\text{-}bp, 2\text{-}lp)$
ICl_4^-	sp^3d^2	square planar	$(4\text{-}bp, 2\text{-}lp)$
$[SbF_5]^{2-}$	sp^3d^2	square pyramidal	$(5\text{-}bp, 1\text{-}lp)$

ASSERTION-REASON TYPE QUESTIONS

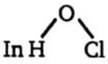
4.



: Non-planar



: Planar



12. (B) In $\overset{O}{H\quad Cl}$, O is more electronegative than Cl. Hence, its will contain mores *s* character in hybrid orbital hence bond angle will be more than expected. Hence, bond angle is HOCl is greater than HOF.

14. (D) $\underset{\substack{\text{Oxidizing}\\\text{agent}}}{Pb^{4+}} + \underset{\substack{\text{strong}\\\text{reducing agent}}}{4I^-} \longrightarrow PbI_2 + I_2$

hence, PbI_4 does not exist

$\underset{\substack{\text{oxidizing}\\\text{agent}}}{Pb^{4+}} + \underset{\substack{\text{not good}\\\text{red, agent}\\\text{like } I^-}}{4Cl^-} \longrightarrow \underset{\text{unstable}}{PbCl_4} \xrightarrow[50°C]{\text{above}} PbCl_2 + Cl_2$

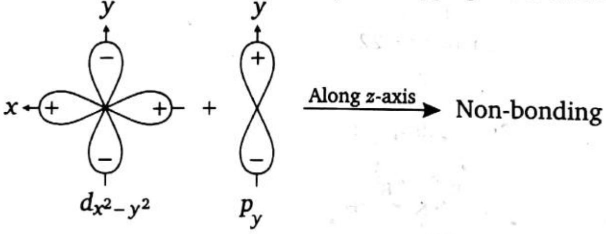
Since Cl_2 is a strong oxidizing agent, hence Cl^- is poor reducing agent, therefore $PbCl_4$ does from but decomposes on heating.

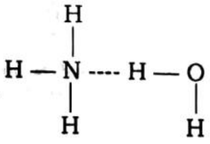
25. (A) In $(CH_3)_3\ddot{N}$, N is sp^3 hybridized, having pyramidal structure because of absence of vacant orbital on carbon atom therefore no back bonding is possible.

In $(SiH_3)_3N$, N is sp^2 hybridized, on the basis of $p\pi\text{-}d\pi$ back bonding $(SiH_3)_3N$ resulting into triangular planar structure

Covalency of both C and Si is four.

28. (B) This combination can not form π-bond by sideways overlapping due to different sign of ψ along z-axis.





29. (B) The correct representation of hydrogen bonding is $H-\underset{\substack{|\\H}}{\overset{\substack{H\\|}}{N}}\text{----}H-\underset{\substack{|\\H}}{O}$

$NH_3 + H_2O \longrightarrow NH_4^+ + OH^-$

and ammonia never acts as acid in aqueous medium.

$NH_3 + H_2O \longrightarrow NH_2^- + H_3O^+$

SUBJECTIVE PROBLEMS

1. $I_3^- \Rightarrow sp^3d$

Group *A*

	l.P.
Px_4	1
Qy_3	2
Rz_2	3

x = Total *l.P.* **= 6**

$AsF_4^+ \Rightarrow sp^3$

Group *B*

	l.P.
Sx_4	0
Ty_3	1
Uz_2	2

y = Total *l.P.* **= 3**

$x/y = 6/3 \Rightarrow 2$

2. $n = 1$, then X = H; A = N

(i) NH_2^- (ii) NH_3 (iii) NH_4^+

lone pair $x = 2, y = 1, z = 0$

$x^3 + y^2 + z = (2)^3 + (1)^2 + (0) = 9$

4. (i) $NO \longrightarrow NO^+$

2.5 → 3.0

Paramagnetic

(ii) $O_2^- \longrightarrow O_2^{2-}$

(1.5) → (1)

(iii) $O_2 \longrightarrow O_2^+$

(2) → (2.5)

Paramagnetic → Paramagnetic

(iv) $NO^+ \longrightarrow NO^-$

(3) → (2)

Diamagnetic → Paramagnetic

(v) $NO^+ \longrightarrow NO^{2+}$

(3) → (2.5)

Diamagnetic → Diamagnetic

(vi) $CO \longrightarrow CO^+$

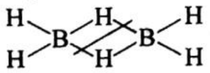
(3) → (3.5)

Diamagnetic → Paramagnetic

$c^3 - b^2 - a = 3^3 - 3^2 - 5 = 27 - 9 - 5 = 13$

5. → Unsymmetrical cleavage of B_2H_6: with small sized strong Lewis base like : NH_3, MNH_2, Me_2NH

→ Symmetrical cleavage of B_2H_6: with large sized strong Lewis base or weaker Lewis base like: PH_3, PF_3, H^-, CO, T.H.F. Me_3N, pyridine.

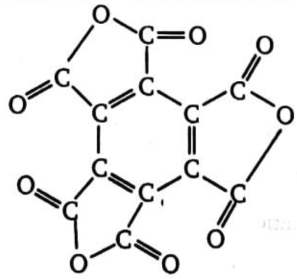


$+ 2L \longrightarrow 2BH_3L$

6. $\frac{6}{2} = 3$, Elements A = Al, B = P, C = S, D = Cl, E = F

Compounds		Polarity
(i)	$CE_4(SF_4)$	P
(ii)	$BD_2E_3(PCl_2F_3)$	P
(iii)	$DE_3(ClF_3)$	P
(iv)	$CE_2(SF_2)$	P
(v)	$BD_3E_2(PCl_3F_2)$	NP
(vi)	$C_2E_2(S_2F_2)$	P
(vii)	$DE(ClF)$	P
(viii)	$A_2D_6(Al_2Cl_6)$	NP

7.

Compounds		Geometry	sp^2 (C)	sp (C)
(i)	CO	$C\equiv O$	0	1
(ii)	CO_2	$O=C=O$	0	1
(iii)	C_3O_2	$O=C=C=C=O$	0	3
(iv)	$C_{12}O_9$		12	0

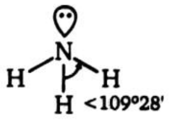
$\Rightarrow \quad |p-q| = |12-5| = 7$

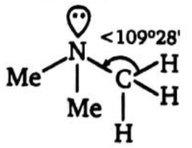
11. Compound

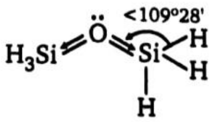
Compound		
SX_2	$n_1 = 2$	$m_1 = 2$
PX_3	$n_2 = 3$	$m_2 = 1$
SiX_4	$n_3 = 4$	$m_3 = 0$
AlX_3	$n_4 = 3$	$m_4 = 0$

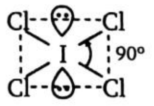
$$\left|\frac{2+3+4+3}{2+1}\right|^2 = \left|\frac{12}{3}\right|^2 = |4|^2 = 16$$

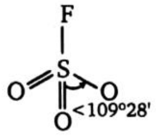
12. Species having bond angle equal to or less than 109°28' and also can act as lewis base are :

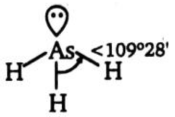












13. $O_2^+[PtF_6]^-$

O_2^+ has one unpaired e^-

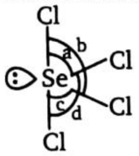
$[PtF_6]^-$ has one unpaired e^-, because Pt is in +5 oxidation state so total unpaired electron is 2.

14. N_2^+, O_2, B_2, N_2^{2-} have symmetrical electronic distribution in their HOMO and are also paramagnetic.

N_2^+ paramagnetic and symmetrical electronic distribution in their HOMO.
O_2 paramagnetic and symmetrical electronic distribution in their HOMO.
B_2 paramagnetic and symmetrical electronic distribution in their HOMO.
N_2^{2-} paramagnetic and symmetrical electronic distribution in their HOMO.
O_2^{2-} diamagnetic and symmetrical electronic distribution in their HOMO.
C_2 diamagnetic and symmetrical electronic distribution in their HOMO.
C_2^{2-} diamagnetic and symmetrical electronic distribution in their HOMO.

15. Back bond found in each covalent bond in → BF_3, PF_3, POF_3

16.

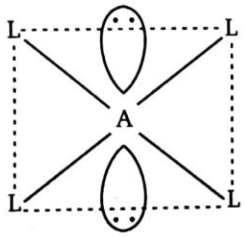


(a = b = c = d) < 90° due to lone pair-bond pair repulsion.

17. In $O(Me)_2$ and MeNCS back bonding is absent.

18. $B(OMe)_2$ and HCHO can not form H-bond.

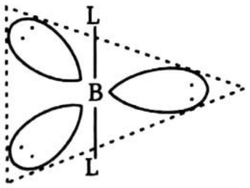
19. ⇒ AL_{n_1}:



⇒ Number of electron pair on $A = 6$
⇒ Non-polar
⇒ Planar

Hence $n_1 = 4$

⇒ BL_{n_2};



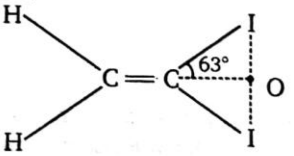
⇒ Number of electron pair on $B = 5$
⇒ Non-polar
⇒ Planar

Hence $n_2 = 2$

$(n_1 - n_2)^2 = (4-2)^2 = 4$

20. $H_2C = CI_2$, has sp^2 hybridised carbon and thus I—C—I bond angle is 120°.

$\therefore \quad \frac{IO}{CI} = \sin 60°$



[In $\Delta ICO \angle ICO = 60°$ and $\angle IOC = 90°$]

$IO = CI \sin 60° = 2.35 \times 0.866$

$= 2.0351$ Å

. I—I distance $= 2.0351 \times 2 = 4.07$ Å ≈ 4

21. $(P) = $ (i), (iii), (iv), (vii) (4)

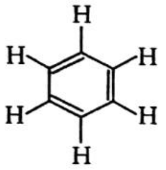
$(Q) = $ (ii), (v) (ix) (3)

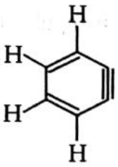
$(R) = $ (vi), (vii) (2)

then $Q \times R - P = 3 \times 2 - 4 \Rightarrow 2$

24. $CH_3^+, (C_3H_5)_3Al, HCHO, TiCl_4, CO_2, SiCl_4, BF_3$

25.





$x = 12 \qquad y = 11$

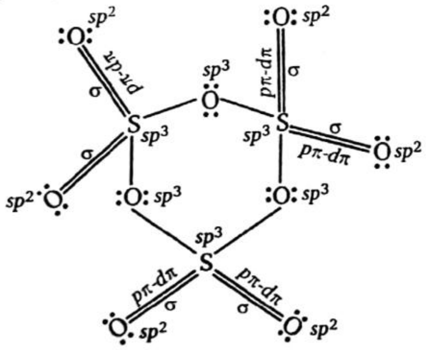
$|x - y| = 1$

26. (i) $IF_5(sp^3d)$
(ii) $ClI_4^-(sp^3d^2)$
(iii) $XeO_2F_2(sp^3d)$
(iv) $NH_2^-(sp^3)$
(v) $BCl_3(sp^2)$
(vi) $BeCl_2(sp)$
(vii) $AsCl_4^+(sp^3)$
(viii) $B(OH)_3(sp^2)$
(ix) $NO_2^-(sp^2)$
(x) $ClO_2^+(sp^2)$

$x = (sp^3)2 + sp^3d(1) + sp^3d^2(2) = 5$

$y = 4, \quad z = 1; \quad 5 + 4 - 1 \Rightarrow 8$

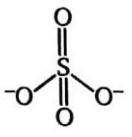
27.

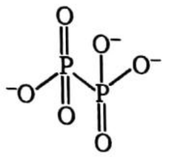


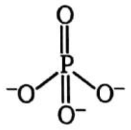
$p = 6, \quad q = 6; \quad \frac{p}{q} = 1$

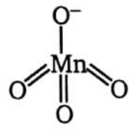
28. $x = 3, \quad y = 1, \quad z = 3$

29.


(R)


(P)


(R)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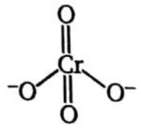
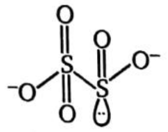
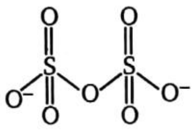

(R)


(P and Q)


(P and Q)

$P = 3, R = 4, Q = 2$

30. $n = 1$, then $X = \text{H}; A = \text{N}$

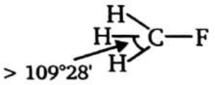
(i) NH_2^- (ii) NH_3 (iii) NH_4^+

lone pair $x = 2$, $y = 1$, $z = 0$

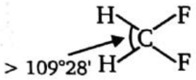
$x^3 + y^2 + z = (2)^3 + (1)^2 + (0) = 9$

32.

(1)



(2)



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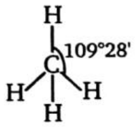

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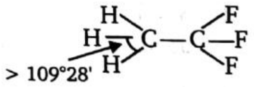

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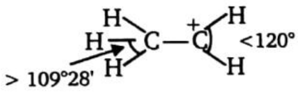

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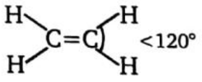


33. → Molecular orbital configuration for upto 14 electrons

$\sigma_{1s} < \overset{*}{\sigma}1s < \sigma_{2s} < \overset{*}{\sigma}2s < \pi_{2px}\pi_{2py} < \sigma_{2pz} < \overset{*}{\pi}2px$

$= \overset{*}{\pi}2py < \overset{*}{\sigma}2pz$

For more than 14 electrons

$\sigma_{1s} < \overset{*}{\sigma}1s < \sigma_{2s} < \overset{*}{\sigma}2s < \sigma_{2pz} < \pi_{2px} = \pi_{2py} < \overset{*}{\pi}2px$

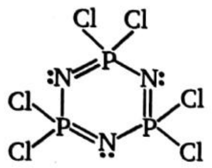
$= \overset{*}{\pi}2py < \overset{*}{\pi}2pz$

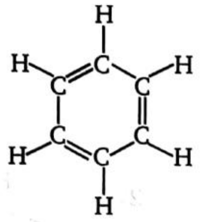
Bond order $= \frac{1}{2}$ number of electrons in [Bonding M.O. – Antibonding M.O.]

No.	Species	Total no.	No. of electrons in	No. of electrons	Bond order
(i)	O_2^+	15	10	5	2.5
(ii)	CO	14	10	4	3
(iii)	B_2	10	6	4	1.0
(iv)	O_2^-	17	10	7	1.5
(v)	NO^+	14	10	4	3
(vi)	He_2^+	3	2	1	0.5
(vii)	C_2^{++}	10	6	4	1.0
(viii)	CN^-	14	10	4	3.0
(ix)	N_2	15	10	5	2.5

34.

	A		B	
σ-bond	12	+	12	
π-bond	3	+	3	$\Rightarrow \frac{24}{6} = 4$





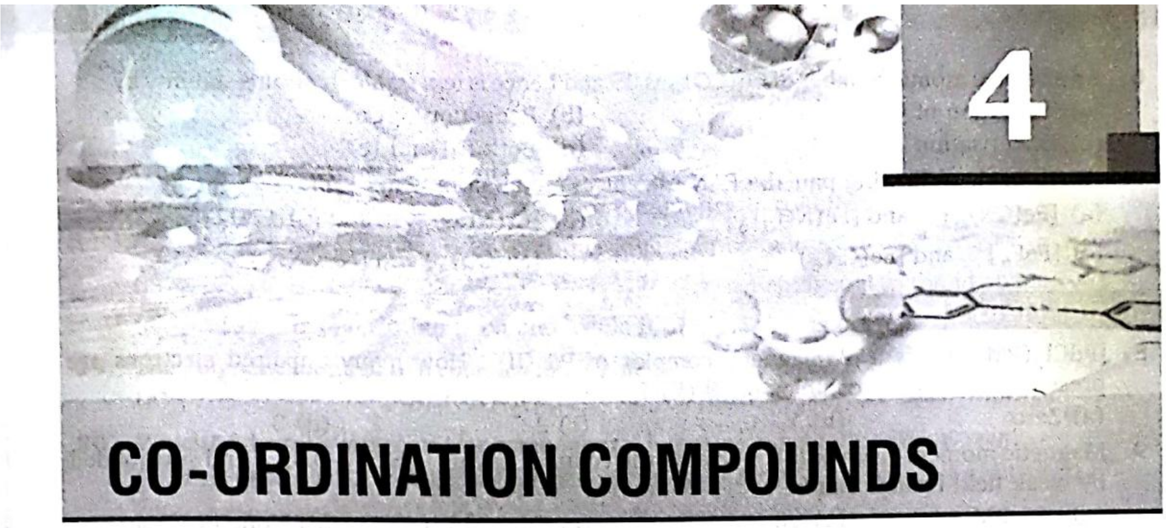
35. $P = 3$ $Q = 2$ $R = 1$ $S = 0$

Hence $P + Q + R + S = 6$

36.

Value of x	Dipole moment
$x_1 = 0$	$\mu = 0$
$x = 1$	$\mu \neq 0$
$x = 2$	$\mu \neq 0$
$x_2 = 3$	$\mu = 0$
$x = 4$	$\mu \neq 0$
$x_3 = 5$	$\mu = 0$

Then, $0 + 3 + 5 = 8$



4

CO-ORDINATION COMPOUNDS

Level 1

Classification of Ligands

1. The common features among the species CN^-, CO and NO^+ are :
(a) Bond order three and diamagnetic
(b) Bond order three and weak field ligands
(c) Paramagnetic and strong field ligands
(d) Paramagnetic and π - acceptor ligands

2. Ni^{2+} ion can be estimated by using dimethyl glyoxime and forms a cherry-red precipitate. The complex is stabilized by :
(a) ionic bonds (b) coordinate covalent bonds
(c) dative π-bonds (d) hydrogen bonds

3. Ammonia forms the complex $[Cu(NH_3)_4]^{2+}$ with copper ions in alkaline solution but not in acidic solution. The reason for this is :
(a) In alkaline solution $Cu(OH)_2$ is precipitated which is soluble in excess of alkali
(b) Copper hydroxide is amphoteric substance
(c) In acidic solution hydration protects Cu^{2+} ions
(d) In acidic solution protons are coordinated with ammonia molecules forming NH_4^+ ions

Sidwick's Rule of EAN

4. If EAN of central metal cation M^{2+} in a non-chelating complex is 36 and atomic no. of metal M is 26, then the number of monodentate ligand in this complex are :
(a) 5 (b) 4
(c) 6 (d) none of these

5. Which of the following is an oxidizing agent?
(a) $Mn(CO)_5$ (b) $Fe(CO)_5$
(c) $Mn_2(CO)_{10}$ (d) $Fe_2(CO)_9$

6. An effective atomic number of $Co(CO)_4$ is 35 and hence is less stable. It attains stability by :
(a) Oxidation of Co
(b) Reduction of Co
(c) Dimerisation
(d) Both (b) and (c)

7. Which of the following pair the EAN of central metal atom is not same?
(a) $[Fe(CN)_6]^{3-}$ and $[Fe(NH_3)_6]^{3+}$
(b) $[Cr(NH_3)_6]^{3+}$ and $[Cr(CN)_6]^{3-}$
(c) $[FeF_6]^{3-}$ and $[Fe(CN_6)]^{3-}$
(d) $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$

Crystal Field Theory

8. $[PdCl_2(PMe_3)_2]$ is a diamagnetic complex of Pd (II) . How many unpaired electrons are present in analogous complex of Ni (II) ?
(a) Zero
(b) 1
(c) 2
(d) 3

9. Magnetic moment (spin only) of octahedron complex having CFSE= $-0.8\Delta_O$ and surrounded by weak field ligands can be:
(a) $\sqrt{15}$ BM
(b) $\sqrt{8}$ BM
(c) (a) & (b) both
(d) None of these

10. Consider the following complex : $[Co(NH_3)_5CO_3]ClO_4$
The coordination number, oxidation number, no. of *d*-electrons and number of unpaired *d*-electrons on the metal are respectively :
(a) 6, 2, 7, 3
(b) 7, 2, 7, 1
(c) 5, 3, 6, 4
(d) 6,3, 6, 0

11. Consider the following complex : $[Co(CO_3)(NH_3)_5]ClO_4$
Mark the correct option :

	Coordination no.	**Oxidation no.**	**No. of *d*-electrons**	**Unpaired *d*-electrons**
(a)	6	3	6	0
(b)	7	2	7	1
(c)	7	1	6	4
(d)	6	2	7	3

12. The magnetic moments of complexes given below are in the order :
(I) $[Ni(CO)_4]$
(II) $[Mn(CN)_6]^{4-}$
(III) $[Cr(NH_3)_6]^{3+}$
(IV) $[CoF_6]^{3-}$
(a) I > II > III > IV
(b) I < II < III < IV
(c) IV > II > I > III
(d) IV < II < I < III

13. Which is low spin complex?
(a) $[Fe(CN_6)]^{3-}$
(b) $[Co(NO_2)_6]^{3-}$
(c) $[Mn(CN)_6]^{3-}$
(d) All of these

14. Which of the following are diamagnetic?
(I) $K_4[Fe(CN)_6]$
(II) $K_3[Cr(CN)_6]$
(III) $K_3[Co(CN)_6]$
(IV) $K_2[Ni(CN)_4]$
Select the correct answer using the codes given below :
(a) I, II and IV
(b) I, III and IV
(c) II and III
(d) I and IV

15. The spin magnetic moment of cobalt in $Hg[Co(SCN)_4]$ is :
(a) $\sqrt{3}$
(b) $\sqrt{8}$
(c) $\sqrt{15}$
(d) $\sqrt{24}$

16. The species having tetrahedral shape is :
(a) $[PdCl_4]^{2-}$
(b) $[Ni(CN)_4]^2$
(c) $[Pd(CN)_4]^{2-}$
(d) $[NiCl_4]^{2-}$

17. Which one of the following has lowest value of magnetic behaviour?

(a) $[Cr(CN)_6]^{3-}$ (b) $[Mn(CN)_6]^{3-}$

(c) $[Fe(CN)_6]^{3-}$ (d) $[Co(CN)_6]^{3-}$

18. Which of the following statements is correct?

(a) $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$ both are paramagnetic complexes

(b) $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$ both are high spin complexes

(c) $[CoF_6]^{3-}$ is octahedral while $[Co(NH_3)_6]^{3+}$ has a pentagonal pyramid shape

(d) $[CoF_6]^{3-}$ is outer orbital complex while $[Co(NH_3)_6]^{3+}$ is inner orbital complex

19. The magnetic moment of a complex ion is 2.83 BM. The complex ion is :

(a) $[V(H_2O)_6]^{3+}$ (b) $[Cr(H_2O)_6]^{3+}$ (c) $[Cu(CN)_4]^{2-}$ (d) $[MnCl_4]^{2-}$

20. Which of the following complex compound(s) is/are paramagnetic and low spin?

(I) $K_3[Fe(CN_6)]$ (II) $[Ni(CO)_4]^0$ (III) $[Cr(NH_3)_6]^{3+}$ (IV) $[Mn(CN)_6]^{4-}$

Choose the correct code :

(a) I only (b) II and III (c) I and IV (d) IV only

21. The diamagnetic species is :

(a) $[Co(H_2O)_6]^{2+}$ (b) $[Ni(H_2O)_6]^{2+}$ (c) $[Co(NH_3)_6]^{3+}$ (d) $[Ni(NH_3)_6]^{2+}$

22. The species which has four unpaired electron is :

(a) $[Co(CN)_6]^{4-}$ (b) $[Cr(H_2O)_6]^{3+}$ (c) $[FeCl_4]^{2-}$ (d) $[Fe(H_2O)_6]^{3+}$

23. Which of the following is a low-spin (spin-paired) complex?

(a) $[Ni(NH_3)_6]^{2+}$ (b) $[Ti(H_2O)_6]^{3+}$

(c) $[Cr(NH_3)_6]^{3+}$ (d) $[Fe(NH_3)_6]^{3+}$

24. The structure of $K[PtCl_3(C_2H_4)]$ and hybridisation of Pt respectively are :

(a) square planar, sp^2d^2 (b) square planar, dsp^2

(c) tetrahedral, sp^3 (d) octahedral, d^2sp^3

25. For which of the following types of ions is the number of unpaired electrons in octahedral complexes fixed at the same number as in the free ion no matter, how weak or strong the crystal field is?

(a) d^3 (b) d^4 (c) d^5 (d) d^6

26. Among the following pairs of complexes, in which case the Δ_0 value is higher for the first one?

(a) $[Co(NH_3)_6]^{3+}$ and $[Co(CN)_6]^{3-}$ (b) $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$

(c) $[Co(H_2O)_6]^{2+}$ and $[Co(H_2O)_6]^{3+}$ (d) $[Rh(H_2O)_6]^{3+}$ and $[Co(H_2O)_6]^{3+}$

27. Dimethyl glyoxime forms a square planar complex with Ni^{2+}. This complex should be :

(a) diamagnetic

(b) paramagnetic having 1 unpaired electron

(c) paramagnetic having 2 unpaired electrons

(d) ferromagnetic

28. What is the magnetic moment (spin only) and hybridisation of the brown ring complex $[Fe(H_2O)_5NO]SO_4$?

(a) $\sqrt{3}$ BM, sp^3d^2 (b) $\sqrt{3}$ BM, d^2sp^3 (c) $\sqrt{15}$ BM, sp^3d^2 (d) $\sqrt{15}$ BM, d^2sp^3

29. Choose incorrect stability order :

(a) $[Cu(NH_3)_4]^{2+} < [Cu(en)_2]^{2+} < [Cu(trien)]^{2+}$

(b) $[Fe(H_2O)_6]^{3+} < [Fe(NO_2)_6]^{3-} < [Fe(NH_3)_6]^{3+}$

(c) $[Co(H_2O)_6]^{3+} < [Rh(H_2O)_6]^{3+} < [Ir(H_2O)_6]^{3+}$

(d) $[Cr(NH_3)_6]^{1+} < [Cr(NH_3)_6]^{2+} < [Cr(NH_3)_6]^{3+}$

30. Aqueous solution of Ni^{2+} contains $[Ni(H_2O)_6]^{2+}$ and its magnetic moment is 2.83 BM. When ammonia is added in it, comment on the magnetic moment of solution :

(a) It will remain same

(b) It increases from 2.83 BM.

(c) It decreases from 2.83 BM.

(d) It cannot be predicted theoretically

31. The correct order of energies of *d*-orbitals of metal ion in a square planar complex is :

(a) $d_{xy} = d_{yz} = d_{zx} > d_{x^2-y^2} = d_{x^2}$ (b) $d_{x^2-y^2} = d_{z^2} > d_{xy} = d_{yz} = d_{zx}$

(c) $d_{x^2-y^2} > d_{z^2} > d_{xy} = d_{yz} = d_{zx}$ (d) $d_{x^2-y^2} > d_{xy} > d_{z^2} > d_{zx} = d_{yz}$

32. Which of the following is true about the complex $[PtCl_2(H_2O)(NH_3)]$?

(a) It exhibits geometrical isomerism (b) It is paramagnetic complex

(c) Its geometry is tetrahedron (d) Platinum is sp^3 hybridised

33. The crystal fieldstabilisation energy of $[Co(NH_3)_6]Cl_3$ is :

(a) $-7.2\Delta_0$ (b) $-0.4\Delta_0$ (c) $-2.4\Delta_0$ (d) $-3.6\Delta_0$

34. The magnitude of crystal field stabilisation energy in octahedral field depends on :

(I) the nature of the ligand

(II) the charge on the metal ion

(III) whether the metal is in the first, second or third row of the transition elements

(a) I, II, III only correct (b) I, II only correct

(c) II, III only correct (d) III only correct

35. Complex compound $[Cr(NCS)(NH_3)_5][ZnCl_4]$ will be :

(a) colourless and diamagnetic

(b) green coloured and diamagnetic

(c) green coloured and shows coordination isomerism

(d) diamagnetic and shows linkage isomerism

36. The most stable ion is :

(a) $[Fe(C_2O_4)_3]^{3-}$ (b) $[Fe(CN)_6]^{3-}$

(c) $[Fe(CN)_6]^{4-}$ (d) $[Fe(H_2O)_6]^{3+}$

37. In the complex $K_2Fe[Fe(CN)_6]$:

(a) both Fe atoms are in the same oxidation state

(b) both Fe atoms are in different oxidation state

(c) the coordination number of ion is 4

(d) the complex is a high spin complex

38. In $Na_2[Fe(CN)_5NO]$, sodium nitroprusside :

(a) oxidation state of Fe is +2 (b) this has NO^+ as ligand

(c) both are correct (d) none is correct

39. An aqueous solution of titanium chloride, when subjected to magnetic measurement, measured zero magnetic moment. Assuming the octahedral complex in aqueous solution, the formulae of the complex is :

(a) $[Ti(H_2O)_6]Cl_2$
(b) $[Ti(H_2O)_6]Cl_4$
(c) $[TiCl_3(H_2O)_3]$
(d) $[TiCl_2(H_2O)_4]$

Structural Isomerism

40. Which of the following pairs of complexes are isomeric with each other but their aqueous solutions exhibit different molar conductivities?

(a) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$
(b) $[CoCl_2(NH_3)_4]NO_2$ and $[CoCl(NO_2)(NH_3)_4]Cl$
(c) $[Co(NO_2)(NH_3)_5]Cl_2$ and $[Co(ONO)(NH_3)_5]Cl_2$
(d) $[CoBr(NH_3)_5]SO_4$ and $[Co(SO_4)(NH_3)_5]Br$

41. The compounds $[Cr(H_2O)_6]Cl_3$, $[Cr(H_2O)_5Cl]Cl_2{\cdot}H_2O$ and $[Cr(H_2O)_4Cl_2]Cl{\cdot}2H_2O$ exhibits :

(a) linkage isomerism
(b) geometrical isomerism
(c) ionization isomerism
(d) hydrate isomerism

42. Which one of the following pairs of isomers and types of isomerism are correctly matched?

(i) $[Co(NH_3)_5(NO_2)]Cl_2$ and $[Co(NH_3)_5(ONO)]Cl_2$...(Linkage)
(ii) $[Cu(NH_3)_4][PtCl_4]$ and $[Pt(NH_3)_4][CuCl_4]$...(Coordination)
(iii) $[PtCl_2(NH_3)_4]Br_2$ and $[PtBr_2(NH_3)_4]Cl_2$...(Ionization)

Select the correct answer using the codes given below :

(a) (ii) and (iii) (b) (i), (ii) and (iii) (c) (i) and (iii) (d) (i) and (ii)

43. The two compounds pentaamminesulphatocobalt (III) bromide and pentaamminesulphatocobalt (III) chloride represent :

(a) Linkage isomerism
(b) Ionization isomerism
(c) Coordination isomerism
(d) No isomerism

44. Select the correct code about complex $[Cr(NO_2)(NH_3)_5][ZnCl_4]$:

(I) IUPAC name of compound is pentaamminenitrito-N-chromium (III) tetrachlorozincate(II)
(II) It shows geometrical isomerism
(III) It shows linkage isomerism
(IV) It shows coordination isomerism

(a) III, IV (b) I, III and IV (c) II, III and IV (d) I, II, III and IV

Werner's Coordination Theory

45. A six coordinate complex of formula $CrCl_3.6H_2O$ has green colour. A 0.1 *M* solution of the complex when treated with excess of $AgNO_3$ gave 28.7g of white precipitate. The formula of the complex would be :

(a) $[Cr(H_2O)_6)]Cl_3$
(b) $[CrCl(H_2O)_5]Cl_2{\cdot}H_2O$
(c) $[CrCl_2(H_2O)_4]Cl{\cdot}2H_2O$
(d) $[Cr(H_2O)_3Cl_3]$

46. A complex has a composition corresponding to the formula $CoBr_2Cl.4NH_3$. What is the structural formula if conductance measurements show two ions per formula unit? Silver nitrate solution given an immediate precipitate of AgCl but no AgBr.

(a) $[CoBrCl(NH_3)_4]Br$
(b) $[CoCl(NH_3)_4]Br_2$
(c) $[CoBr_2Cl(NH_3)_4]$
(d) $[CoBr_2(NH_3)_4]Cl$

47. Mixture X of 0.02 mole of $[Co(NH_3)_5SO_4]Br$ and 0.02 mole of $[Co(NH_3)_5Br]SO_4$ was prepared in 2 litre of solution :
1 litre of mixture X + excess of $AgNO_3 \rightarrow Y$
1 litre of mixture X + excess of $BaCl_2 \rightarrow Z$
Number of moles of Y and Z respectively are :
(a) 0.01, 0.02
(b) 0.02, 0.01
(c) 0.01, 0.01
(d) 0.02, 0.02

48. A Pt complex of ammonia and chlorine produces four ions per molecule in the solution is :
(a) $[Pt(NH_3)_5Cl]Cl_3$
(b) $[Pt(NH_3)_6]Cl_4$
(c) $[Pt(NH_3)_2Cl_4]$
(d) $[Pt(NH_3)_4Cl_2]Cl_2$

Coordination Number

49. The coordination number of a central metal atom in a complex is determined by :
(a) the number of only anionic ligands bonded to the metal ion
(b) the number of monodentate ligands around a metal ion bonded by pi-bonds
(c) the number of monodentate ligands around a metal ion bonded by σ and pi-bonds both
(d) the number of monodentate ligands around a metal ion bonded by σ-bonds

50. Which statement about coordination number of a cation is true?
(a) Most metal ions exhibit only a single characteristic coordination number
(b) The coordination number is equal to the number of ligands bonded to the metal atom
(c) The coordination number is determined solely by the tendency to surround the metal atom with the same number of electrons as one of the rare gases
(d) For most cations, the coordination number depends on the size, and charge of the cation

Synergic Bonding

51. In the isoelectronic series of metal carbonyl, the CO bond strength is expected to increase in the order :
(a) $[Mn(CO)_6]^+ < [Cr(CO)_6] < [V(CO)_6]^-$
(b) $[V(CO)_6]^- < [Cr(CO)_6] < [Mn(CO)_6]^+$
(c) $[V(CO)_6]^- < [Mn(CO)_6]^+ < [Cr(CO)_6]$
(d) $[Cr(CO)_6] < [Mn(CO)_6]^+ < [V(CO)_6]^-$

52. Which is not true about metal carbonyls?
(a) Here CO acts as a Lewis base as well as Lewis acid
(b) Here metal acts as Lewis base as well as Lewis acid
(c) Here $d\pi$-$p\pi$ back bonding takes place
(d) Here $p\pi$-$p\pi$ back bonding takes place

Valence Bond Theory

53. There are four complexes of Ni. Select the complex(es) which will be attracted by magnetic field :
(I) $[Ni(CN)_4]^{2-}$
(II) $[NiCl_4]^{2-}$
(III) $Ni(CO_4)$
(IV) $[Ni(H_2O)_6]^{2+}$
(a) I only
(b) IV only
(c) II, III and IV
(d) II and IV

54. Which of the following complex is an outer orbital complex?
(a) $[Ni(NH_3)_6]^{2+}$
(b) $[Mn(CN)_6]^{4-}$
(c) $[Co(NH_3)_6]^{3+}$
(d) $[Fe(CN)_6]^{4-}$

55. Which of the following complex is an outer orbital complex ?
(a) $[Ni(NH_3)_6]^{2+}$ (b) $[Mn(CN)_6]^{4-}$
(c) $[Co(NH_3)_6]^{3+}$ (d) $[Fe(CN)_6]^{4-}$

56. The magnetic moment of $[MnX_4]^{2-}$ is 5.9 BM. The geometry of the complex ion is :
(X = monodentate halide ion)
(a) tetrahedral (b) square planar (c) both are possible (d) none of these

57. The geometry of $[Ni(CO)_4]$ and $[NiCl_2(PPh_3)_2]$ are :
(a) both square planar
(b) tetrahedral and square planar respectively
(c) both are tetrahedral
(d) square planar and tetrahedral respectively

58. $[Fe(H_2O)_6]^{2+}$ and $[Fe(CN)_6]^{4-}$ differ in :
(a) geometry, magnetic moment (b) geometry, hybridization
(c) magnetic moment, colour (d) hybridization, number of *d*-electrons

59. Which of the following order is correct in spectrochemical series of ligands?
(a) $Cl^- < F^- < C_2O_4^{2-} < NO_2^- < CN^-$ (b) $NO_2^- < C_2O_4^{2-} < Cl^- < F^- < CN^-$
(c) $C_2O_4^{2-} < F^- < Cl^- < NO_2^- < CN^-$ (d) $F^- < Cl^- < NO_2^- < CN^- < C_2O_4^{2-}$

60. The species with spin only magnetic moment of $\sqrt{24}$ BM is :
(a) $[CoF_3(H_2O)_3]$ (b) $[CoCl_4]^{2-}$ (c) $[NiCl_4]^{2-}$ (d) $[Ni(H_2O)_6]^{2+}$

61. For the complexes showing the square pyramidal structure, the *d*-orbital involved in the hybridisation is :
(a) $d_{x^2-y^2}$ (b) d_{z^2} (c) d_{xy} (d) d_{xz}

62. Which of the following aquated metal ions has the highest paramagnetism?
(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
(c) $[Cu(H_2O)_6]^{3+}$ (d) $[Zn(H_2O)_2]^{2+}$

63. The hybridization states of the central atom in the complexes $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$ and $[Co(NO_2)_6]^{3-}$ are :
(a) d^2sp^3, sp^3d^2 and dsp^2 respectively (b) d^2sp^3, sp^3d^2 and sp^3d^2 respectively
(c) d^2sp^3, sp^3d^2 and d^2sp^3 respectively (d) all d^2sp^3

64. Which of the following is incorrectly matched?

Complex	**Number of unpaired electrons**
(a) $[FeF_6]^{3-}$	5
(b) $[Cr(en)_3]^{2+}$	2
(c) $[Co(NH_3)_6]^{3+}$	4
(d) $[Mn(H_2O)_6]^{2+}$	5

65. Which of the following complexes have a maximum number of unpaired electrons?
(a) $[Ni(CO)_4]$ (b) $[Co(NH_3)_4(NO_2)_2]^+$
(c) $[Ag(CN)_2]^-$ (d) $[CuBr_4]^{2-}$

66. The degeneracy of d-orbitals is lost under :
(I) Strong field ligand
(I) Weak field ligand
(III) Mixed field ligand
(IV) Chelated Ligand field
Choose the correct code :
(a) I, II and IV
(b) I and II
(c) I, II, III and IV
(d) I, II and III

67. The complex ion $[Fe(CN)_6]^{4-}$ contains :
(a) total of 36 electrons on Fe^{2+} cation
(b) sp^3d^2 hybrid orbitals with octahedral structure
(c) total of 104 electrons
(d) six sigma bonds

68. In $[Pt(NH_3)_2Cl_2]$, pt—Cl bond length is 2 Å and Cl—Cl distance is 2.88 Å then the compound is :
(a) tetrahedral
(b) square pyramidal
(c) *cis*-square planar
(d) *trans*-square planar

Space/Stereo Isomerism

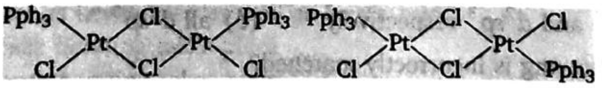
69. Which of the following isomerism, exhibited by $[CrCl_2(OH)_2(NH_3)_2]^-$?
(a) Ionization
(b) Geometrical
(c) Hydrate
(d) Linkage

70. Which kind of isomerism is exhibited by octahedral $[Co(NH_3)_4Br_2]Cl$?
(a) Geometrical and ionization
(b) Geometrical and optical
(c) Optical and ionization
(d) Geometrical only

71. A metal complex of coordination number six having three different types of ligands a, b and c of composition $Ma_2b_2c_2$ can exist in several geometrical isomeric forms; the total number of such isomers is :
(a) 3
(b) 5
(c) 7
(d) 9

72. How many geometrical isomers and stereoisomers are possible for $[Pt(NO_2)(NH_3)(NH_2OH)(Py)]^+$ and $[Pt(Br)(Cl)(I)(NO_2)(NH_3)(Py)]$ respectively?
(a) 3 and 15
(b) 3 and 30
(c) 4 and 15
(d) 4 and 30

73. Complexes given below show :

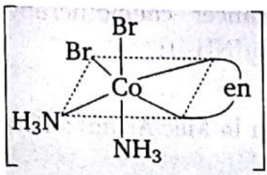


(a) Optical isomerism
(b) Coordinate isomerism
(c) Geometrical isomerism
(d) Bridge isomerism

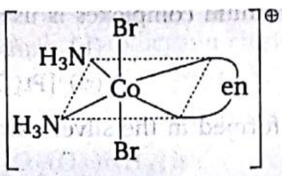
74. Fac and Mer isomerism is associated with which of the following general formula?
(a) $[M(AA)_2]$
(b) $[M(AA)_3]$
(c) $[MABCD]$
(d) $[MA_3B_3]$

75. Which of the following will have two stereoisomeric forms?
(I) $[Cr(NO_3)_3(NH_3)_3]$ (II) $K_3[Fe(C_2O_4)_3]$ (III) $[CoCl_2(en)_2]^+$ (IV) $[CoBrCl(ox)_2]^{3-}$
(a) I only
(b) I and II
(c) III and IV
(d) All of these

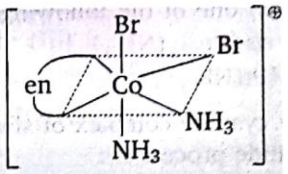
76. Three arrangements are shown for the complex $[CoBr_2(NH_3)_2(en)]^{\oplus}$. Which one is wrong statement?



(I)



(II)



(III)

(a) I and II are geometrical isomers
(b) II and III are optically active isomers
(c) I and III are optically active isomers
(d) II and III are geometrical isomers

77. Which of the following is not optically active?
(a) $[Co(en)_3]^{3+}$
(b) $[Cr(Ox)_3]^{3-}$
(c) *cis*-$[CoCl_2(en)_2]^+$
(d) *trans*-$[CoCl_2(en)_2]^+$

78. Where among the following metal complexes the one which exhibits optical activity is : (AA=bidentate ligand; A, X=monodentate ligand)
(a) *cis*-$[MA_4X_2]$
(b) *trans*-$[MA_4X_2]$
(c) *cis*-$[M(AA)_2X_2]$
(d) *trans*-$[M(AA)_2X_2]$

79. The optically active species among the following is :
(a) $[Cr(NH_3)_6]^{3+}$
(b) $[Co(CN)_6]^{3-}$
(c) $[Co(gly)_3]$
(d) $[Ru(NH_3)_6]^{3+}$

80. *Cis-trans* isomerism is exhibited by :
(a) $[PtCl(NH_3)_3]^+$
(b) $[Pt(NH_3)_4]^{2+}$
(c) $[PtCl_4]^{2-}$
(d) $[PtCl_2(NH_3)_2]$

81. Which of the following will show optical isomers?
(I) *cis*-$[Co(NH_3)_2(en)_2]^{3+}$
(II) *trans*-$[IrCl_2(C_2O_4)_2]^{3-}$
(III) $[Rh(en)_3]^{3+}$
(IV) *cis*-$[Ir(H_2O)_3Cl_3]$
(a) I, III only correct
(b) II, IV only correct
(c) I, III, IV only correct
(d) III only correct

82. The complex with a maximum number of stereoisomers is :
(a) $[PtCl_3(C_2H_4)]^-$
(b) $[CuBr_2Cl_2]^{2-}$
(c) $[Co(C_2O_4)_3]^{3-}$
(d) $[Cr(NH_3)_2(en)_2]^{3+}$

83. A complex with the composition $[MA_3B]^{n\pm}$ is found to have no geometrical isomers. The possible structure(s) of the complex is (Where A and B are monodentate ligands)
(a) Tetrahedral
(b) Square planar
(c) Both (a) and (b)
(d) Cannot be predicted

84. Which of the following isomerism is not possible for complexes having molecular formulae ?
(I) $Pt(SCN)_2 \cdot 3PEt_3$, (II) $CoBr \cdot SO_4 \cdot 5NH_3$ (III) $FeCl_2 \cdot 6H_2O$
(a) Optical
(b) Linkage
(c) Ionisation
(d) Hydrate

Application of Coordination Compounds

85. Coordination compounds have great importance in biological systems. In this context which of the following statements is incorrect?
(a) Carboxypeptidase–A is an enzyme and contains zinc
(b) Haemoglobin is the red pigment of blood and contains iron
(c) Cyanocobalamin is B^{12} and contains cobalt
(d) Chlorophylls are green pigments in plants and contain calcium

86. Which one of the following platinum complexes is used in cancer chemotherapy?

(a) *cis*-$[PtCl_2(NH_3)_2]$ (b) *trans*-$[PtCl_2(NH_3)]$

(c) $[Pt(NH_3)_4]^{2+}$ (d) $[Pt(Cl_4)]^{2-}$

87. The cyanide complex of silver formed in the silver extraction in Mac-Arthur's Forrest cyanide process is :

(a) $[Ag(CN)_2]^-$ (b) $K_2[Ag(CN)_3]$

(c) $[Ag(CN)_4]^{2-}$ (d) $Na_3[Ag(CN)_4]$

88. Complexes formed in the following methods are :

(I) Mond's process for purification of nickel

(II) Removal of unreacted AgBr from photographic plate

(III) Removal of lead poisoning from the body

	I	**II**	**III**
(a)	$Ni(CO)_4$	$[Ag(CN)_2]^-$	$[Pb(EDTA)]^{2-}$
(b)	$Ni(CO)_4$	$[Ag(S_2O_3)_2]^{3-}$	$[Pb(EDTA)]^{2-}$
(c)	$Ni(CO)_6$	$[Ag(S_2O_3)_2]^{3-}$	$[Pb(EDTA)]^{4-}$
(d)	$Ni(CO)_6$	$[Ag(S_2O_3)]^-$	$[Pb(EDTA)]^{2-}$

Oxidation State

89. What is the oxidation number of Fe in $[Fe(H_2O)_5(NO)]^{2+}$ ion?

(a) +2 (b) +3

(c) +1 (d) 0

90. The oxidation state of iron in $Na_4[Fe(CN)_5(NOS)]$ is :

(a) +1 (b) +2

(c) +3 (d) zero

IUPAC Name

91. The correct name for the complex ion $[CoCl(ONO)(en)_2]^+$ is :

(a) chlorobis(ethylenediamine)nitrito-O-cobaltate (III) ion

(b) chlorodiethyldiaminenitrito-O-cobalt (III) ion

(c) chloronitrito-O-diethyldiamine cobaltate (III) ion

(d) chlorobis(ethylenediamine)nitrito-O-cobalt (III) ion

92. IUPAC name of $[Fe(O_2)(CN)_4Cl]^{4-}$ is :

(a) Chlorotetracyano dioxoferrate (II)ion (b) Chlorotetracyano peroxoferrate (II)ion

(c) Chlorotetracyano superoxoferrate (II)ion (d) Tetracyanochloro superoxoferrate (II)ion

93. The IUPAC name of the Wilkinson's catalyst $[RhCl(P\,Ph_3)_3]$ is :

(a) Chlorotris (triphenylphosphine) rhodium (I)

(b) Chlorotris (triphenylphosphine) rhodium (IV)

(c) Chlorotris (triphenylphosphine) rhodium (0)

(d) Chlorotris (triphenylphosphine) rhodium (VI)

94. The correct formula of diammine dichlorodicyano chromate (III) is :

(a) $[CrCl_2(CN)_2(NH_3)_2]^{3+}$ (b) $[CrCl_2(CN)_2(NH_3)_2]^{3-}$

(c) $[CrCl_2(CN)_2(NH_3)_2]$ (d) $[CrCl_2(CN)_2(NH_3)_2]^-$

95. The IUPAC name for $K_2[Cr(CN)_2O_2(O_2)NH_3]$ is :

(a) Potassium amminedicyanotetraoxo chromium (III)

(b) Potassium amminedicyanodioxygendioxo chromate (IV)

(c) Potassium amminedicyanosuperoxoperoxo chromate (III)

(d) Potassium amminedicyanodioxoperoxo chromate (VI)

96. IUPAC name of $H_2[PtCl_6]$ is :

(a) hydrogen hexachloroplatinate (IV) (b) dihydrogen hexachloroplatinate (IV)

(c) hydrogen hexachloroplatinic (IV) acid (d) hexachloroplatinic (IV) acid.

97. The IUPAC name for $[PtCl(NH_2CH_3)(NH_3)_2]Cl$ is :

(a) diamminechloro(methylamine)platinum(II)chloride

(b) (dimethylamine)chlorodiamminoplatinum(II)chloride

(c) bis(ammine)chloro(methylamine)platinate(II)chloride

(d) diaminechloro(mehylamine)platinum(II)chloride

98. The IUPAC nomenclature for the complex $Na[PtBrCl(NO_2)(NH_3)]$ is :

(a) Sodium amminechlorobromonitro-N-platinum(II)

(b) Sodium nitrochlorobromoammine-N-platinate(II)

(c) Sodium amminebromochloronitro-N-platinate(II)

(d) Sodium amminebromochloronitro-N-platinum(II)

99. The IUPAC name of $Xe[PtF_6]$ is :

(a) Hexafluoroplatinate(VI)xenon (b) Xenonhexafluoroplatinate(V)

(c) Xenonhexafluoroplatinate(VI) (d) Xenoniumhexafluoroplatinum(V)

Hybridisation

100. The magnetic moment of $[NiX_4]^{2-}$ ion is found to be zero. Then the ion is :

(X = monodentate anionic ligand)

(a) sp^3 hybridised (b) spd^2 hybridised

(c) dsp^2 hybridised (d) d^2sp hybridised

101. The hybridised orbitals used by silver in the complex $[Ag(NH_3)_2]^+$ are of the type :

(a) sp^2 (b) sp (c) sp^3 (d) dsp^2

Level 2

Classification of Ligands

1. Which of the following ligand does not as π-acid ligand ?

(a) N_2 (b) CO (c) C_2H_4 (d) O_2^{2-}

Sidwick's Rule of EAN

2. If E.A.N.of central metal cation M^{2+} in a non-chelating complex is 36 and atomic no. of metal M is 26, then the number of monodentate ligand is in this complex are :

(a) 5 (b) 4 (c) 6 (d) None of these

3. $[Mn(CO)_4NO]$ is diamagnetic because :

(a) Mn metal is diamagnetic in free state

(b) Mn is in +1 oxidation state in this complex

(c) NO is present as positive ligand

(d) All of the above

4. Choose the correct option regarding the following complex compound which follows (F) and does not follow (NF) the Sidgwick EAN rule :

(I) $[(Ph_3P)_2PdCl_2PdCl_2]$ (II) $[NiBrCl(en)]$

(III) $Na_4[Fe(CN)_5NOS]$ (IV) $Cr(CO)_3(NO)_2$

	(I)	(II)	(III)	(IV)		(I)	(II)	(III)	(IV)
(a)	NF	NF	NF	NF	(b)	F	F	NF	F
(c)	NF	NF	F	F	(d)	NF	NF	F	NF

5. If CO ligands are substituted by NO in respective neutral carbonyl compounds then which of the following will not be correct formula ?

(a) $Cr(CO)_3(NO)_2$ (b) $Fe(CO)_2(NO)_2$

(c) $Cr(NO)_4$ (d) $Ni(CO)_2(NO)_2$

6. Which of the following species can act as reducing agent ?

(a) $[Co(CO)_4]^-$ (b) $Mn(CO)_6$ (c) $Mn(CO)_5$ (d) $Cr(CO)_6$

Crystal Field Theory

7. What is electronic arrangement of metal atom/ion in octahedral complex with d^4 configuration, if $\Delta_0 <$ pairing energy?

(a) $t_{2g}^4 e_g^0$ (b) $e_g^4 t_{2g}^0$ (c) $t_{2g}^3 e_g^1$ (d) $e_g^2 t_{2g}^2$

8. Which of the following statement is not correct?

(a) Bis(glycinatio)Zinc(II) is optically active

(b) $[NiCl_4]^{2-}$ and $[PtCl_4]^{2-}$ have different shape

(c) $[Ni(CN)_4]^{4-}$ is square planar complex

(d) $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$ have the same magnetic moment

9. Give the correct of initials **T** or **F** for following statements. Use **T** if statement is true and **F** if it is false.

(I) Co(III) is stabilised in presence of weak field ligands, while Co(II) is stabilised in presence of strong field ligand.

(II) Four coordinated complexes of Pd(II) and Pt(II) are diamagnetic and square planar.

(III) $[Ni(CN)_4]^{4-}$ ion and $[Ni(CO)_4]$ are diamagnetic tetrahedral and square planar respectively.

(IV) Ni^{2+} ion does not form inner orbital octahedral complexes.

(a) TFTF (b) TTTF

(c) TTFT (d) FTFT

10. Match List-I with List-II and select the correct answer using the codes given below :

List-I	List-II
(I) $[FeF_6]^{3-}$	(A) 1.73 BM
(II) $[Ti(H_2O)_6]^{3+}$	(B) 5.93 BM
(III) $[Cr(NH_3)_6]^{3+}$	(C) 0.00 BM
(IV) $[Ni(H_2O)_6]^{2+}$	(D) 2.83 BM
(V) $[Fe(CN)_6]^{4-}$	(E) 3.88 BM

	(I)	(II)	(III)	(IV)	(V)		(I)	(II)	(III)	(IV)	V
(a)	B	A	C	D	E	(b)	B	A	E	D	C
(c)	B	C	D	E	A	(d)	D	E	A	B	C

11. The value of 'spin only' magnetic moment for one of the following configuration is 2.84 BM. The correct one is :

(a) d^4 (in strong field ligand)

(b) d^2 (in weak field ligand)

(c) d^3 (in weak as well as in strong field ligand)

(d) d^5 (in strong field ligand)

12. The correct order of magnetic moments (spin values in BM) among is :

(a) $[Fe(CN)_6]^{4-} > [CoCl_4]^{2-} > [MnCl_4]^{2-}$ (b) $[MnCl_4]^{2-} > [Fe(CN)_6]^{4-} > [CoCl_4]^{2-}$

(c) $[Fe(CN)_6]^{4-} > [MnCl_4]^{2-} > [CoCl_4]^{2-}$ (d) $[MnCl_4]^{2-} > [CoCl_4]^{2-} > [Fe(CN)_6]^{4-}$

13. Which of the following statements is incorrect?

(a) The stability constant of $[Co(NH_3)_6]^{3+}$ is greater than that of $[Co(NH_3)_6]^{2+}$

(b) The cyano complexes are far more stable than those formed by halide ions

(c) The stability of halide complexes follows the order $I^- < Br^- < Cl^-$.

(d) The stability constant of $[Cu(NH_3)_4]^{2+}$ is greater than that of $[Cu(en)_2]^{2+}$

14. Set of d-orbitals which is used by central metal during formation of MnO_4^- ?

(a) $d_{x^2-y^2}, d_{z^2}, d_{xy}$ (b) d_{xy}, d_{yz}, d_{xz} (c) $d_{x^2-y^2}, d_{xy}, d_{xz}$ (d) $d_{x^2-y^2}, d_{z^2}, d_{xz}$

15. $FeSO_4$ is a very good absorber for NO, the new compound formed by this process is found to contain number of unpaired electrons :

(a) 4 (b) 5 (c) 3 (d) 6

16. A $[M(H_2O)_6]^{2+}$ complex typically absorbs at around 600 nm. It is allowed to react with ammonia to form a new complex $[M(NH_3)_6]^{2+}$ that should have absorption at :
(a) 800 nm (b) 580 nm (c) 620 nm (d) 320 nm

17. An ion M^{2+}, forms the complexes $[M(H_2O)_6]^{2+}$, $[M(en)_3]^{2+}$ and $[MBr_6]^{4-}$, match the complex with the appropriate colour :
(a) Green, blue and red (b) Blue, red and green
(c) Green, red and blue (d) Red, blue and green

18. The CFSE for $[(CoCl)_6]^{4-}$ complex is 18000 cm^{-1}. The Δ for $[CoCl_4]^{2-}$ will be :
(a) 18000 cm^{-1} (b) 16000 cm^{-1} (c) 8000 cm^{-1} (d) 2000 cm^{-1}

19. MnO_4^- is of intense pink colour, though Mn is in (+7) oxidation state, it is due to :
(a) Oxygen gives colour to it
(b) Charge transfer when Mn(+7) gives its electron to oxygen and oxidise to Mn (+8) temporarily
(c) Charge transfer when oxygen gives its electron to Mn (+7) changing in Mn (+6)
(d) None is correct explanation

20. In which of the following complex ion the value of magnetic moment (spin only) is $\sqrt{3}$ B.M. and outer *d*-orbitals is used in hybridization:
(a) $[Fe(NH_3)_6]^{3+}$ (b) $[Mn(CN)_6]^{4-}$ (c) $[CuCl_5]^{2-}$ (d) $[Co(NH_3)_6]^{2+}$

21. Which of the following order of CFSE is incorrect ?
(a) $[Co(en)_3]^{3+} > [Co(NH_3)_6]^{3+} > [Co(H_2O)_6]^{3+}$
(b) $[PtCl_4]^{2-} > [PdCl_4]^{2-} > [NiCl_4]^{2-}$
(c) $[Ni(DMG)_2] < [Ni(en)_2]^{2+}$
(d) $[Co(ox)_3]^{3-} < [Co(en)_3]^{3+}$

22. For which of the following d^n configuration of octahedral complexes, can not exist in both high spin and low spin forms :
(I) d^3 (II) d^5 (III) d^6 (IV) d^8
(a) I, II & III (b) II, III & IV
(c) I & IV (d) None of these

Coordination Number

23. Consider the complex $[Co(NH_3)_4CO_3]ClO_4$, in which coordination number, oxidation number and number of *d*-electrons on the metal are respectively.
(a) 6, 3, 6 (b) 6, 2, 7 (c) 5, 3, 6 (d) 5, 3, 7

Synergic Bonding

24. The π-acid ligand which uses its *d*-orbital during synergic bonding in its complex compound.
(a) CN^- (b) PR_3 (c) NO (d) N_2

25. The IR stretchin frequencies of free CO, and CO in $[V(CO)_6]^-$, $[Cr(CO)_6]^-$ and $[Mn(CO)_6]^-$ are 2143 cm^{-1}, 1860 cm^{-1}, 2000 cm^{-1} and 2090 cm^{-1}, respectively. Then correct statement about metal carbonyls is :
(a) 'C—O' bond is strongest in the cation and weakest in the anion.

(b) 'C—O' bond is weakest in the cation and strongest in the anion.
(c) 'C—O' bond is longer in the cation than in the anion.
(d) 'M—C' pi bonding is higher in the cation.

26. The π-acid ligand which uses its *d*-orbital during synergic bonding in its complex compound:
(a) NO^+ (b) PR_3 (c) C_6H_6 (d) CO

27. Correct sequence of CO bond order in given compounds is :
(P) $Fe(CO)_5$ (Q) CO (R) $H_3B \leftarrow CO$ (S) $[Mn(CO)_5]^-$
(a) P>R>S>Q (b) S>P>R>Q
(c) Q>S>P>R (d) R>Q>P>S

Valence Bond Theory

28. Select correct statement(s) regarding $[Ni(DMG)_2]$ complex compound :
(a) It acts as oxidising agent because Ni^{2+} cation is having E.A.N. 34.
(b) It is extra stabilized by hydrogen bonding
(c) It's IUPAC name is Bis(dimethylglyoximato)nickelate (II)
(d) It's ligand contains two different donar sites

29. In which of the following complex ion the value of magnetic moment (spin only) is $\sqrt{3}$ BM and outer *d*-orbitals is used in hybridization.
(a) $[Mn(CN)_6]^{4-}$ (b) $[Fe(NH_3)_6]^{3+}$ (c) $[Co(CO)_4]$ (d) $[Cu(H_2O)_6]^{2+}$

30. The inner orbital complex which exhibits both geometrical as well as optical isomerism.
(a) $[Cr(en)_3]^{3+}$ (b) $[IrF_3(H_2O)_2(NH_3)]$
(c) $[NiCl_2(en)_2]$ (d) $[Co(CN)_2(ox)_2]^{3-}$

31. Select correct statement regarding $[Ni(DMG)_2]$ complex compound.
(a) It acts as oxidising agent because Ni^{2+} cation is having EAN 34.
(b) It is extra-stabilized by hydrogen bonding
(c) It's IUPAC name is Bis (dimethylglyoximato) nickelate (II)
(d) It's ligand contains two different donar sites

32. Which of the following is correctly matched?
(a) $[Fe(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$ — both are octahedral and diamagnetic with d^2sp^3-hybridisation
(b) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ — both are tetrahedral and diamagnetic with sp^3-hybridisation
(c) $Ni(CO)_4$ and $[Co(CO)_4]^-$ — both are tetrahedral and diamagnetic
(d) $[Co(H_2O)_6]^{3+}$ and $[Cr(H_2O)_6]^{3+}$ — both are paramagnetic and metal is d^2sp^3-hybridised

33. Match List-I with List-II and select the correct answer using the codes given below the lists :

List-I (Compound)	List-II (of Central atom)
(A) $[Ni(NH_3)_6]^{2+}$	(1) sp^3
(B) $[PtCl_4]^{2-}$	(2) sp^3d^2
(C) $[Ni(CO)_4]$	(3) dsp^2
(D) $[Co(ox)_3]^{3-}$	(4) d^2sp^3

	A	B	C	D		A	B	C	D
(a)	2	1	3	4	(b)	2	3	1	4
(c)	4	1	3	2	(d)	4	3	1	2

34. Match List-I (Species) with List-II (Hybrid orbitals used by the central atom in their formation) and select the correct answer :

List-I	List-II
(A) $Ni(CN)_5^{3-}$	(1) sp^3
(B) $CuCl_5^{3-}$	(2) dsp^2
(C) $AuCl_4^-$	(3) $sp^3d_{z^2}$
(D) ClO_4^-	(4) $d_{x^2-y^2}sp^3$

	A	B	C	D		A	B	C	D
(a)	1	3	2	4	(b)	3	4	2	1
(c)	4	2	1	3	(d)	4	3	2	1

35. Which of the following is correctly matched?

Column-I	Column-II	Column-III
(a) $[Cr(CO)_6]$	Paramagnetic	Octahedral, sp^3d^2
(b) $[Fe(CO)_5]$	Paramagnetic	Trigonal bipyramid, sp^3d
(c) $[Co(CO)_4]^-$	Diamagnetic	Tetrahedral, sp^3
(d) $[Ni(CO)_4]$	Diamagnetic	Square planar, dsp^2

36. The hybridization of the complex $[CrCl_2(NO_2)_2(NH_3)_2]^-$ is :

(a) sp^3d^2 (b) d^2sp^3

(c) sp^3d (d) cannot be predicted

37. Which of the following statement is not true for the reaction given below?

$$[Cu(H_2O)_4]^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+} + 4H_2O$$

(a) It is a ligand substitution reaction

(b) NH_3 is a relatively strong field ligand while H_2O is a weak field ligand

(c) During the reaction, there is a change in colour from light blue to dark blue

(d) $[Cu(NH_3)_4]^{2+}$, has a tetrahedral structure and is paramagnetic

38. Which of the following match is incorrect ?

Complex compounds		**Type of hybridization**
(a) $[V(NH_3)_6]^{3+}$	:	d^2sp^3
(b) $[CrCl_3(NMe_3)_3]$	:	d^2sp^3
(c) $[Cu(CN)(NO_2)(NH_3)(py)]$	:	dsp^2
(d) $K_3[Co(ox)_3]$	:	sp^3d^2

Structural Isomerism

39. Select the correct code of TRUE and FALSE for given statements :

(a) Peroxide ion as well as dioxygen molecule both are paramagnetic species

(b) In set of isomers, $[Cr(H_2O)_6]Cl_3$ and $[CrCl(H_2O)_5]Cl_2 \cdot H_2O$, both compounds can easily loose water molecule on treatment with conc. H_2SO_4

(c) During transformation $NO \longrightarrow NO^+$, bond length and magnetic behaviour decreases

(d) An ether is more volatile than alcohol both having same molecular formula

(a) FFTT (b) FTFT (c) FTTT (d) TFFT

40. The total possible coordination isomers for the following compounds respectively are :

$[Co(en)_3][Cr(C_2O_4)_3]$

$[Cu(NH_3)_4][CuCl_4]$

$[Ni(en)_3][Co(NO_2)_6]$

(a) 4, 4, 4 (b) 2, 2, 2 (c) 2, 2, 4 (d) 4, 2, 3

41. Select the incorrect match :

(a) $[Co(NO_2)(H_2O)(en)_2]Cl_2$, $[CoCl(NO_2)(en)_2]Cl \cdot H_2O$: Hydrate isomerism

(b) $[Cu(NH_3)_4][PtCl_4]$, $[CuCl(NH_3)_3][PtCl_3(NH_3)]$: Co-ordination isomerism

(c) $[Ni(CN)(H_2O)(NH_3)_4]Cl$, $[NiCl(H_2O)(NH_3)_4]CN$: Ionization isomerism

(d) $[Cr(NO_2)(NH_3)_5][ZnCl_4]$, $[Cr(NO_3)(NH_3)_5][ZnCl_4]$: Linkage isomerism

42. Select incorrect statement about complex $[Cr(NO_2)(NH_3)_5][Zn(SCN)_4]$:

(a) It shows co-ordination isomerism

(b) It shows optical activity

(c) It shows linkage isomerism

(d) IUPAC name of the compound is Pentaaminenitrito-N-chromium(III) tetrathiocyanato-S-zincate(II)

Space/Stereo Isomerism

43. Complex compound(s) having even number of space (stereo) isomers is/are :
(where *AA*-symmetrical bidentate ligand and a, b, c, d, e-monodentate ligands)

(a) $[M(AA)_2b_2]^{n\pm}$ (b) $[Ma_3b_3]^{n\pm}$ (c) $[Ma_3bcd]^{n\pm}$ (d) $[Ma_2bcde]^{n\pm}$

44. Which of the following isomersm is not possible for complexes having molecular formulae :

(i) $Pt(SCN)_2 \cdot 3PEt_3$ (ii) $CoBr \cdot SO_4 \cdot 5NH_3$ (iii) $FeCl_2 \cdot 6H_2O$

(a) Optical (b) Linkage (c) Ionisation (d) Hydrate

45. Unmatched characteristic of complex $[PdCl_2(H_2O)_2(NH_3)_2]^{2+}$ is :

(a) Diamagnetic (b) Low spin

(c) Geometrical isomerism (d) Fac. and Mer. form

46. Which of the following has largest number of isomers ?

(a) $[Co(en)_2Cl_2]^+$ (b) $[Co(NH_3)_5Cl]^{2+}$

(c) $[Ir(PR_3)_2H(CO)]^{2+}$ (d) $[Ru(NH_3)_4Cl_2]^+$

47. Which one of the following complexes exhibit chirality?

(a) $[Cr(ox)_3]^3$ (b) *cis*-$[PtCl_2(en)]$

(c) *cis*-$[RhCl_2(NH_3)_4]^+$ (d) *mer*-$[Co(NO_2)_3(dien)]$

48. Consider the following isomerism :

(i) Ionization (ii) Hydrate (iii) Coordination (iv) Geometrical (v) Optical

Which of the above isomerisms are exhibited by $[Cr(NH_3)_2(OH)_2Cl_2]^-$?

(a) (i) and (v) (b) (ii) and (iii) (c) (iii), (ii) and (i) (d) (iv) and (v)

49. Which complex is likely to show optical activity?

(a) *trans*-$[Co(NH_3)_4Cl_2]^+$
(b) $[Cr(H_2O)_6]^{3+}$
(c) *cis*-$[Co(NH_3)_2(en)_2]$
(d) *trans*-$[Co(NH_3)_2(en)_2]^{3+}$

50. Which of the following statement is true ?

(a) In $[PtCl_2(NH_3)_2]^{2+}$ the *cis* form is optically inactive while *trans* form is optically active
(b) In $[Fe(C_2O_4)_3]^{3-}$, geometrical isomerism does not exist while optical isomerism exists
(c) In *Mabcd*, square planar complexes show both optical as well as geometrical isomerism
(d) In *Mabcd* tetrahedral complex, optical isomerism cannot be observed

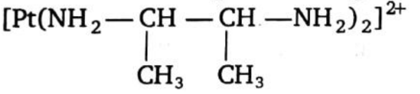
51. The following complexes are given :

(1) *trans*-$[Co(NH_3)_4Cl_2]^+$
(2) *cis*-$[Co(NH_3)_2(en)_2]^{3+}$
(3) *trans*-$[Co(NH_3)_2(en)_2]^{3+}$
(4) $NiCl_4^{2-}$
(5) TiF_6^{2-}
(6) CoF_6^{3-}

Choose the correct code :

(a) (1), (2) are optically active, (3) is optically inactive
(b) (2) is optically active; (1), (3) are optically inactive
(c) (4), (5) are coloured and (6) is colourless
(d) (4) is coloured and (5), (6) are colourless

52. Which of the following can show geometrical isomerism?

(a) 
$[Pt(NH_2-\underset{CH_3}{\underset{|}{CH}}-\underset{CH_3}{\underset{|}{CH}}-NH_2)_2]^{2+}$
(b) $[Co(en)_2NH_3Cl]^{2+}$
(c) Both (a) and (b)
(d) None of these

53. Which of the following complex compound exhibits *cis-trans* isomerism?

(a) $[CoCl(NH_3)_4(H_2O)]$
(b) $[CoCl_3(NH_3)_3]$
(c) $[CoCl_2(NH_3)_4]$
(d) All of these

54. Which of the following will have three stereoisomeric forms?

(i) $[Cr(NO_3)_3(NH_3)_3]$
(ii) $K_3[Co(C_2O_4)_3]$
(iii) $K_3[CoCl_2(C_2O_4)_2]$
(iv) $[CoBrCl(en)_2]$

(a) (iii) and (iv) (b) (i), (iii) and (iv) (c) (iv) only (d) All four

55. A coordination complex of type MX_2Y_2 (*M*-metal ion; *X*, *Y*-monodentate ligands), can have either a tetrahedral or a square planar geometry. The maximum number of possible isomers in these two cases are respectively :

(a) 1 and 2 (b) 2 and 1 (c) 1 and 3 (d) 3 and 2

56. The ratio of *cis* and *trans*-isomers of the complex $[Ma_2bcde]^{n\pm}$ is :

(a) 5 : 3 (b) 2 : 1 (c) 7 : 3 (d) 3 : 1

57. $[PdCl_2(PMe_3)_2]$ is a diamagnetic complex of Pd(II). How many total isomers are possible of analogous paramagnetic complex of Ni(II)?

(a) Zero (b) 1 (c) 2 (d) 3

58. Complex compounds(s) which is optical active and does not depend upon the orientation of the ligands around metal cation :

(i) $[CoCl_3(NH_3)_3]$ (ii) $[Co(en)_3]Cl_3$

(iii) $[Co(C_2O_4)_2(NH_3)_2]^-$ (iv) $[CrCl_2(NH_3)_2(en)]^+$

(a) (ii), (iii) and (iv) (b) (i), (ii) and (iv) (c) (ii) and (iv) (d) only (ii)

59. Choose the correct code regarding, possible number of geometrical isomers exhibited by following complexes :

(I) $[CrCl_2(NO_2)_2(NH_3)_2]^-$ (II) $[Co(NO_2)_3(NH_3)_3]$

(III) $[PtCl(NO_2)(NH_3)(py)]$ (IV) $[PtBrCl(en)]$

	(I)	(II)	(III)	(IV)		(I)	(II)	(III)	(IV)
(a)	4	2	3	1	(b)	5	2	4	0
(c)	3	2	0	1	(d)	5	2	3	0

60. How many geometrical isomers are possible for complex $[Mab(AB)_2]^{n\pm}$?

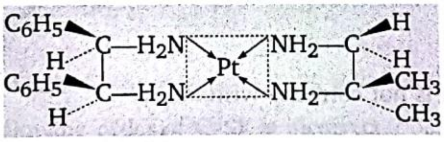
(a) 5 (b) 4 (c) 3 (d) 6

61. $[CoCl_2(NH_3)_4]^+ + Cl^- \longrightarrow [CoCl_3(NH_3)_3] + NH_3$. If in this reaction two isomers of the product are obtained, which is true for the initial (reactant) complex :

(a) compound is in *cis*-form (b) compound is in *trans*-form

(c) compound is in both (*cis* and *trans*) form (d) can't be predicted

62. Select the correct statement about given square planar complex.



(a) It has no geometrical isomer

(b) It is optically active because it does not have plane of symmetry

(c) It is optically inactive because square planar complex have plane of symmetry

(d) It is optically active because it has symmetric carbon

63. Select the correct code regarding total number of space isomers for the following compounds :

(I) $[Ma_3b_2c]^{n\pm}$ (II) $[M(AB)_3]^{n\pm}$ (III) $[Ma_2b_2c_2]^{n\pm}$

	(I)	(II)	(III)		(I)	(II)	(III)
(a)	4	4	6	(b)	4	3	5
(c)	3	3	5	(d)	3	4	6

64. How many geometrical isomers are possible or $[Pd^{2+}(NH_2—CH(CH_3)—CO_2^-)_2]$

(a) 2 (b) 3 (c) 4 (d) 6

65. Total number of stereoisomers of $[Co(acac)_2BrCl)]^{\ominus}$ are :

(a) 4 (b) 3 (c) 6 (d) 2

66. Which of the following complex compound exhibits geometrical isomerism ?

(a) $[Fe(DMG)_2]$ (b) $[Be(gly)_2]$

(c) $[PdClBr(gly)]$ (d) $[Cd(NH_3)Cl(gly)]$

67. In which case racemic mixture is obtained on mixing its mirror images (d & l form) in 1 : 1 molar ratio?

(a) *trans* - $[Co(gly)_3]$ (b) $[Ni(DMG)_2]$

(c) *cis* - $[Cu(gly)_2]$ (d) $[Zn(en)(gly)]^+$

68. Which of the following compound show optical isomerism?

(a) *cis* - $[CrCl_3(NHl_3)_3]$ (b) *cis* - $[Co(NH_3)_4Cl_2]^+$

(c) $[Co(en)_3]^{3+}$ (d) *trans* - $[Co(en)_2Cl_2]^+$

Application of Coordination Compounds

69. Match List-I with List-II and select the correct answer using the codes given below :

List-I (Ion involved)		List-II (agent)
(i)	Ni^{2+}	(A) Sodium thiosulphate
(ii)	Ag^+	(B) Sodium nitroprusside
(iii)	Cu^{2+}	(C) Ammonia
(iv)	S^{2-}	(D) Dimethylglyoxime

	(i)	(ii)	(iii)	(iv)		(i)	(ii)	(iii)	(iv)
(a)	C	A	D	B	(b)	D	C	A	B
(c)	D	C	B	A	(d)	D	A	C	B

IUPAC Name

70. A complex whose IUPAC name is not correctly written is :

	Complex	Name
(a)	$Fe(\sigma - C_5H_5)_2$	Bis(η^5-cyclopentadienyl)iron(0)
(b)	$Cr(C_6H_6)_2$	Bis(η^6-benzene)chromium(0)
(c)	$[CoCl_2(H_2O)_4]Cl.2H_2O$	Tetraaquadichlorocobalt (III)chloride-2-water
(d)	$[Zn(NCS)_4]^{2-}$	Tetrathiocyanato-*N*-zincate (II) ion

71. Which of the following is correct IUPAC name of any complex compound?

(a) Tris(acetylacetonato)iron(III)chloride

(b) Hexachloroplatinum(IV)tetraammine dicyano platinate(IV)

(c) Ammine bromochloro methylamine platinum(II)

(d) *cis*-dichloro (ethylenediamine) platinum (II)

72. Find out correct IUPAC name of complex compound .

(a) Triamminetricyanidochromium(III)hexanitrito-N-irridate(III)

(b) Pentaamminecyanidochromium(III)hexanitrito-N-irridium(III)

(c) Hexanitrito-N-irridium(III)pentaamminecyanidochromate(II)

(d) Pentaamminecyanidochromium(III)hexanitrito-*n*-irridate(III)

Level 3

PASSAGE 1

Magnetic moment, ionic conductance and colligative properties are useful in deciding structure/constitution of a given unknown complex compound.

1. If molar conductivity of complex is almost equal to that of NaCl and it does not exhibits stereoisomerism then the complex will be :

(a) $[Co(CO_3)(en)_2]Br$ (b) $[Co(CO_3)(H_2O)_2(NH_3)_2]Br$

(c) $[Co(CN)(NH_3)_5]Br_2$ (d) $[Co(CO_3)(NH_3)_4]Br$

2. A metal M having electronic configuration $(n-1)d^8ns^2$ forms complexes with co-ordination No. = 4 and 6, if it forms diamagnetic complexes then permissible oxidation states of metal cation and geometry is :

(a) +2, octahedral (b) +4, octahedral (c) +2, square planar (d) (b) and (c) both

3. The cyano complex that exhibit highest value of paramagnetism is :

(a) $[Mn(CN)_6]^{4-}$ (b) $[Co(CN)_6]^{3-}$ (c) $[Fe(CN)_6]^{3-}$ (d) $[Cr(CN)_6]^{3-}$

PASSAGE 2

The crystal field theory assumes interaction between metal ion and the ligands as a purely electrostatic and ligands are supposed to be point charges.

1. Which of the following order of CFSE is incorrect ?

(a) $[Cr(NO_2)_6]^{3-} > [Cr(NH_3)_6]^{3+} > [Cr(H_2O)_6]^{3+}$

(b) $[PtF_4]^{2-} > [PdF_4]^{2-} > [NiF_4]^{2-}$

(c) $[Ni(DMG)_2] < [Ni(en)_2]^{2+}$

(d) $[Co(EDTA)]^- > [Co(en)_3]^{3+}$

2. Which of the following match are incorrect ?

Complex Compound	Magnetic Moment
(a) $[VCl_3(NMe_3)_3]$	$\sqrt{8}$ BM
(b) $[CrCl_3(NMe_3)_3]$	$\sqrt{15}$ BM
(c) $[Cu(CN)(NO_2)(NH_3)(Py)]$	$\sqrt{3}$ BM
(d) $[Co(ox)(H_2O)_4]^+$	$\sqrt{24}$ BM

3. Amongst the following complexes which has square planar geometry ?

(a) $[RhCl(CO)(PPh_3)_2]$ (b) $K_2[Cu(SCN)_4]$

(c) $K_2[Ni(PH_3)_2Cl_2]$ (d) MnO_4^{2-}

PASSAGE 3

The magnetic property, dipole moment, plane of symmetry, colour and absorption band can be helpful in structure elucidation of complex compounds.

1. Which of the following complex ion is expected to absorb light in 4000 Å to 7800 Å region ?

(a) $[Ti(en)_3]^{4+}$
(b) $[Cr(H_2O)_6]^{3+}$
(c) $[Sc(NH_3)_4(H_2O)_2]^{3+}$
(d) $[Zn(en)_2(NH_3)_2]^{2+}$

2. Compound 'X' has molecular formula $CrCl_2Br \cdot 6H_2O$ can show type of isomerism.

(i) hydrate isomerism
(ii) ionization isomerism
(iii) geometrical isomerism
(iv) optical isomerism
(a) (i), (ii) and (iii) only
(b) (i) and (ii) only
(c) (i), (ii), (iii) and (iv)
(d) (i) and (iii) only

3. Complex compound(s) having even number of space (stereo) isomers is/are :
(Where *AA*-symmetrical bidentate ligand and *a*, *b*, *c*, *d* *e*-monodentate ligands)

(a) $[M(AA)_2b_2]^{n\pm}$
(b) $[Ma_3b_3]^{n\pm}$
(c) $[Ma_3bcd]^{n\pm}$
(d) $[Ma_2bcde]^{n\pm}$

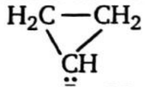
PASSAGE 4

Ligands are broadly classified into two classes classical and non-classical ligands, depending on their donor and acceptor ability. Classical ligands form classical complexes while non-classical ligands form non-classical complexes. Bonding mechanism in non-classical is called synergic bonding.

1. Synergic bonding is absent in :

(a) $[Mo(CO)_6]$
(b) $[Cr(CO)_3(B_3N_3H_6)]$
(c) $[Sc(CO)_6]^{3+}$
(d) $[Ni(CN)_4]^{4-}$

2. Which is not π-acceptor ligand ?

(a) 

(b) $\sigma - C_5H_5^-$
(c) PH_3
(d) $B_3N_3H_6$

3. In compound $[M(CO)_n]^z$, the correct match for highest '*M*—C' bond length for given *M*, *n* and *z* respectively :

	M	*n*	*z*
(a)	Cr	6	0
(b)	V	6	−1
(c)	Ti	6	−2
(d)	Mn	6	+1

PASSAGE 5

An isomer of the complex $CoBrCl_2(en)_2(H_2O)$, on reaction with concentrated H_2SO_4 (dehydrating agent), suffers no loss in weight and on reaction with $AgNO_3$ solution it gives only white precipitate, which is soluble in NH_3 solution.

1. The incorrect statement about complex is :
   (a) It can show geometrical isomerism
   (b) cis isomer is optically active
   (c) Trans isomer is optically active
   (d) It can exhibit solvate isomerism
2. The correct formula of the complex is :
   (a) $[CoBrH_2O(en)_2]Cl_2$
   (b) $[CoCl(en)_2H_2O]BrCl$
   (c) $[CoBrCl(en)_2]Cl \cdot H_2O$
   (d) $[CoCl_2(en)_2]Br \cdot H_2O$

PASSAGE 6

Crystal field theory provides correct electronic distribution of central metal under surrounding ligand field, hence it clearly explains magnetic moment, colour of a complex.

1. Which of the following complex is high spin ?
   (a) $K_4[Fe(CN)_6]$
   (b) $[PtCl_4]^{2-}$
   (c) $[CoF_6]^{3-}$
   (d) $[Ni(NH_3)_6]^{2+}$
2. In which of the following complex transition of electron occurs from one shell to other shell of central metal.
   (a) $[Fe(H_2O)_5(NO)]^{2+}$
   (b) $[Co(H_2O)_6]^{2+}$
   (c) $[Rh(NH_3)_6]^{2+}$
   (d) $[Ni(CN)_6]^{4-}$
3. Which of the following hydrated complex ion has high intensity colour in aqueous solution.
   (a) $[Mn(H_2O)_6]^{3+}$
   (b) $[Co(H_2O)_6]^{2+}$
   (c) $[Ni(H_2O)_6]^{2+}$
   (d) $[Mn(H_2O)_6]^{2+}$

PASSAGE 7

Two important physical evidences supporting the synergic bonding in non-classical complexes are bond lengths and vibrational spectra. Vibrational spectra is based on the fact that the compression and extension of a bond may be analogous to the behavior of a spring and obeys Hook's law.

$$\bar{\nu} = \frac{1}{2\pi c}\sqrt{\frac{k}{\mu}}\ \text{cm}^{-1}$$

where, k = force constant of the bond which is directly proportional to bond strength of CO
μ = reduced mass of ligand
$\bar{\nu}$ = stretching frequency of the CO bond
c = velocity of light

1. In which of the following complex stretching frequency for CO ligand is least as well as bond energy of M—C bond is higher .
   (a) (dien) $Mo(CO)_3$
   (b) $(Et_3P)_3Mo(CO)_3$
   (c) $(F_3P)_3Mo(CO)_3$
   (d) $(Cl_3P)_3Mo(CO)_3$
2. In $Mn_2(CO)_{10}$ carbonyl complex, the d-orbital of Mn-atom which can not be involved in synergic bonding between Mn and CO ligands :
   (a) d_{xz}
   (b) d_{xy}
   (c) d_{yz}
   (d) None of these

3. In which of the following ligand, σ-bond order does not change during synergic bonding in their respective complexes :
(a) CO (b) N_2
(c) $CH_2 = CH_2$ (d) PEt_3

PASSAGE 8

Complex compounds that have the same molecular formula but have different structural/ space arrangements of ligands around central metal atom/ ion are called isomers, these are of two types namely structural and stereoisomers.

1. Which of the following is different among structural isomers?
(a) Oxidisation state (b) Co-ordination number
(c) IUPAC name (d) None of these

2. Types of isomerism exhibited by $[CrCl_2(NO_2)_2(NH_3)_2]^-$ complex ion are :
(a) ionisation, optical (b) hydrate, optical
(c) geometrical, optical (d) co-ordinate, geometrical

3. Complex species that exhibits isomerism is :
(a) $[Ag(NH_3)_2]^+$ (b) $[Co(NO_2)(NH_3)_5]^{2+}$ (c) $[PtCl_2(en)]$ (d) $[CoCl(NH_3)_5]^{2+}$

PASSAGE 9

A complex compound of chromium contains five NH_3 molecules, one nitro group and two chloride ions for one Cr^{3+} cation. One molecule of this compound produces three ions in aq. solution, on reacting with excess of $AgNO_3$ solution, two moles of AgCl get precipitated.

1. The formula of the complex compound is :
(a) $[CrCl(NO_2)(NH_3)_4]NH_3 \cdot Cl$ (b) $[CrCl(NH_3)_5]Cl \cdot NO_2$
(c) $[Cr(NO_2)(NH_3)_5]Cl_2$ (d) $[Cr(NH_3)_5]NO_2 \cdot Cl_2$

2. The types of isomerism shown by the complex compound is:
(a) geometrical, ionization (b) ionization, linkage
(c) linkage, optical (d) geometrical, optical

3. Magnetic moment of complex compound is :
(a) 0 BM (b) $\sqrt{24}$ BM (c) $\sqrt{15}$ BM (d) $\sqrt{3}$ BM

PASSAGE 10

According to C.F.T. , attraction between the central metal ion and ligands in a complex is purely electrostatic. The transition metal which forms the central atom cation in the complex is regarded as a positive ion. It is surrounded by negative ligands or neutral molecules which have a lone pair of electrons, if the ligand is a neutral molecule such as NH_3, the negative end of the dipole in the molecule is directed towards the metal cation. The electrons on the central metal ion are under repulsive forces from those on the ligands. Thus the electrons occupy the *d*-orbitals remain away from the direction of approach of ligands.

1. Correct relationship between pairing energy (P) and C.F.S.E (Δ_o) in complex ion $[Ir(H_2O)_6]^{3+}$ is :
(a) $\Delta_o < P$ (b) $\Delta_o > P$ (c) $\Delta_o = P$ (d) cannot comment
2. The crystal field-spliting order for Cr^{3+} cation is octahedral field for ligands CH_3COO^-, NH_3 H_2O, CN^- is :
(a) $CH_3COO^- < H_2O < NH_3 < CN^-$ (b) $CH_3COO^- < NH_3 < H_2O < CN^-$
(c) $H_2O < CH_3COO^- < NH_3 < CN^-$ (d) $NH_3 < CH_3COO^- < H_2O < CN^-$
3. The value of 'x' in the complex H_x $[Co(CO)_4]$ (on the basis of EAN rule) ; and geometry arround Co ion respectively is :
(a) 1, square planar (b) 2, tetrahedral (c) 1, tetrahedral (d) 2 , square planar

PASSAGE 11

An isomer of the complex $Co(en)_2(H_2O)ICl_2$, on reaction with concentrated H_2SO_4 it suffers loss in weight and on reaction with $AgNO_3$ solution gives a yellow precipitate, which is insoluble in NH_3 solution .

1. If all the ligands in the co-ordination sphere of the above complex are replaced by CN^- ion, then the magnetic moment of the complex ion will be :
(a) 0.0 BM (b) 5.9 BM (c) 4.9 BM (d) 1.73 BM
2. If one mole of original complex is treated with excess $Pb(NO_3)_2$ solution, then the number of moles of white precipitate formed will be :
(a) 2.0 (b) 1.0 (c) 0.0 (d) 3.0
3. Total number of space isomers of the formula of the above complex is :
(a) 2 (b) 3 (c) 4 (d) 1

PASSAGE 12

In complexes of weak field ligands, $\Delta_O < P$ (Pairing energy), the energy difference between t_{2g} and e_g sets is relatively less. Under the influence of strong field ligands, $\Delta_O > P$ (Pairing energy), the energy difference between t_{2g} and e_g sets is relatively high.

1. Which of the following is correct statement ?
(a) Complex $[Co(H_2O)_6]^{2+}$ is more stable than $[Co(H_2O)_6]^{3+}$
(b) All complexes of Ni (II) are bound to be outer *d*-orbital complexes.
(c) Stability constant for $[Ni(en)_3]^{2+}$ is greater than stability constant for $[Ni(NH_3)_6]^{2+}$
(d) Δ_{oct} for $[Cr(H_2O)_6]^{3+}$ is greater than Δ_{oct} for $[Cr(NH_3)_6]^{3+}$
2. Select the correct increasing order of 10 Dq. value for chromium complexes:
(1) $[Cr(en)_3]^{3+}$ (2) $[Cr(ox)_3]^{3-}$ (3) $[CrF_6]^{3-}$ (4) $[Cr(H_2O)_6]^{3+}$
(a) 4< 3< 1< 2 (b) 3< 4< 2< 1 (c) 4< 3< 2< 1 (d) 3< 4< 1< 2

3. Select the correct statement regarding $[Cr(en)_2Cl_2]^+$ and $[Co(C_2O_4)_2(NH_3)_2]^-$ complex ions:

(a) Both are equally stable complexes
(b) Both have equal number of stereoisomers
(c) Both are diamagnetic complexes
(d) (a) and (c) both

PASSAGE 13

Complex compounds are molecular compounds which retain their identities even when dissolved in water. They do not give all the simple ions in solution but instead furnish complex ions. The complex compounds are often called coordination compounds because certain groups called ligands are attached to the central metal ion by coordinate or dative bonds. Coordination compounds exhibit isomerism, both structural and stereoisomerism. The structure, magnetic property, colour and electrical properties of complexes are explained by various theories.

1. Arrange the following compounds in order of their molar conductance :

(i) $K[Co(NO_2)_4(NH_3)_2]$
(ii) $[Cr(ONO)_3(NH_3)_3]$
(iii) $[Cr(NO_2)(NH_3)_5]_3[Co(NO_2)_6]_2$
(iv) $Mg[Cr(NO_2)_5(NH_3)]$

(a) (ii) < (i) < (iv) < (iii)
(b) (i) < (ii) < (iii) < (iv)
(c) (ii) < (i) < (iii) < (iv)(d) (iv) < (iii) < (ii) < (i)

2. The oxidation number, coordination number and magnetic moment in the following complex is :

$$[Cr(C_2O_4)_2(NH_3)_2]^-$$

(a) O.N. $= +3$, C.N. $= 6$, M.M. $= \sqrt{15}$ BM
(b) O.N. $= -1$, C.N. $= 6$, M.M. $= \sqrt{15}$ BM
(c) O.N. $= +3$, C.N. $= 6$, M.M. $= \sqrt{3}$ BM
(d) O.N. $= +3$, C.N. $= 6$, M.M. $= \sqrt{12}$ BM

3. In which of the following pairs, both the complexes have the same geometry?

(a) $[NiCl_4]^{2-}, [Ni(CN)_4]^{2-}$
(b) $[CoF_6]^{3-}, [Co(NH_3)_6]^{3+}$
(c) $[Ni(CO)_4], [Ni(CN)_4]^{2-}$
(d) $[Cu(NH_3)_4]^+, [Ni(NH_3)_4]^{2+}$

PASSAGE 14

Recent X-ray work, IR and other spectroscopic methods have proved that Turnbull's blue is identical to Prussian blue.

1. What is the common formula of Turnbull's blue and Prussian blue?

(a) $Fe_3[Fe(CN)_6]_2$
(b) $Fe_4[Fe(CN)_6]_3$
(c) $KFe[Fe(CN)_6]$
(d) $KFe_2[Fe(CN)_6]$

2. Intense blue colour arises as a result of :

(a) electron transfer between Fe(II) and Fe(I)
(b) electron transfer between Fe(II) and Fe(III)
(c) *d-d* transition
(d) spin magnetic moment

PASSAGE 15

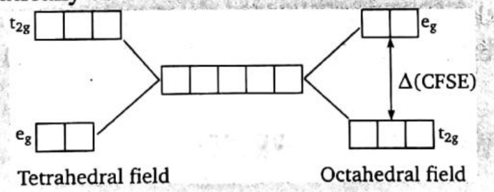
On the basis of stability of complex ion in the solution, complexes may be of two types, perfect and imperfect complexes. The stability depends upon the extent of dissociation which in turn depends upon the strength of metal-ligand bond. The stability of complex also depends upon charge on central metal atom, basic nature of ligand, chelation, and nature of metal ion and ligand according to HSAB principle.

1. Which one of the following does not follow EAN rule?
(a) $Fe(CO)_5$ (b) $V(CO)_6$ (c) $K_4[Fe(CN)_6]$ (d) $Mn_2(CO)_{10}$

2. Which complex is most stable?
(a) $[Cu(CN)_2]^- \; K_d = 1 \times 10^{-16}$
(b) $[Fe(CN)_6]^{4-} \; K_d = 1 \times 10^{-37}$
(c) $[Fe(CN)_6]^{3-} \; K_d = 1 \times 10^{-44}$
(d) $[Ag(CN)_2]^- \; K_d = 1 \times 10^{-20}$

PASSAGE 16

When degenerate *d*-orbitals of an isolated atom/ion come under influence of magnetic field of ligands, the degeneracy is lost. The two set $t_{2g}(d_{xy}, d_{yz}, d_{xz})$ and $e_g(d_{z^2}, d_{x^2-y^2})$ are either stabilized or destabilized depending upon the nature of magnetic field. It can be expressed diagrammatically as :



Value of CFSE depends upon nature of ligand and a spectrochemical series has been made experimentally, for tetrahedral complexes, Δ is about 4/9 times to Δ_0 (CFSE for octahedral complex). This energy lies in visible region and *i.e.,* why electronic transition are responsible for colour. Such transitions are not possible with d^0 and d^{10} configuration.

1. The value of CFSE (Δ_0) for complexes given below follow the order :
(I) $[Co(NH_3)_6]^{3+}$ (II) $[Rh(NH_3)_6]^{3+}$ (III)$[Ir(NH_3)_6]^{3+}$
(a) $I < II < III$ (b) $I > II > III$
(c) $I < II > III$ (d) $I = II = III$

2. Cr^{3+} form four complexes with four different ligands which are $[Cr(Cl)_6]^{3-}$, $[Cr(H_2O)_6]^{3+}$, $[Cr(NH_3)_6]^{3+}$ and $[Cr(CN)_6]^{3-}$. The order of CFSE (Δ_0) in these complexes is in the order :
(a) $[CrCl_6]^{3-} = [Cr(H_2O)_6]^{3+} = [Cr(NH_3)_6]^{3+} = [Cr(CN)_6]^{3-}$
(b) $[CrCl_6]^{3-} < [Cr(H_2O)_6]^{3+} < [Cr(NH_3)_6]^{3+} < [Cr(CN)_6]^{3-}$
(c) $[CrCl_6]^{3-} > [Cr(H_2O)_6]^{3+} > [Cr(NH_3)_6]^{3+} > [Cr(CN)_6]^{3-}$
(d) $[CrCl_6]^{3-} < [Cr(H_2O)_6]^{3+} = [Cr(NH_3)_6]^{3+} < [Cr(CN)_6]^{3-}$

3. The *d*-orbitals, which are stabilized in an octahedral magnetic field, are :

(a) d_{xy} and d_{z^2} (b) $d_{x^2-y^2}$ and d_{z^2}

(c) d_{xy}, d_{xz} and d_{yz} (d) d_{z^2} only

4. For an octahedral complex, which of the following *d*-electron configuration will give maximum CFSE?

(a) High spin d^6 $-0.4\Delta_O$ (b) Low spin d^4 $-1.6\Delta_O$ (c) Low spin d^5 $-2.0\Delta_O$ (d) High spin d^7 $-0.8\Delta_O$

5. Ti^{3+} (*aq.*) is purple while Ti^{4+} (*aq.*) is colourless because :

(a) There is no crystal field effect in Ti^{4+}

(b) The energy difference between t_{2g} and e_g Ti^{4+} is quite high and does not fall in the visible region

(c) Ti^{4+} has d^0 configuration

(d) Ti^{4+} is very small in comparison to Ti^{3+} and hence does not absorb any radiation

6. Which of the following is correct arrangement of ligand in terms of the Dq values of their complexes with any particular 'hard' metal ion :

(a) $Cl^- < F^- < NCS^- < NH_3 < CN^-$ (b) $NH_3 < F^- < Cl^- < NCS^- < CN^-$

(c) $Cl^- < F^- < NCS^- < CN^- < NH_3$ (d) $NH_3 < CN^- < NCS^- < Cl^- < F^-$

7. The extent of crystal field splitting in octahedral complexes of the given metal with particular weak field ligand are :

(a) Fe(III) < Cr(III) < Rh(III) < Ir(III) (b) Cr(III) < Fe(III) < Rh(III) < Ir(III)

(c) Ir(III) < Rh(III) < Fe(III) < Cr(III) (d) Fe(III) = Cr(III) < Rh(III) < Ir(III)

ONE OR MORE ANSWERS IS/ARE CORRECT

1. Consider the following two reactions :

$$Cd^{2+}(aq.) + 4CH_3NH_2 \xrightarrow{K_1} \text{'}A\text{'}, \Delta G_1^\circ$$

$$Cd^{2+}(aq.) + 2H_2NCH_2CH_2NH_2 \xrightarrow{K_2} \text{'}B\text{'}, \Delta G_2^\circ$$

According to given information the correct statement(s) is/are :

(a) ΔG_2° is more negative than ΔG_1°

(b) Compound '*A*' is optically inactive

(c) Compound '*B*' is optically active

(d) Formation constant K_2 is greater than formation constant K_1

2. Complex compound $[Co(SCN)_2(NH_3)_4]Cl$ exhibits :

(a) Ionization isomerism (b) Geometrical isomerism

(c) Optical isomerism (d) Linkage isomerism

3. Which of the following compound has/have effective atomic number equal to the atomic number of a noble gas ?

(a) $K[Co(CO)_4]$ (b) $K_2[Fe(CO)_4]$

(c) $[Co(NH_3)_6]Cl_2$ (d) $[CoCl_3(H_2O)_3]$

4. Select correct statement(s) regarding octahedron complex having CFSE = $-1.2\Delta_0$.
(a) Compound is neither low spin nor high spin complex
(b) Type of hybridisation complex does not depend upon nature of ligands
(c) Magnetic moment of complex compounds is either $\sqrt{15}$ B.M. or $\sqrt{8}$ B.M.
(d) All are incorrect statements

5. Consider the following two carbonyl compounds
(i) $[Tc(CO)_6]^+$ and (ii) $[Nb(CO)_6]^-$
Select incorrect statement(s) for given carbonyl compounds.
(a) $[Tc(CO)_6]^+$ acts as reducing agent and $[Nb(CO)_6]^-$ acts as oxidizing agent
(b) $[Nb(CO)_6]^-$ acts as reducing agent and $[Tc(CO)_6]^+$ acts as oxidizing agent
(c) "Nb—C" bond order in $[Nb(CO)_6]^-$ is greater than "Tc—C" bond order in $[Tc(CO)_6]^+$
(d) "CO" bond order is greater in $[Nb(CO)_6]^-$ than in $[Tc(CO)_6]^+$

6. Which of the following ligand(s) can act as π-acid ligand. ?
(a) σ-cyclopentadienyl
(b) π-Allyl
(c) $B_3N_3H_6$
(d) π-cyclopentadienyl

7. Find out correct I.U.P.A.C. name of complex compound.
(a) Pentaamminecyanidochromium(II) hexanitrito-N-irridate(III)
(b) Triamminetricyanidochromium(III)hexanitrito-N-irridate(III)
(c) Hexanitrito-N-irridium(III)pentaamminecyanidochromate(II)
(d) Pentaamminecyanidochromium(III) hexanitrito-N-irridate(III)

8. Consider the following reactions of complex compounds A, B and C
(i) $CoCl_2Br \cdot 5NH_3 + \text{excess } Ag^+(aq.) \longrightarrow 1AgCl(s)$
(Compound A)
(ii) $CoCl_2Br \cdot 5NH_3 + \text{excess } Ag^+(aq.) \longrightarrow 2AgCl(s)$
(Compound B)
(iii) $CoCl_2Br \cdot 4NH_3 + \text{excess } Ag^+(aq.) \longrightarrow 1AgCl(s)$
(Compound C)
Then according to the given information the correct statement(s) is/are :
(a) Compounds (A) and (B) are ionisation isomers
(b) Molar conductivity of compounds (A) and (B) are almost same
(c) Compounds (A), (B) and (C) do not exhibit geometrical isomerism
(d) Order of CFSE values : $\Delta_0(A) > \Delta_0(B) > \Delta_0(C)$

9. Which complex species does/do not exhibit geometrical isomerism and only have two stereoisomers.
(a) $[Co(EDTA)]^-$
(b) $[PtBrCl(gly)]^-$
(c) $[Co(acac)_2(en)]^+$
(d) $[Pd(NO_2)(ox)(gly)]$

10. Which of the following complex(s) can not exhibit both geometrical and optical isomerism ?
(a) $[Ru(en)_3]^{3+}$ (b) $[Co(H_2O)Cl_3]$ (c) $[PtBrCl(H_2O)NH_3]$ (d) $[FeBr_2(en)_2]^+$

11. Complex ions $[NiCl_6]^{4-}$, $[Ni(CN)_6]^{4-}$ similar in their given properties :
(a) oxidation state, geometry
(b) co-ordination number , EAN
(c) magnetic moment, geometry
(d) stability , colour

12. Select correct statement(s) regarding given complexes:

(a) $[Fe(CO)_5]$, the orbitals used for hybridization in Fe atom are $s, p_x, p_y, p_z, d_{z^2}$ and it is high spin complex

(b) $[Pt(NH_3)_2Cl_2]$, the orbitals used for hybridization on Pt atom are $s, p_x, p_y, d_{x^2-y^2}$ and it is low spin complex

(c) $[Cr(H_2O)_6]^{3+}$, the orbitals used for hybridization in Cr atom are $s, p_x, p_y, p_z, P_{z^2}, d_{x^2-y^2}$ and it is high spin complex

(d) $Ni(CO)_4$, the orbitals used for hybridization in Ni atom are, s, p_x, p_y, p_z, and it is low spin complex

13. Complex compound $[Co(SCN)_2(NH_3)_4]Cl$ exhibits :

(a) ionization isomerism
(b) geometrical isomerism
(c) optical isomerism
(d) linkage isomerism

14. Which of the following compound has/have effective atomic number equal to the atomic number of a noble gas ?

(a) $K[Co(CO)_4]$
(b) $K_2[Fe(CO)_4]$
(c) $[Co(NH_3)_6]Cl_2$
(d) $[CoCl_3(H_2O)_3]$

15. $K_2[Ni(CN)_4] \xrightarrow[NH_3]{\text{K in liq.}}$ 'X'

Regarding this reaction correct statement is/are:

(a) 'X' is $K_4[Ni(CN)_4]$

(b) The oxidation state of Ni changed +2 to zero

(c) The structure of 'X' is tetrahedral

(d) $[Ni(CN)_4]^{2-}$ is square planar complex

16. Which of the following statement(s) is/are correct?

(a) The oxidation state of iron in sodium nitro prusside $Na_2[Fe(CN)_5(NO)]$ is +II

(b) $[Ag(NH_3)_2]^+$ is linear in shape

(c) In $[Fe(H_2O)_6]^{3+}$, Fe is d^2sp^3 hybridized

(d) In $[Co(H_2O)_6]^{3+}$ complex ion, Co is d^2sp^3 hybridized

17. Which one of the following statement(s) is/are false?

(a) Weak ligands like F^-, Cl^- and OH^- usually form low spin complexes

(b) Strong ligand like CN^- and NO_2^-, generally form high spin complexes

(c) $[FeF_6]^{3-}$ is high spin complex

(d) $[Ni(CO)_4]$ is high spin complex

18. A *d*-block element forms octahedral complex but its magnetic moment remains same either in strong field or in weak field ligand. Which of the following is/are correct?

(a) Element always forms colourless compound

(b) Number of electrons in t_{2g} orbitals are higher than in e_g orbitals

(c) It can have either d^3 or d^8 configuration

(d) It can have either d^7 or d^8 configuration

19. For which of the following d^n configuration of octahedral complex(es), cannot exist in both high spin and low spin forms?
(a) d^3 (b) d^5 (c) d^6 (d) d^8

20. Which of the following pairs show coordination isomerism?
(a) $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$
(b) $[Co(NH_3)_3(H_2O)_2Cl]Br_2$ and $[Co(NH_3)_3(H_2O)Cl\cdot Br]Br\cdot H_2O$
(c) $[Pt(NH_3)_4Cl_2]Br_2$ and $[Pt(NH_3)_3B_2]Cl_2$
(d) $[Co(NH_3)_6][Cr(C_2O_4)_3]$ and $[Cr(NH_3)_6][Co(C_2O_4)_3]$

21. Which of the following are coordination isomers of $[Co(NH_3)_6][Cr(CN)_6]$?
(a) $[Cr(NH_3)_6][Co(CN)_6]$ (b) $[Cr(NH_3)_4(CN)_2][Co(CN)_4(NH_3)_2]$
(c) $[Cr(NH_3)_3(CN)_3][Co(NH_3)_3(CN)_3]$ (d) None of these

22. Which of the following statements is not true about the complex ion $[CrCl(NO_2)(en)_2]^+$?
(a) It has two geometrical isomers *cis* and *trans*
(b) *cis* and *trans* forms are not diastereomers to each other
(c) Only the *cis* isomer displays optical activity
(d) It has three optically active isomers : d, l and *trans* forms

23. Which of the following statement(s) is/are incorrect?
(a) In $[CoBrCl(en)_2]^+$ geometrical isomerism exists, while optical isomerism does not exist
(b) Potassium aquadicyanosuperoxoperoxoperoxoch-romate(III) is IUPAC name $K_2[Cr(N)_2O_2(O_2)(H_2O)]$
(c) There are 3 geometrical and 15 stereoisomers possible for $[Pt(NO_2)(NH_3)(NH_2OH)(py)]^+$ and $[PtBrClI(NO_2)(NH_3)(py)]$ respectively
(d) *cis* and *trans* forms are not diastereomers to each other

24. Which of the following statement is true about the complex $[CrCl_3(OH)_2(NH_3)]^{2-}$ ion?
(a) It has three geometrical isomers
(b) Only one space isomers is optically active and remaining are inactive
(c) There are total four space isomers
(d) The magnetic moment of complex ion is 3.89 BM

25. Which of the following is correct about
Tetraamminedithiocyanato-*s* cobalt (III) tris(oxalato)cobaltate(III)?
(a) Formula of the complex is $[Co(SCN)_2(NH_3)_4][Co(ox)_3]$
(b) It is a chelating complex and show linkage isomerism
(c) It shows optical isomerism
(d) It shows geometrical isomerism

26. Which of the following statement(s) is/are false?
(a) In $[PtCl_2(NH_3)_4]^{2+}$ complex ion, the *cis*-form is optically active, while *trans*-form is optically inactive
(b) In $[Fe(C_2O_4)_3]^{3-}$, geometrical isomerism does not exist, while optical isomerism exists
(c) In $[Mabcd]^{n\pm}$ tetrahedral complexes, optical isomerism cannot be observed
(d) In $[Mabcd]^{n\pm}$ square planar complexes, optical isomerism can be observed

27. Which of the following statement(s) is/are true?

(a) In metal carbonyl complexes d_{C-O} increases compared to that in CO molecule

(b) The pair of compounds $[Cr(H_2O)_6]Cl_3$ and $[CrCl_3(H_2O)_3]\cdot 3H_2O$ show hydrate isomerism

(c) d_{z^2} orbital of central metal atom/ion is used in dsp^2 hybridisation

(d) Facid and Meridional isomers associated with $[Ma_3b_3]^{n\pm}$ type complex compound, both are optically inactive

28. Select the correct statement :

(a) Chelation effect is maximum for five and six membered rings

(b) Greater the charge on the central metal cation, greater the value of Δ (CFSE)

(c) In complex ion $[CoF_6]^{3-}$, F^- is a weak field ligand, so that $\Delta_{oct} < P$ (Pairing energy) and it is low spin complex

(d) $[CoCl_2(NH_3)_2(en)]^{\oplus}$ complex ion will have four different isomers

29. Which of the following statement(s) is/are true?

(a) In ferrocyanide ion, the effective atomic number is 36

(b) Chelating ligands are atleast bidentate ligand

(c) $[CrCl_2(CN)_2(NH_3)_2]^{\ominus}$ and $[CrCl_3(NH_3)_3]$ both have d^2sp^3 hybridisation

(d) As the number of rings in complex increases, stability of complex (chelate) also increases

30. In test of NO_3^- ion, the dark brown ring complex is formed, which is true of this complex?

(a) The colour is due to charge transfer spectra

(b) Iron and NO both have +1 charge

(c) The complex species can be represented as $[Fe^{I}(H_2O)_5NO]^{2+}$

(d) Iron has +2 oxidation state and NO is neutral

31. The complex(es) which is/are blue in colour :

(a) $Fe_4[Fe(CN)_6]_3$ (b) $Zn_2[Fe(CN)_6]$

(c) $Cu_2[Fe(CN)_6]$ (d) $Fe_3[Fe(CN)_6]_2$

32. What is/are the coordination number(s) of Au in the complexes formed by Au?

(a) 6 (b) 4 (c) 5 (d) 2

33. The *d*-orbitals involved in sp^3d^2 or d^2sp^3 hybridisation of the central metal ion are :

(a) $d_{x^2-y^2}$ (b) d_{xy}

(c) d_{yz} (d) d_{z^2}

34. Which is not correctly matched ?

Complex compounds	**IUPAC name**
(a) $K[CrF_4O]$	Potassium tetrafluorooxo chromate (v)
(b) $Na[BH(OCH_3)_3]$	Sodium hydido trimethoxy borate (III)
(c) $[Be(CH_3-CO-CH-CO-C_6H_5)_2]^0$	Bis (Benzoylacetonato beryllium (III)
(d) $H[AuCl_4]$	Hydrogen tetrachloro aurate (III)

35. Which of the following statement(s) is(are) correct?

(a) The complexes $[NiCl_4]^{2-}$ and $[NiCN_4]^{2-}$ differ in the magnetic properties

(b) The complexes $[NiCl_4]^{2-}$ and $[NiCN_4]^{2-}$ differ in the geometry

(c) The complexes $[NiCl_4]^{2-}$ and $[NiCN_4]^{2-}$ differ in primary valencies of nickel

(d) The complexes $[NiCl_4]^{2-}$ and $[NiCN_4]^{2-}$ differ in the state of hybridization of nickel

36. Which is correct statement(s)?

(a) $[Ag(NH_3)_2]^+$ is linear with *sp* hybridised Ag^+ ions

(b) $NiCl_4^{2-}$, CrO_4^{2-} and MnO_4^- have tetrahedral geometry

(c) $[Cu(NH_3)_4]^{2+}$, $[Pt(NH_3)_4]^{2+}$ and $[Ni(CN)_4]^{2-}$ have dsp^2 hybridisation of the metal ion

(d) $Fe(CO)_5$ has trigonal bipyramidal structure with $d_{z^2}sp^3$ hybridised ion

MATCH THE COLUMN

Column-I and **Column-II** contains four entries each. Entries of Column-I are to be matched with one or more than one entries of Column-II. Each entry of Column-I may have the matching with one or more than one entries of Column-II.

1.

Column-I	Column-II
(A) Co^{2+} (aq.)	(P) Pink/Light Pink
(B) Mn^{2+} (aq.)	(Q) Purple
(C) V^{2+} (aq.)	(R) Outer orbital complex and M.M. $=\sqrt{15}$ B.M.
(D) Ti^{3+} (aq.)	(S) Iinner orbital complex and M.M. $=\sqrt{3}$ B.M.
	(T) Paramagnetic

2.

Column-I	Column-II (Characteristics of complex ion compound)
(A) $[Pt(NO_2)_2(en)]^{2+}$	(P) Stable according to E.A.N. rule
(B) $[Cr(\pi\text{-}C_6H_6)(NO)_2]$	(Q) Ligand acts as ambidentate
(C) $[Ir(SCN)(SO_4)(NH_3)_4]$	(R) Bond order of M—L bond > 1.0
(D) $[Cr(C_2H_4)(CO)_5]$	(S) Bond order of ligand decreases
	(T) Co-ordination number of central metal is six

3.

Column-I (Complex compounds)	**Column-II (Characteristics of complex)**
(A) $[PtBrCl(acac)(H_2O)_2]NO_3$	(P) Difference between optical isomers and optically active isomers is two
(B) $[IrBr_2(en)(H_2O)(NH_3)]Br$	(Q) Only *cis* configurations are optically active.
(C) $[CrCl_2(acac)(H_2O)_2]$	(R) Exhibit structural isomerism.
(D) $[Pt(ox)_2(NH_3)_2]$	(S) Two trans are optically inactive.
	(T) Optically active when both monodentate neutral ligands are at adjacent sites in cis configuration.

4.

Column-I	**Column-II**
(A) $[Cr(CN)_3(NO_2)_3]^{4-}$	(P) Outer orbital complex
(B) $[Co(C_2O_4)_3]^{3-}$	(Q) Inner orbital complex
(C) $[Fe(EDTA)]^-$	(R) $\mu = 2.83$ BM
(D) $[Ni(en)_3](NO_3)_2$	(S) Shows optical activity
	(T) $\mu = 0$

5.

Column-I (complex ion)	**Column-II (CFSE and hybridisation)**
(A) $[Cr(NH_3)_6]^{3+}$	(P) $0.0\ \Delta_o$, sp^3d^2-hybridisation
(B) $[Cu(NH_3)_6]^{2+}$	(Q) $-0.6\ \Delta_o$, sp^3d^2-hybridisation
(C) $[Fe(H_2O)_6]^{3+}$	(R) $-1.2\ \Delta_o$, d^2sp^3-hybridisation
(D) $[IrF_6]^{3-}$	(S) Diamagnetic
	(T) Paramagnetic

6.

Column-I	**Column-II**
(A) $[MnCl_4]^{2-}$	(P) sp^3hybridisation
(B) $[Ni(CN)_4]^{2-}$	(Q) Diamagnetic
(C) $[Ni(CO)_4]$	(R) Paramagnetic
(D) $[Cu(NH_3)_4]^{2+}$	(S) dsp^2 hybridisation

7.

Column-I	**Column-II**
(A) $[Fe(CN)_6]^{4-}$	(P) Paramagnetic
(B) $[Fe(H_2O)_6]^{2+}$	(Q) Diamagnetic
(C) $[Cu(NH_3)_6]^{2+}$	(R) Inner orbital complex
(D) $[Ni(CN)_6]^{4-}$	(S) Outer orbital complex

8.

Column-I	**Column-II**
(A) $[Ni(H_2O)_6]Cl_2$	(P) d^2sp^3 hybridisation
(B) $[Co(CN)_2(NH_3)_4]OC_2H_5$	(Q) Ionisation isomerism
(C) $[IrCl_6]^{3-}$	(R) $\mu = 2.83$ BM
(D) $[PtCl_2(NH_3)_4]Br_2$	(S) $\Delta_O < P$

9.

Column-I	**Column-II**
(A) $[Cr(gly)_3]^0$	(P) Low spin complex
(B) $[CoBr_2Cl_2(SCN)_2]^{3-}$	(Q) High spin complex
(C) $[Fe(NH_3)_6]^{3+}$	(R) Optical isomerism
(D) $Na[PtBrCl(NO_2)(NH_3)]$	(S) Geometrical isomerism

10.

Column-I	**Column-II**
(A) Sodium nitroprusside	(P) $\mu = 0$ BM
(B) Brown ring complex	(Q) Octahedral
(C) Complex of Ag formed during its extraction	(R) $\mu = \sqrt{15}$ BM
(D) Potassium ferrocyanide	(S) NO^+ ligand

11.

Column-I **(Pair of complex compounds)**	**Column-II** **(Property which is different in given pair)**
(A) $[Ni(CO)_4]$ and $K_2[Ni(CN)_4]$	(P) Magnetic moment
(B) $[Cu(NH_3)_4]SO_4$ and $K_3[Cu(CN)_4]$	(Q) Oxidation no. of central metal
(C) $K_2[NiCl_4]$ and $K_4[Ni(CN)_4]$	(R) Geometry
(D) $K_2[NiCl_4]$ and $K_2[PtCl_4]$	(S) EAN of central metal

12.

Column-I (Pair of complexes)	**Column-II (Property which is similar in given pair)**
(A) $[Fe(CN)_6]^{3-}$ and $[Co(NH_3)_6]^{2+}$	(P) Magnetic moment
(B) $[Fe(H_2O)_6]^{2+}$ and $[Fe(CN)_6]^{4-}$	(Q) Geometry
(C) $[Ni(CN)_4]^{4-}$ and $[Ni(CO)_4]$	(R) Hybridisation
(D) $[Ni(H_2O)_6]^{2+}$ and $[NiCl_4]^{2-}$	(S) Number of *d*-electrons

13.

Column-I (Coordination compound)	**Column-II (Type of isomerism shown)**
(A) $Na_2[Pt(SCN)_2(ox)_2]$	(P) Ionization isomerism
(B) $[CrCl_2(NH_3)_4]NO_3$	(Q) Linkage isomerism
(C) $[Pt(NO_2)(Gly)(NH_3)]$	(R) Geometrical isomerism
(D) $K_3[Fe(OH)_2(C_2O_4)_2]$	(S) Optical isomerism

14.

Column-I	**Column-II**
(A) $K_3[Fe(CN)_5(CO)]$	(P) Complex having lowest bond length of CO ligand
(B) $K[PtCl_3(C_2H_4)]$	(Q) Follow rule of EAN
(C) $Na[Co(CO)_4]$	(R) Complex involved in synergic bonding
(D) $V(CO)_6$	(S) Complex having highest bond length of CO ligand

15.

Column-I (Molar conductance at infinite dilution)	**Column-II (Complex compound)**
(A) 229	(P) $[Pt(NH_3)_5Cl]Cl_3$
(B) 0	(Q) $[Pt(NH_3)_2Cl_4]$
(C) 404	(R) $[Pt(NH_3)_4Cl_2]Cl_2$
(D) 523	(S) $[Pt(NH_3)_6]Cl_4$

16.

Column-I (Complex ions)	Column-II (Number of unpaired electrons)
(A) $[CrF_6]^{4-}$	(P) One
(B) $[MnF_6]^{4-}$	(Q) Two
(C) $[Cr(CN)_6]^{4-}$	(R) Three
(D) $[Mn(CN)_6]^{4-}$	(S) Four
	(T) Five

17.

Column-I (Complexes)	Column-II (Hybridization of central atom)
(A) $Ni(CO)_4$	(P) sp^3
(B) $[Ni(CN)_4]^{2-}$	(Q) dsp^2
(C) $[Fe(CN)_6]^{4-}$	(R) sp^3d^2
(D) $[MnF_6]^{4-}$	(S) d^2sp^3

18.

Column-I (Coordination compounds)	Column-II (Type of isomerism)
(A) $[Co(NH_3)_4Cl_2]$	(P) Optical isomerism
(B) $[Co(en)_3]Cl_2$	(Q) Ionization isomerism
(C) $[Co(en)_2(NO_2)Cl]SCN$	(R) Coordination isomerism
(D) $[Co(NH_3)_6][Cr(CN)_6]$	(S) Geometrical isomerism

ASSERTION-REASON TYPE QUESTIONS

These questions consist of two statements each, printed as assertion and reason, while answering these questions you are required to choose any one of the following responses :

(A) If assertion is true but the reason is false

(B) If assertion is false but reason is true

(C) If both assertion and reason are true and the reason is the correct explanation of assertion

(D) If both assertion and reason are true but reason is not the correct explanation of assertion

1. **Assertion :** In N_2 molecule, any N-atom can coordinate with central atom/ion.
   Reason : N_2 molecule can also act as ambidentate ligand.
2. **Assertion :** In N_2H_4, any one N-atom can coordination with central metal cation in a coordination compound.

Reason : N_2H_4 can also act as ambidentate ligand.

3. **Assertion** : $[Ti(H_2O)_6]^{4+}$ is coloured while $[Sc(H_2O)_6]^{3+}$ is colourless.
Reason : d -d transition is not possible in $[Sc(H_2O)_6]^{3+}$.

4. **Assertion** : Acidified $[Cu(NH_3)_4]^{2+}$ and $[Cu(H_2O)_4]^{2+}$ both react with $K_4[Fe(CN)_6]$ to give brown ppt.
Reason : Both complexes are blue in colour of little different shade.

5. **Assertion** : $[Fe(EDTA)]^-$ complex is octahedral in shape.
Reason : EDTA is a hexadentate ligand and undergoing sp^3d^2 hybridisation.

6. **Assertion** : Tetrahedral complexes with chiral structure exhibit optical isomerism.
Reason : They lack plane of symmetry.

7. **Assertion** : Oxidation state of Fe in $Fe(CO)_5$ is zero.
Reason : Synergic bonding takes place in this metal carbonyl complex.

8. **Assertion** : Zeise's salt is a π-bonded organometallic compound.
Reason : Zeise's salt contain C_2H_4 molecules as one of the ligand.

9. **Assertion** : $[CoCl_3(NH_3)_3]$ does not give white precipitate with $AgNO_3$ solution.
Reason : $[CoCl_3(NH_3)_3]$ complex is optically inactive.

10. **Assertion** : Transition metal ion forming octahedral complexes undergo sp^3d^2 or d^2sp^3 hybridisation.
Reason : Strong field ligands force the unpaired electrons of central metal ion to pair up causing d^2sp^3 hybridisation whereas weak field ligands do not affect electronic configuration of the metal ion undergoes in sp^3d^2 hybridisation.

11. **Assertion** : Complex ion $[Co(NH_3)_6]^{2+}$ is readily oxidized to $[Co(NH_3)_6]^{3+}$.
Reason : Unpaired electron in complex ion $[Co(NH_3)_6]^{2+}$ is present in $4p$ orbital.

12. **Assertion** : Hydrazine is a neutral ligand.
Reason : It has two N as donor atoms and behaves as a chelating ligand.

13. **Assertion** : Complex anion $[Re_2Cl_8]^{2-}$ has one δ-bond, one sigma and one π-bond.
Reason : d_{z^2} orbital can never form δ-bond.

SUBJECTIVE PROBLEMS

1. Consider the following compounds with their regular geometries.

Compounds	Geometry
A	Square planar
B	Trigonal bipyramidal
C	Square pyramidal
D	Octahedral
E	Pentagonal bipyramidal

Calculate value of $(x + y - z)^2$, where x is total number of axial d-orbitals having zero nodal plane, y and z are total no. of non-axial and axial d-orbitals respectively each one having two nodal planes used in hybridization of central atoms of compounds A to E.

2. How many π-bonds are present in ferrocene?

3. Consider the following complex compounds

(i) $[Cu(NH_3)_4][Cu(NO_2)_4]$ (ii) $[Cr(py)_6][Cr(SCN)_6]$

(iii) $[Co(NH_3)_5(NO_2)][Pt(SCN)_4]$

If x_1, x_2, x_3 are more possible coordination isomers of given complex compounds respectively then calculate value of $x_1^2 + x_2^2 + x_3^2$.

4. Consider the following carbonyl complex compounds.

(i) $Mo(CO)_x$ (ii) $H_y[Cr(CO)_5]$ and (iii) $Ru_3(CO)_z$

Then calculate value of $|z + y - x|$.

5. If x and y are total number of electrons which are present in non-axial and axial set of d-orbitals respectively in Ni cation of $[Ni(DMG)_2]$, then calculate value of $\frac{2x^2}{y}$.

6. Consider the following complex compounds :

(i) $[Pt(NH_3)_2(SCN)_2]$ (ii) $[Co(NH_3)_3(NO_2)_3]$

(iii) $[Pt(en)Cl_2]$ (iv) $[Cr(en)_2Br_2]^+$

(v) $[Rh(en)_3]^{3+}$ (vi) $[CoCl_2Br_2]^{2-}$

Then calculate sum of total number of geometrical isomers in all above complex compounds.

7. Consider the following transformation

$$Cr(CO)_x \longrightarrow Cr(CO)_y(NO)_z$$

If both reactant and product follow EAN rule, then calculate value of $x + z - y$ (where x, y and z are natural numbers).

8. Brown colour of the complex $[Fe(H_2O)_5(NO)]SO_4$ is due to C.T. spectrum which causes momentary change in oxidation state. Find out oxidation state of Fe in this complex.

9. Calculate |C.F.S.E.| (mod value) is term of Dq. for complex ion $[MnF_6]^{3-}$.

10. Total number of geometrical isomers of $[CoBrClI(CN)(H_2O)(NH_3)]^-$ complex ion, in which all halides are in *cis*-position.

11. What is CFSE of complex ion $[FeF_6]^{4-}$ in terms of Dq ?

12. How many more co-ordination isomers are possible of the compound $[Cu(NH_3)_4][PtCl_4]$?

13. Total number of space (stereo) isomers of complex ion $[Cr(gly)(en)_2]^{2+}$ are....................

14. Calculate CFSE of light pink compound formed, when $KMnO_4$ is reduced by acidified H_2S.

15. How many electrons are present in t_{2g} set of d-orbitals of central metal cation in $[Fe(H_2O)_5(NO)]SO_4$ brown ring complex ?

16. A (Light pink colour complex) $\xrightarrow[\Delta]{Pb_3O_4/\text{dil.}HNO_3}$ $HMnO_4$ $\xrightarrow{H_2S/H^+}$ A (Light pink colour complex).

Calculate CFSE value in light pink colour complex.

17. Calculate value of "$x + y$" if x is the total number of σ bonds and y is total number of π bonds in ligand EDTA and phenanthrolene.
{EDTA = Ethylene diamine tetraacetate, phen = 1, 10 – N, N-Phenanthrolene}

18. Consider the following complex compounds.

(i) $[Pt(NH_3)_2(SCN)_2]$ (ii) $[Co(NH_3)_3(NO_2)_3]$
(iii) $[Pt(en)Cl_2]$ (iv) $[Cr(en)_2Br_2]^+$
(v) $[Rh(en)_3]^{3+}$ (vi) $[Co\,Cl_2\,Br_2]^{2-}$

Then calculate sum of total number of geometrical isomers in all above complex compounds.

19. Total number of complexes among the following which are optically active ?

(i) $[Cr(Ox)_3]^{3-}$ (ii) cis-$[Pt(Cl_2)(en)]$
(iii) *cis*-$[Rh(Cl_2)(NH_3)_4]^+$ (iv) $[Ru(dipy)_3]^{3+}$
(v) *cis*-$[Co(NO_2)_3(dien)]$ (vi) *Trans*-$[Co(NO_2)_3(dien)]$
(vii) *cis*-$[Co(NO_2)_3(NH_3)_3]$

20. Consider the following complexes.

(i) $[Fe\,IF(CN)(H_2O)(en)]$ (ii) $[Mo\,Cl_2F_2(gly)]^{2-}$

Then, calculate value of $|x - y|$ (where x and y are total number of possible optically active isomers in (i) and (ii) complex respectively).

21. Consider the following ligands NH_2^-, acac, OH^-, Gly, O_2^-, Phen, DMG, NO_2^-, CO_3^{2-}, Cl^-, CH_3COO^-, en, SO_4^{2-}. Then calculate value of "$P + Q - R - S$"

Here

P : Total number of ligands which act as bridging as well as monodentate only.
Q : Total number of flexidentate ligands
R : Total number of bidentate ligands only
S : Total number of unsymmetrical bidentate ligands

22. $M(CO)_x(NO)_y \xrightarrow[-CO]{+NO} M(NO)_z$

Where EAN of metal (M) in both product and reactant is same and it is 54. Then calculate value of $(x + y - z)$. (where x, y and z are natural numbers and M belong to 6th group according to long form of periodic table)

ANSWERS

Level 1

1.	(a)	**2.**	(d)	**3.**	(d)	**4.**	(c)	**5.**	(a)	**6.**	(d)	**7.**	(d)	**8.**	(c)	**9.**	(c)	**10.**	(d)
11.	(a)	**12.**	(b)	**13.**	(d)	**14.**	(b)	**15.**	(c)	**16.**	(d)	**17.**	(d)	**18.**	(d)	**19.**	(a)	**20.**	(c)
21.	(c)	**22.**	(c)	**23.**	(d)	**24.**	(b)	**25.**	(a)	**26.**	(d)	**27.**	(a)	**28.**	(c)	**29.**	(b)	**30.**	(a)
31.	(d)	**32.**	(a)	**33.**	(c)	**34.**	(a)	**35.**	(c)	**36.**	(b)	**37.**	(a)	**38.**	(c)	**39.**	(b)	**40.**	(d)
41.	(d)	**42.**	(b)	**43.**	(d)	**44.**	(b)	**45.**	(b)	**46.**	(d)	**47.**	(c)	**48.**	(a)	**49.**	(d)	**50.**	(d)
51.	(b)	**52.**	(d)	**53.**	(d)	**54.**	(a)	**55.**	(a)	**56.**	(a)	**57.**	(c)	**58.**	(c)	**59.**	(a)	**60.**	(a)
61.	(a)	**62.**	(b)	**63.**	(d)	**64.**	(c)	**65.**	(d)	**66.**	(c)	**67.**	(a)	**68.**	(c)	**69.**	(b)	**70.**	(a)
71.	(b)	**72.**	(b)	**73.**	(c)	**74.**	(d)	**75.**	(b)	**76.**	(b)	**77.**	(d)	**78.**	(c)	**79.**	(c)	**80.**	(d)
81.	(a)	**82.**	(d)	**83.**	(c)	**84.**	(a)	**85.**	(d)	**86.**	(a)	**87.**	(a)	**88.**	(b)	**89.**	(c)	**90.**	(b)
91.	(d)	**92.**	(c)	**93.**	(a)	**94.**	(d)	**95.**	(d)	**96.**	(d)	**97.**	(a)	**98.**	(c)	**99.**	(b)	**100.**	(c)
101.	(b)																		

Level 2

1.	(c)	**2.**	(a)	**3.**	(d)	**4.**	(d)	**5.**	(d)	**6.**	(d)	**7.**	(a)	**8.**	(d)	**9.**	(d)	**10.**	(d)
11.	(b)	**12.**	(d)	**13.**	(b)	**14.**	(b)	**15.**	(d)	**16.**	(a)	**17.**	(d)	**18.**	(d)	**19.**	(c)	**20.**	(a)
21.	(b)	**22.**	(b)	**23.**	(a)	**24.**	(c)	**25.**	(b)	**26.**	(a)	**27.**	(b)	**28.**	(c)	**29.**	(d)	**30.**	(d)
31.	(d)	**32.**	(c)	**33.**	(a)	**34.**	(a)	**35.**	(c)	**36.**	(c)	**37.**	(b)	**38.**	(b)	**39.**	(d)	**40.**	(d)
41.	(a)	**42.**	(c)	**43.**	(c)	**44.**	(d)	**45.**	(d)	**46.**	(a)	**47.**	(a)	**48.**	(c)	**49.**	(a)	**50.**	(c)
51.	(d)	**52.**	(a)	**53.**	(c)	**54.**	(c)	**55.**	(a)	**56.**	(c)	**57.**	(b)	**58.**	(a)	**59.**	(c)	**60.**	(a)
61.	(b)	**62.**	(d)	**63.**	(d)	**64.**	(c)	**65.**	(b)	**66.**	(c)	**67.**	(d)	**68.**	(b)	**69.**	(a)	**70.**	(d)
71.	(d)	**72.**	(a)																

Level 3

Passage–1	1. (d)	2. (d)	3. (d)				
Passage–2	1. (c)	2. (d)	3. (a)				
Passage–3	1. (b)	2. (a)	3. (b)				
Passage–4	1. (c)	2. (a)	3. (d)				
Passage–5	1. (c)	2. (a)					
Passage–6	1. (c)	2. (c)	3. (a)				
Passage–7	1. (a)	2. (b)	3. (d)				
Passage–8	1. (c)	2. (c)	3. (b)				
Passage–9	1. (c)	2. (b)	3. (c)				
Passage–10	1. (b)	2. (a)	3. (c)				
Passage–11	1. (a)	2. (c)	3. (b)				
Passage–12	1. (c)	2. (b)	3. (b)				
Passage–13	1. (a)	2. (a)	3. (b)				
Passage–14	1. (c)	2. (b)					
Passage–15	1. (b)	2. (c)					
Passage–16	1. (a)	2. (b)	3. (c)	4. (c)	5. (c)	6. (a)	7. (a)

One or More Answers is/are correct

1. (a,b,d)	2. (a,b,d)	3. (a,b,d)	4. (a,b,c)	5. (a,b,d)	6. (a,b,c,d)	7. (a,d)	8. (a,b,d)
9. (a,c)	10. (b)	11. (a,b,c)	12. (b,d)	13. (a,b,d)	14. (a,b,d)	15. (a,b,c,d)	16. (a,b,d)
17. (a,b,d)	18. (b,c)	19. (a,d)	20. (a,d)	21. (a,b)	22. (b,d)	23. (a,b,c,d)	24. (a,d)
25. (b,c,d)	26. (a,c,d)	27. (a,d)	28. (a,b,d)	29. (a,b,c,d)	30. (a,b,c)	31. (a, d)	32. (b,d)
33. (a,d)	34. (b,c,d)	35. (a,b,d)	36. (a,b,c,d)				

Match the Column

1.	A → P, R, T;	B → P, T;	C → Q, T;	D → Q, S, T
2.	A → P, T;	B → P, R, S;	C → P, Q, T;	D → P, R, S, T
3.	A → P, Q,R,S, T;	B → P, Q, S, T;	C → P, Q, S, T;	D → Q, T
4.	A → Q, R;	B → Q, S, T;	C → Q, S;	D → P, R, S
5.	A → R, T;	B → Q, T;	C → P, T;	D → S
6.	A → P, R;	B → Q, S;	C → P, Q;	D → R, S
7.	A → Q, R;	B → P, S;	C → P, S;	D → P,S
8.	A → R, S;	B → P, Q	C → P;	D → P, Q
9.	A → R, S;	B → Q, R, S;	C → P;	D → P, S
10.	A → P, Q, S;	B → Q, R, S;	C → P;	D → P, Q
11.	A → Q, R, S;	B → P, Q, R,S;	C → P, Q, S;	D → P, R, S
12.	A → P, Q, R;	B → Q, S;	C → P, Q, R, S;	D → P, S
13.	A → Q, R, S;	B → P, R;	C → Q, R;	D → R, S
14.	A → P, Q, R;	B → R;	C → Q, R, S;	D → R
15.	A → R;	B → Q;	C → P;	D → S
16.	A → S;	B → T;	C → Q;	D → P
17.	A → P;	B → Q;	C → S;	D → R
18.	A → S;	B → P;	C → P,Q,S;	D → R

Assertion-Reason Type Questions

1. (A) **2.** (A) **3.** (B) **4.** (D) **5.** (A) **6.** (C) **7.** (D) **8.** (C)
9. (D) **10.** (C) **11.** (A) **12.** (A) **13.** (B)

Subjective Problems

1. 0 **2.** 6 **3.** 41 **4.** 8 **5.** 36 **6.** 6 **7.** 5
8. 1 **9.** 6 **10.** 6 **11.** 4 **12.** 3 **13.** 2 **14.** 0
15. 5 **16.** 0 **17.** 5 **18.** 6 **19.** 2 **20.** 8 **21.** 1
22. 1

Hints and Solutions

Level 1

3. (d) $Cu^{2+}(aq) + 4NH_3 \overset{OH^-}{\rightleftharpoons} [Cu(NH_3)_4]^{2+}$

$Cu^{2+}(aq) + 4NH_3 \overset{OH^+}{\rightleftharpoons} Cu^{2+} + 4NH_4^+$ (No complex formation)]

As NH_3 combines with H^+ of acid and changes to NH_4^+ which have no donor site.

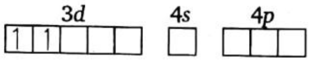
5. (a) $Mn(CO)_5 + \bar{e} \longrightarrow [Mn(CO)_5]^-$

less stable more stable, as EAN of Mn = 36 (Kr)

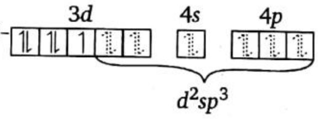
(O.A.)

19. (a) V^{3+} in $[V(H_2O)_6]^{3+}$

$\mu_{Exp} = \sqrt{2(2+2)} = 2.83$ BM

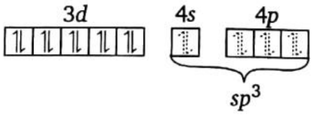


20. (c) Fe^{3+} in $[Fe(CN)_6]^{3-}$



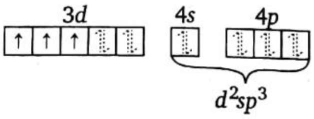
⇒ low spin complex $\mu = 1.732$ BM

Ni in $[Ni(CO)_4]$



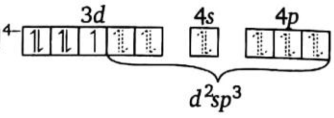
$\mu = 0$

Cr^{3+} in $[Cr(NH_3)_6]^{3+}$



⇒ low and high spin complex is applicable for d^4 to d^7 configuration.

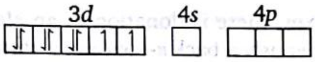
Mn^{2+} in $[Mn(CN)_6]^{4-}$



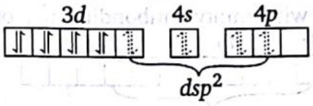
⇒ low spin complex $\mu = 1.732$ BM

26. (d) In complexes $[Rh(H_2O)_6]^{3+}$ and $[Co(H_2O)_6]^{3+}$, central metal cations have same oxidation state as well as same ligands and they fall in same group, but Δ_0 of $[Rh(H_2O)_6]^{3+} > \Delta_0$ of $[Co(H_2O)_6]^{3+}$ because Rh^{3+} has high Z_{eff} value than CO^{3+}.

27. (a) Ni^{2+}



Ni^{2+} in $[Ni(dmg)_2]$



$\mu = 0$

28. (c) Number of unpaired electrons = 3

$\mu_{eff} = 3.9$ BM

type of hybridisation = sp^3d^2

29. (b) Increasing stability order :

(a) $[Cu(NH_3)_4]^{2+} < [Cu(en)_2]^{2+} < [Cu(trien)]^{2+}$

Their formation entropy increases in the same order, because denticity of ligand increases

(b) $[Fe(H_2O)_6]^{3+} < [Fe(NO_2)_6]^{3-} < [Fe(NH_3)_6]^{3+}$

NO_2^- is stronger ligand than NH_3

(c) $[Co(H_2O)_6]^{3+} < [Rh(H_2O)_6]^{3+} < [Ir(H_2O)_6]^{3+}$

Z_{eff} value increases from Co^{3+} to Ir^{3+}

(d) $[Cr(NH_3)_6]^{1+} < [Cr(NH_3)_6]^{2+} < [Cr(NH_3)_6]^{3+}$

Oxidation state of Cr atom increases from +1 to +3

30. (a) $[Ni(H_2O)_6]^{2+} + 6NH_2 \rightleftharpoons [Ni(NH_3)_6]^{2+} + 6H_2O$

sp^3d^2 Hyb. $\qquad$ sp^3d^2 Hyb.

$\mu_{eff} = 2.8$ BM $\qquad$ $\mu_{eff} = 2.8$ BM

32. (a) $[PtCl_2(NH_3)(OH)_2]$; Pt-oxidation state +2 ;

Valence configuration = $5d^8$

Complex is diamagnetic and exhibits geometrical isomerism.

35. (c) Due to the cationic part of the complex, it is green, because there are three unpaired electrons in t_{2g} orbitals of Cr^{3+} cation, both cationic and anionic parts are complex ions, hence, coordination isomerism will be exhibited by it.

39. (b) $[Ti(H_2O)_6]Cl_4$

Coordination number 6 $\Rightarrow$ octahedral complex

Ti is in +4 oxidations state $\Rightarrow$ no unpaired electrons

$\Rightarrow$ magnetic moment = 0 B.M.

40. (d) $[CoBr(NH_3)_5]SO_4 \rightleftharpoons [CoBr(NH_3)_5]^{2+} + SO_4^{2-}$; Total charges = 4

$[Co(SO_4)(NH_3)_5]Br \rightleftharpoons [Co(SO_4)(NH_3)_5]^+ + Br^-$; Total charges = 2

hence, both have different molar conductivities.

43. (d) Complexes $[Co(SO_4)(NH_3)_5]Br$ and $[Co(SO_4)(NH_3)_5]Cl$ are not any isomers to each other.

44. (b) (I) IUPAC name is Pentaamminenitrito-N-chromium(III) tetrachlorozincate (II)

(II) It does not exhibit geometrical isomerism

(III) It shows linkage isomerism due to presence of ambidentate ligand NO_2^-

(IV) Its coordination isomers are :

$[CrCl(NH_3)_5][ZnCl_3(NO_2)]$,

$[CrCl_2(NH_3)_4][ZnCl_2(NO_2)NH_3]$

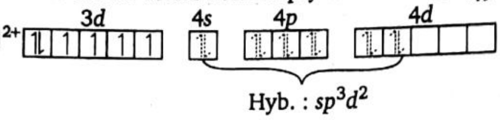
$[Zn(NO_2)(NH_3)_3][CrCl_4(NH_3)_2]$

51. (b) CO bond strength is reciprocal to the extent of back donation involved in synergic bonding

i.e. $M \rightleftharpoons CO$

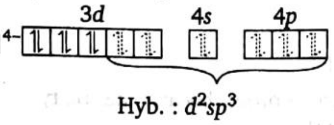
52. (d) CO is called π-acid ligand. In metal carbonyl complexes, there is donation of an electron pair from carbon to the empty orbital of metal and then simultaneously a back π-bonding is formed by sideways overlap of a filled orbital on the metal with empty antibonding π^*_{2py} orbital of CO.

58. (c) Fe^{2+} in $[Fe(H_2O)_6]^{2+}$



Colour : Pale green $\mu = 4.9$ B.M.; octahedral

Fe^{2+} in $[Fe(CN)_6]^{4-}$



Colour : Yellow; $\mu = 0$; octahedral

65. (d)

$Ni(CO)_4$; $\mu_{eff} = 0$

$[Co(NH_3)_4(NO_2)_2]^+$; $\mu_{eff} = 0$

$[Ag(CN)_2]$; $\mu_{eff} = 0$

$[CuBr_4]^{2-}$; $\mu_{eff} = 1.732$ BM

66. (c) Degenerate *d*-orbitals undergo splitting under ligand field created by strong, weak or mixed ligands.

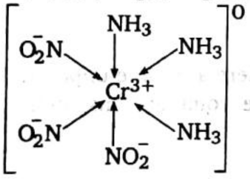
69. (b) $[CrCl_2(OH)_2(NH_3)_2]$ show *cis* and *trans* isomerism, *cis* isomer is optically active.

72. (b) No. of geometrical isomers

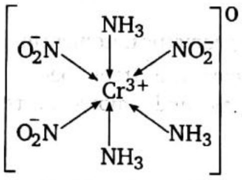
$[Pt(NO_2)(NH_3)(NH_2OH)(Py)]^+ = 3$ and No. of stereoisomers for

$[Pt(Br)(Cl)(I)(NO_2)(NH_3)(Py)] = 15 + 15$

75. (b) (I)



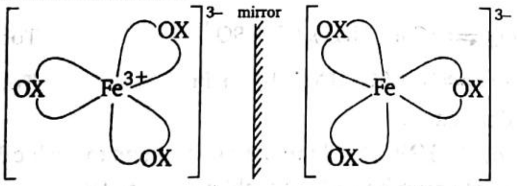
Facial (or *cis*)
Optically inactive



Meridional (*trans*)
Optically inactive

⇒ Two stereoisomers

(II)

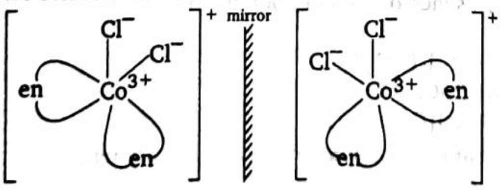


d-form

l-form

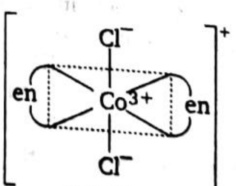
⇒ Two stereoisomers

(III)



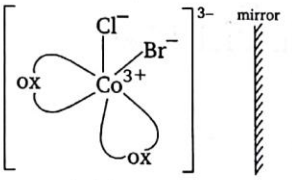
cis-d-form

cis-l-form

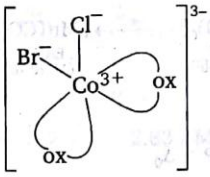


trans-form
(meso-form)

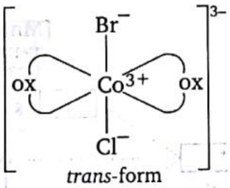
⇒ Three stereoisomers

(IV)


cis-d-form



cis-l-form

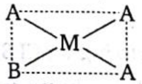


trans-form
(*meso*-form)

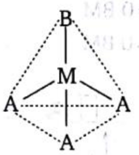
⇒ Three stereoisomers

76. (b) II and III are geometrical isomers as II is *trans* while III is *cis* of the given complex.

77. (d) *Trans* complex is optically inactive.

83. (c)


⇒ In this square planar complex, only one configuration is possible. Hence, geometrical isomerism is not observed.



⇒ Tetrahedral complexes never show geometrical isomerism.

84. (a) (I) $[Pt(SCN)(3PEt_3)](SCN)$: Exhibits only linkage isomerism.
(II) $[CoBr(NH_3)_5]SO_4$: Exhibit only ionization isomerism.
(III) $[Fe(H_2O)_6]Cl_2$: Exhibits only hydrate isomerism.

88. (b) (I) Mond's process for purification of Ni - $[Ni(CO)_4]$
(II) Removal of unreacted AgBr from photographic plate— $[Ag(S_2O_3)_2]^{3-}$
(III) Removal of lead poisoning from body—$[Pb(EDTA)]^{2-}$

91. (d) The correct name is chlorobis(ethylenediamine)nitritocobalt (III).

96. (d) $H_2[PtCl_6]$ is an acid, not salt hence its name : Hexachloroplatinic(IV)acid.

Level 2

1. (d) Due to absence of vacant atomic orbital as well as π * molecular orbital, O_2^{2-} does not as π acid ligand.

3. (c) $[\overset{+1}{Mn}(CO)_4(NO^-)]$: Paramagnetic due to presence of unpaired e^-s in NO^-

$[\overset{-1}{Mn}(CO)_4(NO^+)]$: No unpaired e^- either on ligands or on $\overset{-1}{Mn}$ hence it is diamagnetic

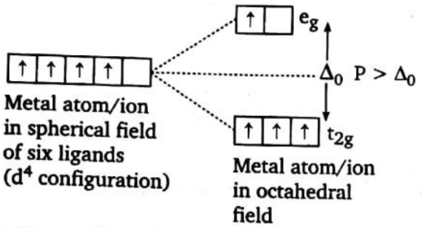
4. (c) (I) $[(Ph_3P)_2PdCl_2PdCl_2]$; EAN of Pd = 46 − 2 + 4 × 2 = 52
(II) [NiBrCl(en)]; EAN of Ni = 28 − 2 + 8 = 34
(III) $Na_4[Fe(CN)_5NOS]$;
EAN of Fe = 26 − 2 + 5 × 2 + 2 = 36 [Kr]
(IV) $Cr(CO)_3(NO)_2$; EAN of
Cr = 24 − 0 + 3 × 2 + 3 × 2 = 36[Kr]

5. (d) Ligand NO is $3e^-$ donar hence three CO ligands can be substituted by two NO ligands.

6. (b) $Mn(CO)_6$ can act as reducing agent because the metal corbonyl is stable when EAN is equal to nearest noble gas configuration.

$$\underset{\substack{\text{EAN} = 37 \\ \text{(Less stable)}}}{[Mn(CO)_6]} \xrightarrow{-e^-} \underset{\substack{\text{EAN} = 36 \\ \text{(More stable)}}}{[Mn(CO)_6]^+}$$

7. (c)



8. (c) $[Ni(CN)_4]^{4-}$; sp^3; Tetrahedral complex.

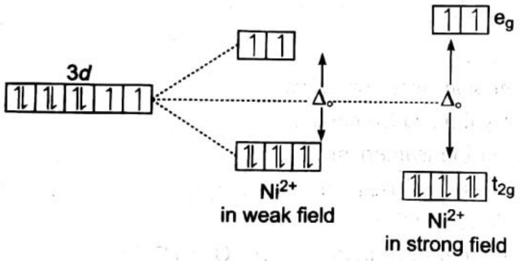
9. (d) (I) Both CO^{2+} and Co^{3+} are stabilized in the presence of strong field ligands due to higher CFSE values.

(II) Because of higher Z_{eff} value on the valence shell of Pd^{2+} and Pt^{2+} cations they, always from inner orbital complex.

(III) $[Ni(CO)_4]$; sp^3, tetrahedral, $\mu = 0$ BM

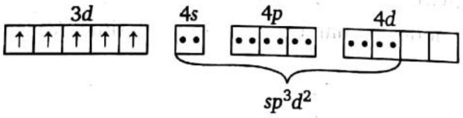
$[Ni(CN)_4]^{4-}$; sp^3, tetrahedral, $\mu = 0$ BM

(IV) Ni^{2+} in the octahedral field.



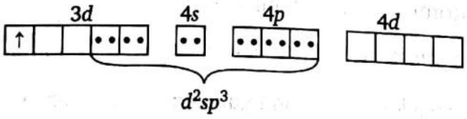
⇒ *i.e.*, electronic distribution remains unaffected.

10. (b) (I) Fe^{3+} in $[FeF_6]^{3-}$



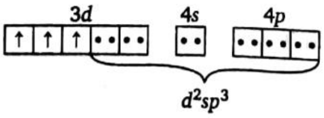
$$\mu = \sqrt{5(5+2)} = 5.93 \text{ BM}$$

(II) Ti^{3+} in $[Ti(H_2O)_6]^{3+}$



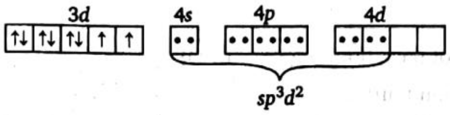
$$\mu = \sqrt{1(1+2)} = 1.732 \text{ BM}$$

(III) Cr^{3+} in $[Cr(NH_3)_6]^{3+}$



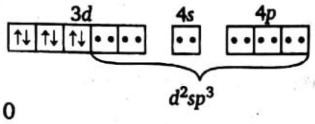
$$\mu = \sqrt{3(3+2)} = 3.88 \text{ BM}$$

(IV) Ni^{2+} in $[Ni(H_2O)_6]^{2+}$



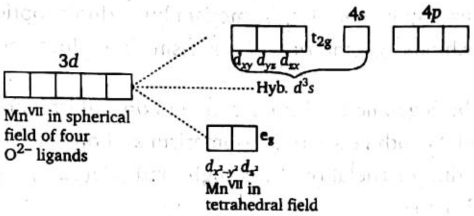
$$\mu = \sqrt{2(2+2)} = 2.83 \text{ BM}$$

(V) Fe^{2+} in $[Fe(CN)_6]^{4-}$



$\mu = 0$

14. (b) Hybridisation of Mn in MnO_4^- : d^3s



15. (c) $Fe^{2+}(aq) + NO + SO_4^{2-}(aq) \rightarrow [Fe(H_2O)_5(NO)]^{2+} + SO_4^{2-}$

$\mu_{eff} = 3.89$ BM

Hence, no. of unpaired electrons = 3

16. (b) As NH_3 is stronger ligand than H_2O, hence CFSE value for $[M(NH_3)_6]^{2+}$ > CFSE of $[M(H_2O)_6]^{2+}$ therefore, absorption shifts to smaller wavelength. Also difference between splitting power of NH_3 and H_2O is not very high.

18. (c) $\Delta_t = \frac{4}{9}\Delta_0$

$\therefore \; \Delta_t$ for $[CoCl_4]^{2-} = \frac{4}{9} \times 18000 \text{ cm}^{-1} = 8000 \text{ cm}^{-1}$

20. (c) $[CuCl_5]^{2-}$; sp^3d-hybridisation (outer orbital complex) (Magnetic moment = $\sqrt{3}$ B.M.)

$[Fe(NH_3)_6]^{3+}$, $[Mn(CN)_6]^{4-}$ and $[Co(NH_3)_6]^{2+}$ are inner orbital complexes and are also paramagnetic in nature having magnetic moment of $\sqrt{3}$ B.M.

21. (c) $[Ni(DMG)_2] < [Ni(en)_2]^{2+}$ is incorrect order of C.F.S.E. because stability of chelated complex is directly related to number of stable rings.

22. (c) Octahedral complexes having metal cation with d^3 and d^8 configuration can not be defined in terms of high and low spin complex.

23. (a) $[\overset{III}{Co}(NH_3)_4CO_3]^+ ClO_4^-$, CO_3^- is working as bidentate ligand, have coordination number of $\overset{III}{Co} = 6$.

24. (b) Vaccant non-axial d-orbital participate in $M \xrightarrow{\pi} PR_3$ back bonding in its complexes.

25. (a) In metal carbonyls :

Higher the negative oxidation state of central metal : $\propto$ Bond length of C—O

$$: \propto \frac{1}{\text{Bond order of CO}}$$

: Bond order of M—C bond

26. (b) In PR_3 there is vacant atomic d-orbital on P-atom, which can be involved in Synergic bonding.

27. (d) CO bond order $\propto \dfrac{1}{\text{Extent of back bonding } (M \to \text{CO})}$

Correct sequence of CO bond order :

$$\underset{(\text{CO bond order} > 3.0)}{H_3B \leftarrow CO} > \underset{\text{B.O.} = 3.0}{CO} > \underset{\text{CO bond order} < 3.0}{Fe(CO)_5} > \underset{(\text{CO bond order} < 3.0)}{[Mn(CO)_5]^-}$$

29. (d) $[\overset{II}{M}n(CN)_6]^{4-}$: Hyb. : $d^2sp^3, \mu_{eff} = \sqrt{3}$ B.M.

$[\overset{III}{F}e(NH_3)_6]^{3+}$: Hyb. : $d^2sp^3, \mu_{eff} = \sqrt{3}$ B.M.

$[Co(CO)_4]$: Hyb : $dsp^2, \mu_{eff} = \sqrt{3}$ B.M

$[Cu(H_2O)_6]^{2+}$: Hyb. : $sp^3d^2, \mu_{eff} = \sqrt{3}$ B.M

30. (d) $[Cr(en)_3]^{3+}$; Hyb. : d^2sp^3; does not exhibit geometrical isomerism but exhibits optical isomerism.

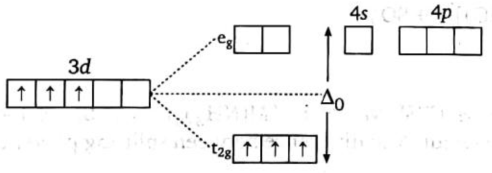
$[IrF_3(H_2O)_2(NH_3)]$; Hyb. : d^2sp^3; exhibits geometrical isomerism but does not exhibit optical isomerism.

$[NiCl_2(en)_2]$; Hyb. : sp^3d^2; exhibits both geometrical isomerism and optical isomerism.

$[Co(CN)_2(ox)_2]^{3-}$; Hyb. : d^2sp^3; exhibits both geometrical isomerism and optical isomerism.

33. (b) $C_2O_4^{2-}$ is a bidentate ligand, hence due to chelation Δ_0 is high, and $[Co(ox)_3]^{3-}$ is an inner-orbital complex having d^2sp^3-hybridization.

36. (b)



Hence, hybridization : d^2sp^3

37. (d) In $[Cu(NH_3)_4]^{2+}$, Cu^{2+} is dsp^2 hybridized, hence structure is square planar and complex is paramagnetic.

38. (d) $K_3[Co(ox)_3]$ is inner orbital complex with d^2sp^3-hybridisation.

39. (a) Peroxide ion is diamagnetic while dioxygen is paramagnetic.

Conc. H_2SO_4 can dehydrate water of crystallization from $[CrCl(H_2O)_5]Cl_2 \cdot H_2O$ but it can not remove those water molecules which are working as ligands.

40. (d) $[Co(en)_3][Cr(C_2O_4)_3]$, $[Co(C_2O_4)(en)_2][Cr(C_2O_4)_2(en)]$,

$[Cr(C_2O_4)(en)_2]\ [Co(C_2O_4)_2(en)]$,

$[Cr(en)_3][Co(C_2O_4)_3]$, Total coordination isomers = 4

$[Cu(NH_3)_4][CuCl_4]$, $[CuCl(NH_3)_3][CuCl_3(NH_3)]$

Total coordination isomers = 2

$[Ni(en)_3][Co(NO_2)_6]$, $[Ni(NO_2)_2(en)_2][Co(NO_2)_4(en)]$,

$[Co(NO_2)_2(en)_2][Ni(NO_2)_4(en)]$, $[Co(en)_3][Ni(NO_2)_6]$

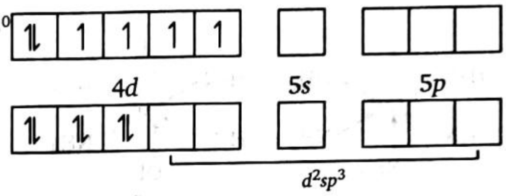
Total no. of coordination isomers = 4

41. (d) NO_3^- ion never acts as ambidentate ligand.

42. (b) Complex $[Cr(NO_2)(NH_3)_4][Zn(SCN)_4]$ can not shows optical activity.

44. (a) (i) $Pt(SCN)_2$

45. (d) $[PdCl_2(H_2O)_2(NH_3)_2]^{2+}$ $Pd^{4+} \rightarrow 4d^6 5s^0 5p^0$



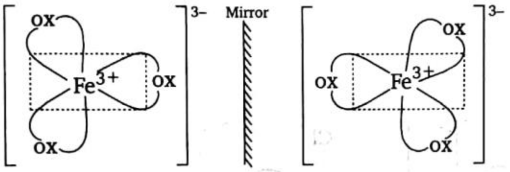
(a) m.m. = 0 B.M. (Diamagnetic)

(b) Low spin complex

(c) Show geometrical isomerism 5 geometrical isomer (1 *cis* + 4 *trans*)

(d) Ma_3b_3 type complex show fac and mer form and this complex is $Ma_2b_2c_2$ type, so does not show fac and mer form

50. (b)

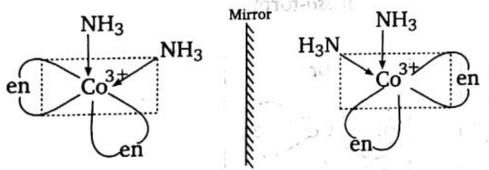


Above configuration is asymmetrical, hence optically active.

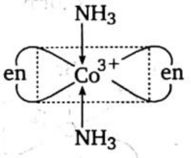
Mabcd square planar exhibits geometrical isomerism.

Mabcd tetrahedral complex is optically active.

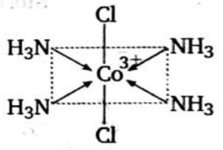
51. (b)



d-form *l*-form

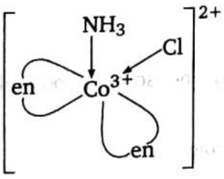


optically inactive

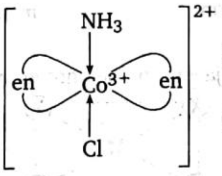


optically inactive

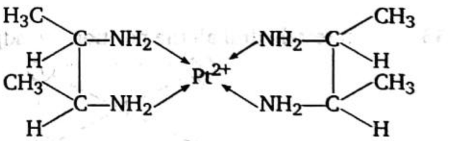
52. (c)



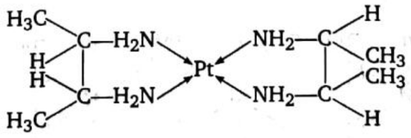
cis-form



trans-form

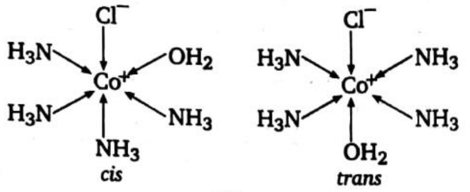


cis-form



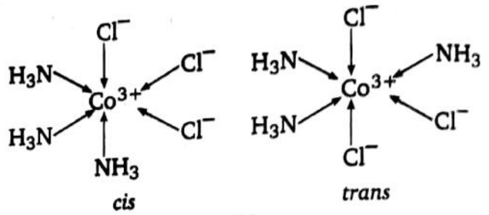
trans-form

53. (d)



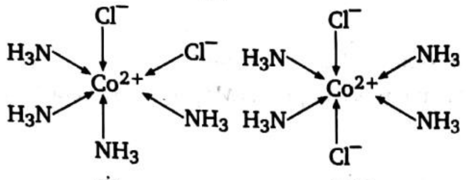
cis *trans*

(a)



cis *trans*

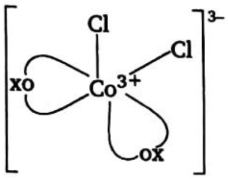
(b)



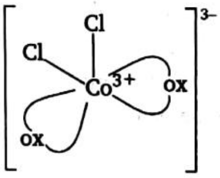
cis *trans*

(c)

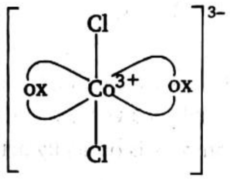
54. (a)



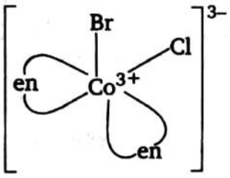
d-form



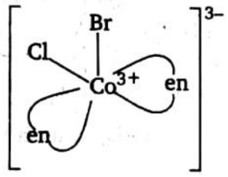
l-form



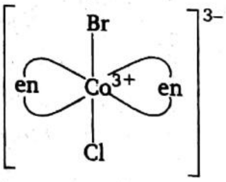
meso-form



d-form

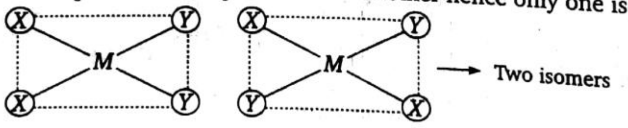


l-form



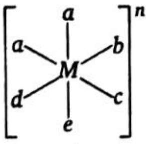
meso-form

55. (a) In tetrahedral all the position are adjacent to one another hence only one isomer is possible

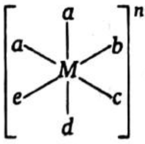


cis *trans*

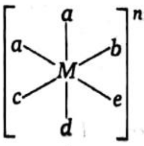
56. (b)



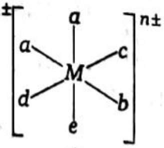
cis



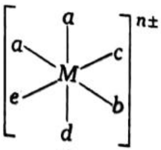
cis



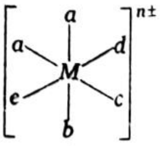
cis



cis



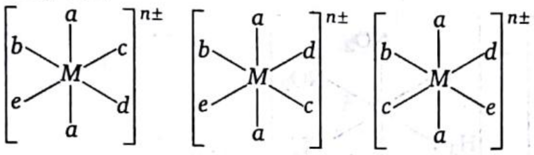
cis



cis

No. of *cis*-isomers = 6

They are :

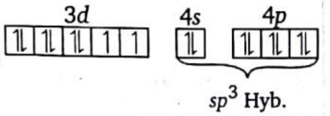


trans *trans* *trans*

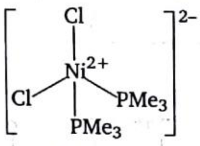
No. of *trans*-isomers = 3

57. (b) [NiCl$_2$(PMe$_3$)$_2$]

Ni^{2+} in [NiCl$_2$(PMe$_3$)$_2$]



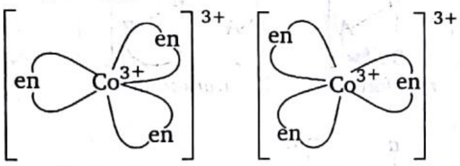
Structure : Tetrahedral



No isomer is possible.

58. (d) (i) [CoCl$_3$(NH$_3$)$_3$] : Both *cis* and *trans* forms are optically inactive

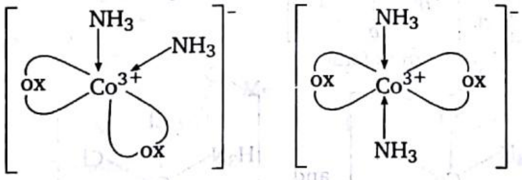
(ii)



(*d*-form) (*l*-form)

Orientation of the ligands does not affect asymmetric of the complex.

(iii)

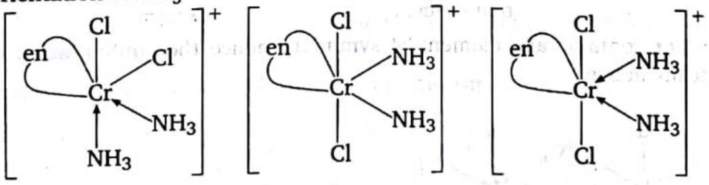


(*cis*-form) optically active

(*trans*-form) optically inactive

Orientation of NH$_3$ molecules determine asymmetric character of the complex.

(iv)



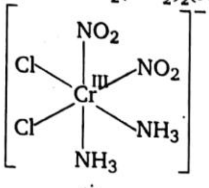
(*cis*-form) optically active

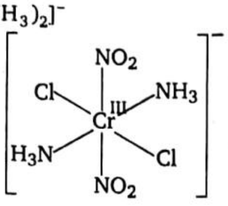
(*trans*-form) optically inactive

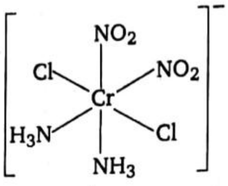
(*trans*-form) optically active

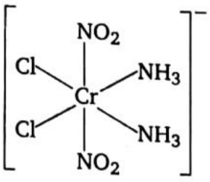
Hence, orientation of ligands determine asymmetric nature of the complex.

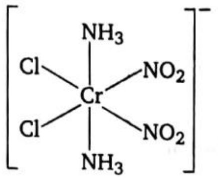
59. (d) (I) $[CrCl_2(NO_2)_2(NH_3)_2]^-$


cis


trans

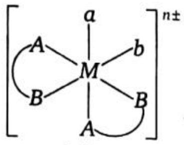

trans

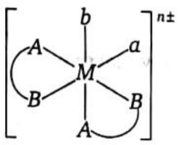

trans

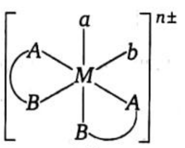

trans

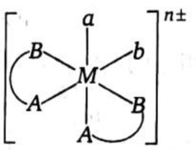
⇒ No. of Geo. Iso.

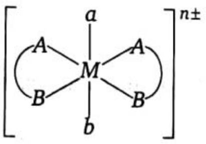
60. (d)

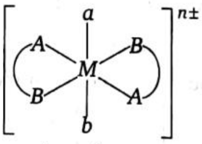

cis-form


cis-form

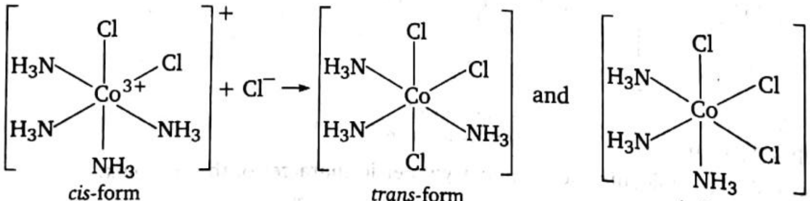

trans-form


trans-form


trans-form

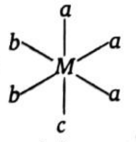

trans-form

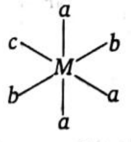
61. (a)

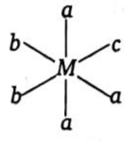

cis-form *trans*-form *cis*-form

62. (b) The complex does not contain any element of symmetry hence the configuration is asymmetric, therefore, it is optically active.

63. (d) (I)

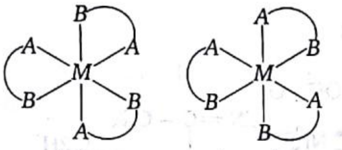

cis-form


trans-form


trans-form

⇒ **All are optically inactive; No. of stereoisomers = 3**

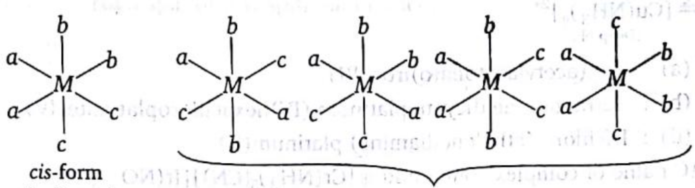
(II)



cis-form optically active trans-form optically active

⇒ Both are optically active; No. of stereoisomers = **4**

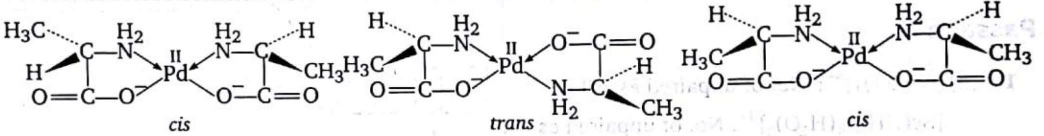
(III)



cis-form optically active trans-form optically inactive

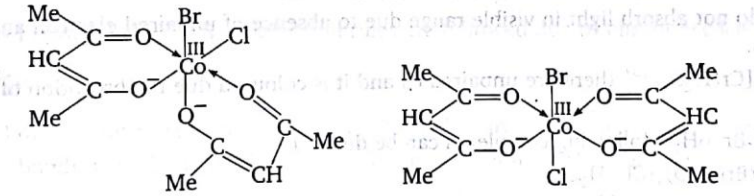
⇒ No. of stereoisomers = 6

64. (c)



cis trans cis

65. (b)



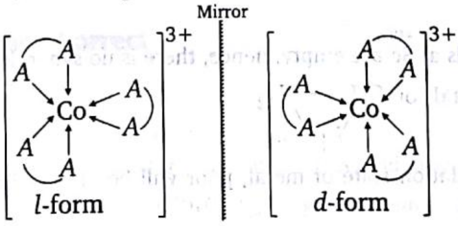
cis-form optically active trans-form optically inactive

∴ No. of stereoisomers = 3

66. (c) [Pd(Cl)(Br)(gly)] is square planer complex hence it can exhibits geometrical isomerism.

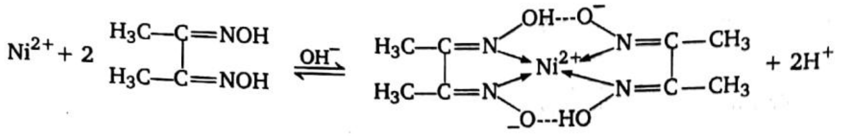
67. (a) *Trans* [Co(gly)$_3$] is optically active complex, hence equimolar mixture of '*d*' and '*l*' form on mixing gives racemic mixture.

68. (c) Compound [Co(en)$_3$]$^{3+}$ can show optical isomerism.



l-form *d*-form

69. (d) $\underset{\text{(Sod. nitroprusside)}}{Na_2[Fe(CN)_5NO]} + Na_2S \longrightarrow \underset{\text{(Purple)}}{Na_4[Fe(CN)_5(NO\,S)]}$



(Rosy red ppt.)

$Ag^+ + 2Na_2S_2O_3 \rightleftharpoons Na_3[Ag(S_2O_3)_2] + Na^+$

$Cu^{2+} + 4NH_3 \rightleftharpoons \underset{\text{(Deep blue)}}{[Cu(NH_3)_4]^{2+}}$

71. (c) Correct name of (a) : Tris(acetylacetonato)iron(III)
Correct name of (b) : Tetraammine dicyanoplatinum (IV)hexachloroplatinate(IV)
Correct name of (d) : Dichloro (ethylenediamine) platinum(II)

72. (d) The correct IUPAC name of complex compound is $[Cr(NH_3)_5(CN)][Ir(NO_2)_6]$.
Pentaamminecyanidochromium(III)hexanitrito-N-irridate(III).

Level 3

Passage-3

1. (b) $[\overset{+IV}{Ti}(en)_3]^{4+}$: No. of unpaired $\bar{e}s = 0$

$[Sc(NH_3)_4(H_2O)_2]^{3+}$: No. of unpaired $\bar{e}s = 0$

$[Zn(en)_2(NH_3)_2]^{2+}$: No. of unpaired $\bar{e}s = 0$

These complexes do not absorb light in visible range due to absence of unpaired electron and hence they are colourless.

While, in complex $[Cr(H_2O)_6]^{3+}$ there are unpaired $\bar{e}s$ and it is coloured due to absorption of light in visible range.

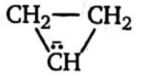
2. (a) From formula $CrCl_2Br \cdot 6H_2O$ following complexes can be derived
$[Cr(H_2O)_6]BrCl_2 [CrBr(H_2O)_5]Cl_2 \cdot H_2O$
$[CrCl(H_2O)_5]BrCl \cdot H_2O [CrCl_2(H_2O)_4]Br \cdot 2H_2O$
$[CrBrCl(H_2O)_4]Cl \cdot 2H_2O$

3. (b) $[M(AA)_2b_2]^{n\pm}$: No. of space/stereoisomers = 3
$[Ma_3b_3]^{n\pm}$: No. of space/stereoisomers = 2
$[Ma_3bcd]^{n\pm}$: No. of space/stereoisomers = 5
$[Ma_2bcde]^{n\pm}$: No. of space/stereoisomers = 5

Passage-4

1. (c) $\overset{+III}{Sc} : 3d^{\circ}4s^{\circ}$, As d-orbitals at $\overset{+III}{Sc}$ are empty, hence, there is no synergic bonding in $[Sc(CO)_6]^{3+}$.

2. (a) No vacant 'd' or π^* orbitals on



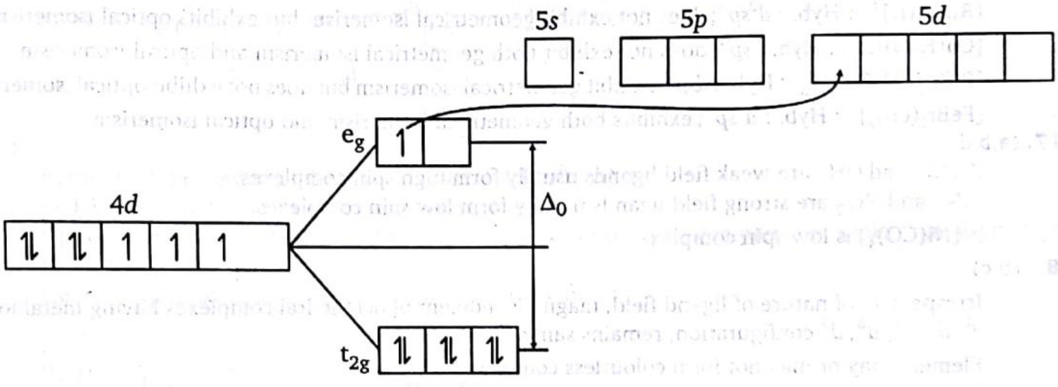
3. (d) Higher the positive oxidation state of metal, poor will be $M \xrightarrow{\pi} L$ hence $\overset{+1}{Mn}—C$ bond will longer among given complexes.

Passage-5

1. (c) $[CoBr(en)_2(H_2O)]Cl_2$: Its trans isomer is optically inactive.
2. (a) $[CoBr(en)_2(H_2O)]Cl_2$

Passage-6

1. (c) $K_4[Fe(CN)_6]$: Low spin complex : $P < \Delta_0$
   $[PtCl_4]^{2-}$: Low spin complex : $P < \Delta_0$
   $[CoF_6]^{3-}$: High spin complex : $P > \Delta_0$
   $[Ni(NH_3)_6]^{2+}$: High spin or low spin not defined.
2. (c)



$P < \Delta_0$
Rh^{++} in $[Rh(NH_3)_6]^{2+}$

3. (a) In $[Mn(H_2O)_6]^{3+}$: Both selection rules are followed due to unsymmetrical filling of e_g set of orbitals.

Passage-7

1. (a) dien is not π-acid ligend while PF_3, PCl_3, PEt_3 are π-acid ligands, therefore extent of $Mo \xrightarrow{\pi} CO$ back bonding in (dien) $Mo(CO)_3$ is maximum in order to disperse increased electron density at Mo; while in other complexes all ligands participate in $M \xrightarrow{\pi} L$ back bonding.

   Extent of back bonding αMo—CO bond order $\propto \dfrac{1}{\text{stretching frequency of CO}}$
2. (b) As d_{xy} forms δ-bond in $Mn_2(CO)_{10}$
3. (d) As PEt_3 accepts $M \xrightarrow{\pi} L$ back bonding into non-axial d-orbital of phosphorus and it forms $M \xrightarrow{\pi} L$ bond using its non-bonding molecular orbital.

One or More Answers is/are Correct

5. (a,b,d)
   $[Tc(CO)_6]^+$ E.A.N. of Tc = 43 −1 + 6 × 2 = 54 (Xe)
   $[Nb(CO)_6]^-$ E.A.N. of Nb = 41 + 1 + 6 × 2 = 54 (Xe)
   Hence, both complexes are stable and they can not act as oxidizing or reducing agent.
   Extent of $M \xrightarrow{\pi} CO$ back bonding in $[Nb(CO)_6]^-$ is greater than in $[Tc(CO)_6]^+$, hence
   Bond order of Nb—C > bond order of Tc —C
   Bond order of C—O in $[Tc(CO)_6]^+$ > C—O bond order in $[Nb(CO)_6]^-$

6. (a, b, c, d)

Given ligands accept $M \xrightarrow{\pi} L$ back bonding to disperse increased electron density at metal.

8. (a, b, d)

$A : [CoCl(NH_3)_5] \cdot BrCl$
$B : [CoBr(NH_3)_5] \cdot Cl_2$
$C : [CoBrCl(NH_3)_4] \cdot Cl$

9. (a, c)

$[PtBrCl(gly)]^-$ and $[Pd(NO_2)(ox)(gly)]$ exhibit geometrical isomerism.

10. (b)

$[Ru(en)_3]^{3+}$: Hyb. : d^2sp^3; does not exhibit geometrical isomerism but exhibits optical isomerism.
$[Co(H_2O)Cl_3]$: Hyb. : sp^3; does not exhibit both geometrical isomerism and optical isomerism.
$[PtBrCl(H_2O)NH_3]$: Hyb. : dsp^2; exhibit geometrical isomerism but does not exhibit optical isomerism.
$[FeBr_2(en)_2]^+$: Hyb. : d^2sp^3; exhibits both geometrical isomerism and optical isomerism.

17. (a,b,d)

F^-, Cl^- and OH^- are weak field ligands usually form high spin complexes.
CN^- and NO_2^- are strong field ligands usually form low spin complexes.
$[Ni(CO)_4]$ is low spin complex.

18. (b,c)

Irrespective of nature of ligand field, magnetic moment of octahedral complexes having metal ions in d^1, d^2, d^3, d^8, d^9 configuration, remains same.
Element may or may not form colourless complex.

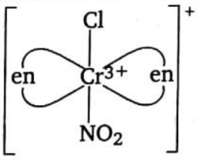
19. (a, d)

Irrespective nature of ligand, complex compound having d^1 to d^3 configuration-inner orbital complex.
Irrespective nature of ligand, complex compound having d^8 to d^{10} configuration-outer orbital complex.

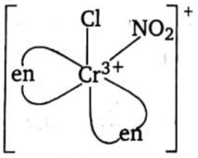
20. (a,d)

Coordination isomerism occurs when both cation and anion are complex, caused due to interchange of ligands between two complex ions of the same complex.

22. (b, d)



Trans-form
(optically inactive)



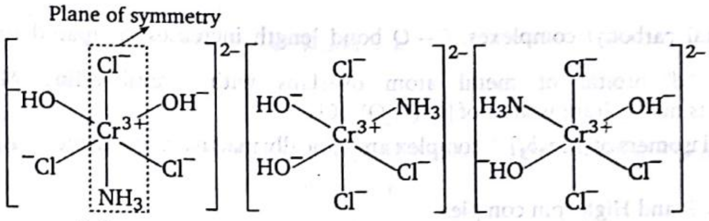
cis-form
(optically active)

cis and *trans* are diastereomers to each other.

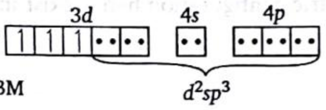
23. (a,b,c,d)

cis-$[CoBrCl(en)_2]^+$ will exhibit optical isomerism. No. of geometrical isomers of $[Pt(NO_2)(NH_3)(NH_2OH)py]^{3+}$ and space isomers for $[PtBrCl](NO_2)(NH_3)(py)$ are 30 *cis* and *trans* forms are diastereomers to each other.

24. (a, d)



cis-form Optically inactive | *trans*-form Optically inactive | *trans*-form Optically inactive

Cr^{3+}in$[CrCl_3(OH)_2(NH_3)]^{2-}$ 

μ = 3.9 BM

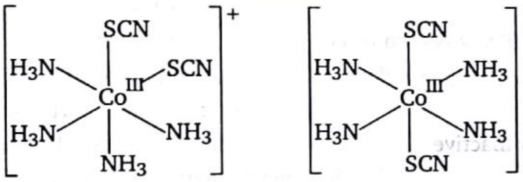
25. (b, c, d)

Formula of the complex $[Co^{III}(SCN_2)(NH_3)_4]_3[Co^{III}(ox)_3]$

Linkage isomerism is due to presence of SCN^-

Optical isomerism is exhibited due to presence of $[Co(ox)_3]^{3-}$ complex ion, which has asymmetric structure.

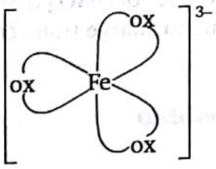
Geometrical isomerism is exhibited due to cationic part :



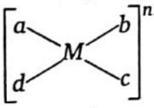
cis *trans*

26. (a, c, d)

$[PtCl_2(NH_3)_4]^{2+}$ ⇒ both *cis* and *trans* forms are optically inactive

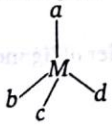
(b) 

⇒ Due to asymmetrical configuration, it exhibits optical isomerism.

(c) 

square planar

⇒ Due to plane of symmetry does not exhibit optical isomerism, but exhibits geometrical isomerism.

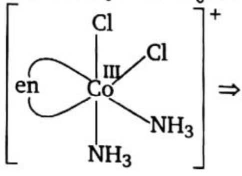
(d) 

⇒ Tetrahedral complex, Asymmetric configuration, hence exhibits optical isomerisms.

27. (a, d) $M \underset{\sigma}{\overset{\pi}{\rightleftharpoons}} L$, In metal carbonyl complexes, C—O bond length increases compared to that in CO molecule as filled '*d*' orbital of metal atom overlaps with π-antibonding M.O. of CO $[CrCl_3(H_2O)_3].3H_2O$ is not hydrate isomer of $[Cr(H_2O)_6]Cl_3$.

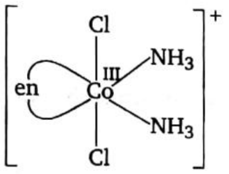
Facial and Meridional isomers of $[Ma_3b_3]^{n+}$ complex are optically inactive as each one contains plane of symmetry.

28. (a,b,d) $[CoF_6]^{3-}$: $\Delta_0 < P$ and High spin complex



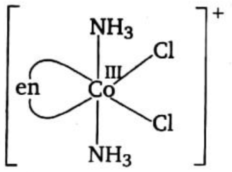
cis-form

$\Rightarrow$Asymmetric configuration hence exist in *d* and *l* forms



trans-form

$\Rightarrow$ Optically inactive



trans-form

$\Rightarrow$ Optically inactive

Total isomers = 4

30. (a,b,c) Nitrate ion gives a brown ring when reacts with conc. H_2SO_4 in presence of $FeSO_4$ due to formation of $[Fe(H_2O)_5NO]SO_4$ complex compound. Brown colour is just due to charge transfer spectra.

34. (b, c, d)

(b) Sodium hydridotrimethoxoborate(III)

(c) Bis (benzoyl acetaonate) beryllium(II)

(d) Tetrachloroauric(III)acid.

Match the Column

2. $[Pt(NO_2)_2(en)]^{2+}$

→ E.A.N. = 78 − 4 + 12 = 86 ($_{86}Rn$)

→ Co-ordination number of Pt = 6

$[Cr(\pi\text{-}C_6H_6)(NO)_2]$

→ E.A.N. = 24 + 6 + 2 × 3 = 36 ($_{36}Kr$)

→ Synergic bonding is present hence, bond order of *M*—*L* bond > 1.0 and bond order of ligand decreases.

→ Co-ordination number for central metal not applicable.

$[Ir(SCN)(SO_4)(NH_3)_4]$

→ E.A.N = 77 − 3 + 12 = 86 ($_{86}Rn$)

→ SCN^- : Ambidentate ligand

→ Co-ordination number of central metal = 6

$[Cr(C_2H_4)(CO)_5]$

→ E.A.N. = 24 + 2 + 10 = 36 ($_{36}Kr$)

→ Synergic bonding is present hence, bond order of $M—L$ bond > 1.0 and bond order of ligand decreases.

→ Co-ordination number of central metal = 6

3. (a) : $[Pt(acac)BrCl(H_2O)_2]NO_3$

⇒ *Cis* configurations = 2 *Trans* configurations = 2

both optically active both optically inactive

⇒ Exhibits ionization isomerism

⇒ Total number of optical isomers = 6.

Optically active isomers = 4

(b) : $[IrBr_2(en)(H_2O)(NH_3)]Br$:

⇒ *Cis* configurations = 2, both are optically active.

Trans configurations = 2, both are optically inactive.

⇒ Does not exhibit structural isomerism.

⇒ Total number of optical isomers = 6

Optically active isomers = 4

(c) : $[Cr(acac)Cl_2(H_2O)_2]$

⇒ *Cis* configuration = 1, which is optically active.

Trans configurations = 2, which are optically inactive.

⇒ Does not exhibit structural isomerism.

⇒ Total number of optical isomers = 4

Optically active isomers = 2

(d) : $[Pt(Ox)_2(NH_3)_2]$

⇒ *Cis* configuration = 1, which is optically active.

Trans configuration = 1, which is optically inactive.

⇒ Does not exhibit structural isomerism.

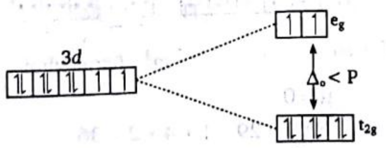
⇒ Total number of optical isomers = 3

Optically active isomers = 2.

7.

Complex	Oxidation state	Type	Magnetic property
$[Fe(CN)_6]^{4-}$	+2	d^2sp^3 (inner-orbital complex)	Diamagnetic
$[Fe(H_2O)_6]^{2+}$	+2	sp^3d^2 (outer-orbital complex)	Paramagnetic
$[Cu(NH_3)_6]^{2+}$	+2	sp^3d^2 (outer complex)	Paramagnetic
$[Ni(CN)_6]^{4-}$	+2	sp^3d^2 (outer complex)	Diamagnetic

8. (A)R, S



Ni^{2+} in Octahedral field

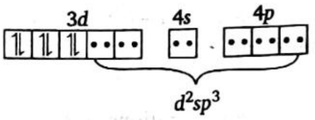
μ = 2.8 BM, Hyb. : sp^3d^2

(B) P, Q

$[Co(CN)_2(NH_3)_4]OC_2H_5$

Its ionization isomer $[Co(CN)(OC_2H_5)(NH_3)_4]CN$

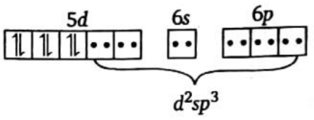
Co^{3+} in $[Co(CN)_2(NH_3)_4]$



, $\mu = 0$

(C) P

$[IrCl_6]^{3-}$ Ir^{3+} in $[IrCl_6]^{3-}$



, $\mu = 0$

(D) P, Q

$[PtCl_2(NH_3)_4]Br_2$, d^2sp^3, octahedral , $\mu = 0$

There are two ionisation isomers : $[PtBrCl(NH_3)_4]BrCl$, $[PtBr_2(NH_3)_4]Cl_2$

10. Sodium nitroprusside—$Na_2[Fe(CN)_5NO]$

Hyb^n — d^2sp^3; $\mu = 0$; octahedral, NO^+ ligand

Brown ring $[\overset{+1}{Fe}(H_2O)_5NO]^{2+}$

Hyb^n.—sp^3d^2; octahedral, $m = 3.89$ BM, NO^+ ligand

Complex formed during extraction of Ag is $[Ag(CN)_2]^-$

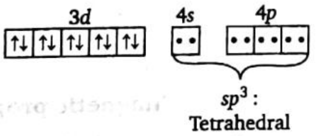
Hyb^n—sp; linear, $\mu = 0$

Potassium ferrocyanide—$K_4[Fe(CN)_6]$

Hyb^n—d^2sp^3; octahedral, $\mu = 0$

11. (A) $[Ni(CO)_4]$

Ni in $[NI(CO)_4]$

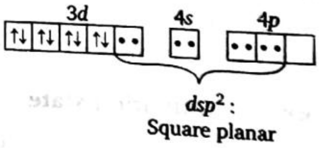


$\mu = 0$

EAN $= 28 - 0 + 4 \times 2 = 36$

$K_2[Ni(CN)_4]$

Ni^{2+} in $[Ni(CN)_4]^{2-}$

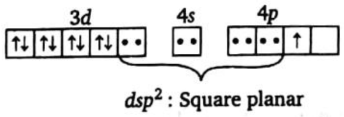


$\mu = 0$

EAN $= 28 - 2 + 4 \times 2 = 34$

(B) $[Cu(NH_3)_4]SO_4$

Cu^{2+} in $[Cu(NH_3)_4]^{2+}$

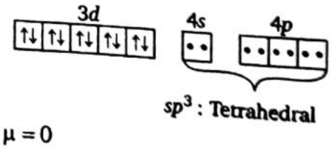


$\mu = 1.732$ BM

EAN $= 29 - 2 + 4 \times 2 = 35$

$K_3[Cu(CN)_4]$

Cu^+ in $[Cu(CN)_4]^{3-}$

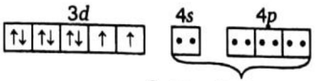


$\mu = 0$

EAN $= 29 - 1 + 4 \times 2 = 36$

(C) $K_2[NiCl_4]$

Ni^{2+} in $[NiCl_4]^{2-}$



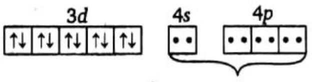
sp^3 : Tetrahedral

$\mu = 2.8$ BM

EAN $= 28 - 2 + 4 \times 2 = 34$

$K_4[Ni(CN)_4]$

Ni in $[Ni(CN)_4]^{4-}$



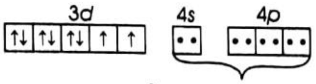
sp^3 : Tetrahedral

$\mu = 0$

EAN $= 28 - 0 + 4 \times 2 = 36$

(D) $K_2[NiCl_4]$

Ni^{2+} in $[NiCl_4]^{2-}$



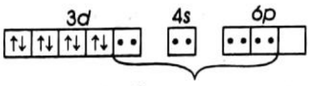
sp^3 : Tetrahedral

$\mu_{eff} = 2.8$ BM

EAN $= 28 - 2 + 4 \times 2 = 34$

$K_2[PtCl_4]^{2-}$

Pt^{2+} in $[PtCl_4]^{2-}$

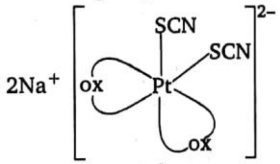


dsp^2 : Square planar

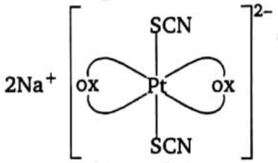
$\mu_{eff} = 0$

EAN $= 78 - 2 + 4 \times 2 = 84$

13. (A) SCN^- is ambidentate ligand, therefore it shows linkage isomerism



cis-form



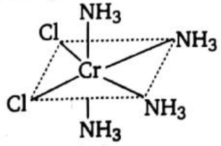
trans-form

cis-form is optically active.

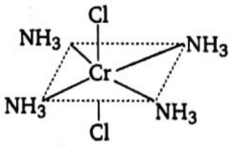
(B) $[CrCl_2(NH_3)_4]NO_3$

$[Cr(Cl)(NO_3)(NH_3)_4]Cl$

Ionization isomer of complex



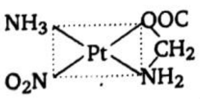
cis-form

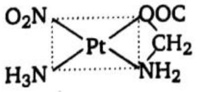


trans-form

Both *cis* and *trans*-form are optically inactive.

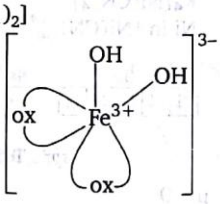
(C)



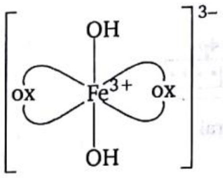


NO_2^- is ambidentate ligand so it also shows linakge isomerism. It is optically inactive square planar complex.

(D) $K_3[Fe(OH)_2(C_2O_4)_2]$



cis-form
Optically active



trans-form
Optically active

14. (A) $K_3[Fe(CN)_5(CO)]$

→ Due to +2 oxidation state of Fe extent of $d\pi(Fe^{II}) \longrightarrow \pi^*$ (CO) is poor, hence C—O bond length is not increased considerably as in $[Co(CO)_4]^-$ and $[V(CO)_6]$

→ EAN of Fe = 26 − 2 + 5 × 2 + 2 = 36 (Kr)

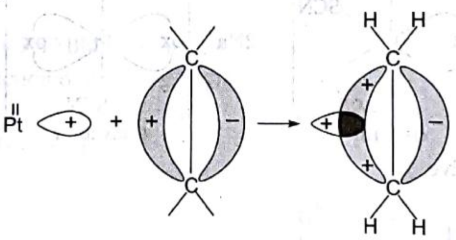
$\overset{\text{II}}{\text{Fe}} \underset{\sigma}{\overset{\pi}{\rightleftharpoons}} \text{CO}$, hence synergic bonding is present.

(B) $K[PtCl_3(CH_2{=}CH_2)]$

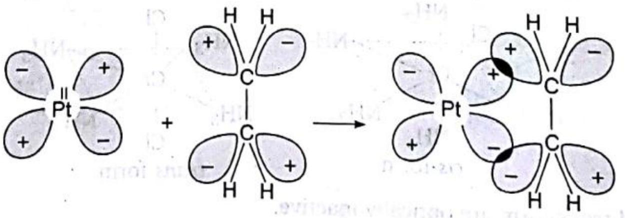
EAN of Pt = 78 − 2 + 3 × 2 + 2 = 84, (At. no. of Rn = 86)

$\overset{\text{II}}{\text{Pt}} \underset{\pi}{\overset{\pi}{\rightleftharpoons}} (CH_2{=}CH_2)$, synergic bonding is present.

$\text{Pt} \xleftarrow{\pi} (CH_2{=}CH_2)$



$\text{Pt} \xrightarrow{\pi} (CH_2{=}CH_2)$

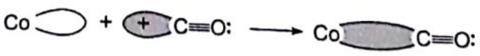


(C) $Na[CO(CO)_4]$

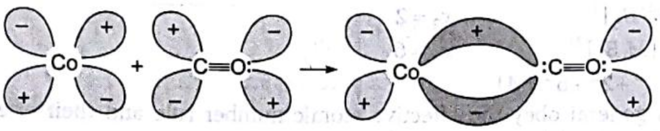
EAN of Co = 27 + 1 + 4 × 2 = 36 (Kr)

$\text{Co} \underset{\sigma}{\overset{\pi}{\rightleftharpoons}} \text{CO}$, synergic bonding takes place.

$\text{Co} \xleftarrow{\sigma} \text{CO}$

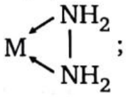


$\text{Co} \xrightarrow{\pi} \text{CO}$



Assertion-Reason Type Questions

2. (A) N_2H_4 can only act as monodentate ligand.



; Three membered (unstable) ring. Hence it acts as monodentate ligand only.

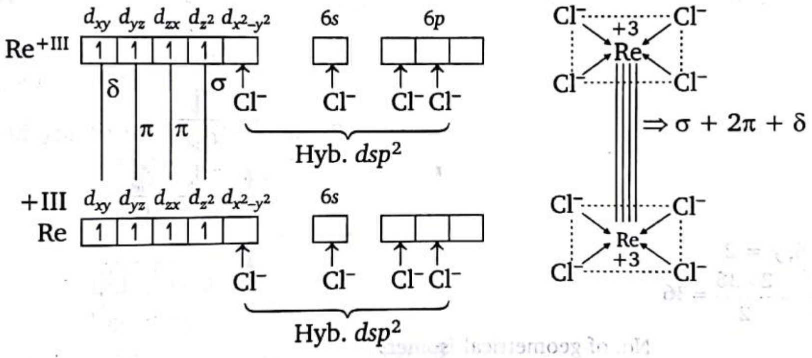
3. (B) Both $[Ti(H_2O)_6]^{4+}$ and $[Sc(H_2O)_6]^{3+}$ are colourless, due to absence of free electrons in 3*d* subshell.

5. (A) EDTA is hexadentate ligand. When it forms complex with a metal cation, the hybridisation of central atom will be d^2sp^3.

12. (A) $\ddot{N}H_2 — \ddot{N}H_2$ Neutral ligand

It does not act as bidentate because when it acts as bidentate, because when it acts as bidentate a three membered ring (chelat complex) will be formed, that will be highly strained.

13. (B)



Subjective Problems

1.

Compounds	Geometry	Hybridization	used *d*-orbital
A	Square planar	dsp^2	$d_{x^2-y^2}$
B	Trigonal bipyramidal	sp^3d	d_{z^2}
C	Square pyramidal	sp^3d	$d_{x^2-y^2}$
D	Octahedral	sp^3d^2	$d_{x^2-y^2}, d_{z^2}$
E	Pentgaonal bipyramidal	sp^3d^3	$d_{x^2-y^2}, d_{z^2}, d_{xy}$

$x = d_{z^2} = 3$

$y = d_{xy} = 1$; $(x + y - z)^2 = (3 + 1 - 4)^2 = 0$

$z = d_{x^2-y^2} = 4$

3. $[M_1^{2+}A_4]^{2+}[M_1^{2+}B_4]^{2-}$ $x_1 = 1$

$[M_2^{3+}A_6]^{3+}[M_2^{3+}B_6]^{3-}$ $x_2 = 2$

$[M_2^{3+}C(A)_5]^{2+}[M_1B_4]^{2-}$ $x_3 = 6$

$x_1^2 + x_2^2 + x_3^2 = 1^2 + 2^2 + 6^2 = 41$

4. The carbonyls in general obey the effective atomic number rule and their effective atomic number = atomic number of next noble gas

(i) $Mo(CO)_x \Rightarrow$ EAN '54'

$42 + 2x = 54$

$x = 6$

(ii) $H_yCr(CO)_5 \Rightarrow$ EAN '36'

$24 + (2 \times 5) + y = 36$

$y = 2$

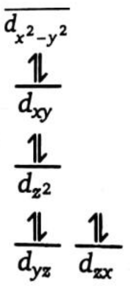
(iii) $Co_2(CO)_z \Rightarrow$ EAN '36'

$27 + 1$ (from other Co-atom) $+ 2z = 36$

Then $x + y - z = 6 + 2 - 4 = 4$

5. $\underset{\text{green}}{Ni^{2+}(aq)} + DMG \xrightarrow{AqNH_3} \underset{\substack{\text{Rosy Red voluminous ppt.} \\ \text{Hyb. of } Ni^{2+}:\, dsp^2}}{[Ni(DMG)_2]\downarrow} + 2H^+$

Distribution of electrons in the d-orbitals of $Ni^{2+}(3d^8)$ in $[Ni(DMG)_2]$:



Hence $x = 6, y = 2$

$\therefore$ Value of $\frac{2x^2}{y} = \frac{2 \times 36}{2} = 36$

6.

Complexes	No. of geometrical isomers
(i) $[Pt(NH_3)_2(SCN)_2]$	2
(ii) $[Co(NO_2)_3(NH_3)_3]$	2
(iii) $[Pt(en)Cl_2]$	0
(iv) $[Cr(en)_2Br_2]^+$	2
(v) $[Rh(en)_3]^{3+}$	0
(vi) $[CoCl_2Br_2]^{2-}$	0

Hence, sum of total number of geometrical isomers = 6

7. $Cr(CO)_x \longrightarrow Cr(CO)_y(NO)_z$

$x = 6, y = 3, z = 2$

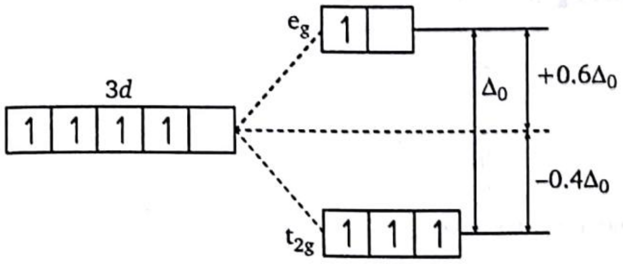
Hence, $x + z - y = 6 + 2 - 3 = 5$

8. $[\overset{+1}{Fe}(H_2O)_5(NO)]SO_4$

Experimental evidence : $\mu_{eff}(obs) = 3.89$

: Complex is highly unstable

9.



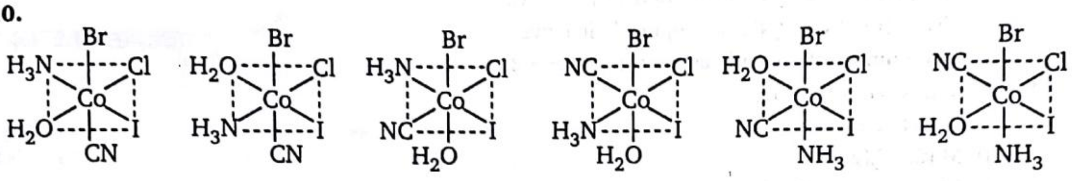
$P > \Delta_0$

$\overset{3+}{Mn}$ in $[MnF_6]^{3-}$

C.F.S.E. value $= -(3\times0.4\Delta_0)+(1\times0.6\Delta_0) = -0.6\Delta_0 = -6Dq$

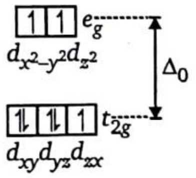
$|CFSE| = 6Dq.$

10.



15. ⇒ $[\overset{+I}{Fe}(H_2O)_5(NO)]^{2+}SO_4^{2-}$

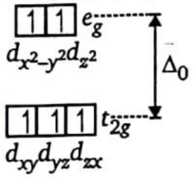
$\overset{+I}{Fe}(3d^7)$ in $(\overset{+I}{Fe}(H_2O)_5(NO))]^{2+}$; $\Delta_0 < P$



Number of electrons in t_{2g} set of d-orbitals = **5**

16. ⇒ Pink colour complex : $[Mn(H_2O)_6]^{2+}$

$Mn^{2+}(3d^5)$ in $[Mn(H_2O)_6]^{++}$, $\Delta_0 < P$



CFSE of pink colour complex

$$=3\times\left(-\frac{2}{5}\Delta_0\right)+2\times\left[\frac{3}{5}\Delta_0\right]=0$$

17.

	EDTA		Phen		
σ bond	31	+	24	=	55
π bond	4	+	7	=	11

18.

	Complexes	**No. of geometrical isomers**
(i)	$[Pt(NH_3)_2(SCN)_2]$	2
(ii)	$[Co(NO_2)_3(NH_3)_3]$	2
(iii)	$[Pt(en)Cl_2]$	0
(iv)	$[Cr(en)_2Br_2]^+$	2
(v)	$[Rh(en)_3]^{3+}$	0
(vi)	$[CoCl_2Br_2]^{2-}$	0

Hence, sum of total number of geometrical isomers = 6

19. ⇒ (i) $[Cr(ox)_3]^{3-}$: optically active.

(ii) *cis*-$[Pt(Cl_2)(en)]$: optically inactive

(iii) *cis*-$[Rh(Cl_2)(NH_3)_4]$: optically inactive

(iv) $[Ru(dipy)_3]^{3+}$: optically active

(v) *cis*-$[Co(NO_2)_3(dien)]$: optically inactive

(vi) *Trans*-$[Co(NO_2)_3(dien)]$: optically inactive

(vii) *cis*-$[Co(NO_2)_3(NH_3)_3]$: optically inactive

⇒ Total number of optically active complexes = 2

20. (i) $[Fe\ IF(CN)(H_2O)(en)]$

$x = 12$ (active isomer)

(ii) $[MoCl_2\ F_2(gly)]^-$

$y = 4$ (active isomer)

$x - y = 12 - 4 \quad \Rightarrow 8$

21. $P = NH_2^-, O_2^-, OH^-, Cl^- = 4$

$Q = SO_4^{2-}, NO_2^-, CO_3^{2-}, CH_3COO^- = 4$

$R =$ en, acac, Phen, DMG, Gly = 5

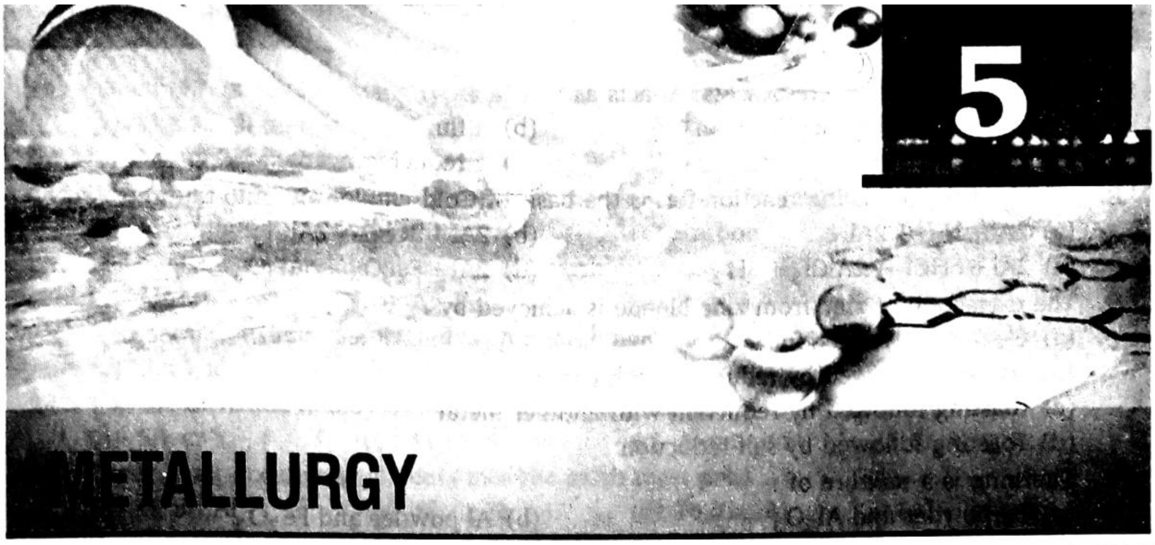
$S =$ DMG, Gly = 2

$4 + 4 - 5 - 2 = 1$

22. Metal $(M) \Rightarrow$ Mo $(z = 42)$

$Mo(CO)_x(NO)_y \xrightarrow[-CO]{+NO} Mo(NO)_z$

If $y = 2$, then $x = 3$ and $z = 4$, hence $x = y - z = 3 + 2 - 4 = 1$



5

METALLURGY

Level 1

General Principal Involved in Metallurgy

1. Highly electropositive metal(s) can not be commercially extracted by carbon reduction process at high temperature because these :

(a) matals combine with carbon to form covalent carbide

(b) metals combine with carbon to form ionic carbide

(c) ΔG_f of highly electropositive metal oxide is having low negative value

(d) metal oxides are not reduced by carbon

2. Consider the following reactions at 1000°C.

(I) $Zn(s) + 1/2\,O_2(g) \xrightarrow{\Delta} ZnO(g);\ \Delta G^\circ = -360\ \text{kJ mol}^{-1}$

(II) $C(s) + 1/2\,O_2(g) \xrightarrow{\Delta} CO(g);\quad \Delta G^\circ = -460\ \text{kJ mol}^{-1}$

and choose the correct statement at 1000°C.

(a) ZnO is more stable than CO (b) ZnO can be reduced to Zn by C

(c) ZnO and CO are formed at equal rate (d) ZnO can not be reduced to Zn by C

3. Which of the following pair of ores cannot be converted into corresponding metals by pyrometallurgy ?

(a) Ag_2S, ZnS (b) Cu_2S, HgS (c) MnO_2, SnO_2 (d) None of these

4. Ellingham diagram represents:

(a) change of ΔG with temperature (b) change of ΔH with temperature

(c) change of ΔG with pressure (d) change of $(\Delta G - T\Delta S)$ with temperature

5. The process of the isolation of a metal by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called:

(a) hydrometallurgy (b) electrometallurgy (c) zone refining (d) electrorefining

6. The process of the isolation of a metal by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called :

(a) hydrometallurgy (b) electrometallurgy (c) zone refining (d) electrorefining

7. In the alumino-thermite process, Al acts as :
(a) an oxidising agent
(b) a flux
(c) solder
(d) a reducing agent

8. Which of the following reaction forms the basis of Goldschmidt alumino-thermite process?
(a) $2Al + N_2 \rightarrow 2AlN$
(b) $2Al + 3Cl_2 \rightarrow 2AlCl_3$
(c) $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
(d) $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$

9. The extraction of zinc from zinc blende is achieved by :
(a) electrolytic reduction
(b) roasting followed by reduction with carbon
(c) roasting followed by reduction with another metal
(d) roasting followed by self-reduction

10. Thermite is a mixture of :
(a) Fe powder and Al_2O_3
(b) Al powder and Fe_2O_3
(c) Cu powder and Fe_2O_3
(d) Zn powder and Cr_2O_3

11. If a metal has low oxygen affinity then the purification of metal may be carried out by:
(a) liquation
(b) distillation
(c) zone refining
(d) cupellation

12. Neutral refractory material used in furnaces is :
(a) Graphite
(b) CaO
(c) SiO_2
(d) MgO

Ores and their Concentration

13. Which of the following set of elements mostly occur as sulphide ores ?
(a) Zn, Cu, Na
(b) Zn, Cu, Pb
(c) Fe, Al, [illegible]
(d) Cu, Ag, Au

14. Which one contains both Ca and Mg?
(a) Limestone
(b) Dolomite
(c) Chalk
(d) Feldspar

15. Match Column-I with Column-II and select the correct answer using the codes given below:

Column-I (Metals)	Column-II (Ores)
(A) Tin	(1) Calamine
(B) Zinc	(2) Cassiterite
(C) Titanium	(3) Cerrusite
(D) Lead	(4) Rutile

	(A)	(B)	(C)	(D)
(a)	1	2	3	4
(b)	2	1	4	3
(c)	4	3	2	1
(d)	2	1	3	4

16. Which of the following is not an ore of magnesium?
(a) Carnallite
(b) Magnesite
(c) Dolomite
(d) Gypsum

17. Which one of the following is not an ore of aluminium?
(a) Bauxite
(b) Corundum
(c) Epsomite
(d) Cryolite

18. Cinnabar is the ore of :
(a) Zn
(b) Cd
(c) Hg
(d) Ag

19. Which of the following minerals does not contain iron?
(a) Magnetite
(b) Magnesite
(c) Haematite
(d) Limonite

20. Which one of the following types of metals is expected to occur in the native state?
(a) The alkali metals (b) The alkaline earth metals
(c) The noble metals (d) The rare earth metals

21. Which one of the following elements is most abundant in earth crust?
(a) Aluminium (b) Silicon (c) Carbon (d) Oxygen

22. The two most abundant metals in the earth crust are :
(a) Al, Zn (b) Ag, Au (c) Fe, Cu (d) Fe, Al

23. A mineral is usually associated with a large amount of unwanted material called :
(a) Gangue (b) Flux (c) Slag (d) Ore

24. The metal which mainly occurs as oxide ore in nature is :
(a) Silver (b) Lead (c) Aluminium (d) Copper

25. Three most occurring elements into the earth crust are :
(a) O, Si, Al (b) Si, O, Fe (c) Fe, Ca, Al (d) Si, O, N

26. Froth floatation process for the concentration of sulphide ores is an illustration of the practical application of:
(a) adsorption (b) absorption (c) sedimentation (d) coagulation

27. Froth floatation process is used for the concentration of the ore of :
(a) Fe (b) Al (c) Cr (d) Cu

28. Haematite ore is concentrated by :
(a) gravity separation method (b) froth floatation process
(c) amalgamation (d) hand picking

29. Electromagnetic separation is used in the concentration of :
(a) Copper pyrite (b) Bauxite
(c) Cassiterite (d) Cinnabar

30. Which one of the following is not a method of concentration of ore?
(a) Electromagnetic separation (b) Smelting
(c) Gravity separation (d) Froth floatation process

31. Chemical leaching is useful in the concentration of :
(a) Copper pyrite (b) Bauxite (c) Cassiterite (d) Galena

32. The ore which is concentrated wetting by oil is :
(a) oxide ore (b) sulphate ore
(c) carbonate ore (d) sulphide ore

33. Rutile is separated from chlorapatite by :
(a) Froth floatation method (b) Levigation
(c) Magnetic separation method (d) Electrostatic separation method

34. In the extraction of copper from its sulphide ore, the metal is formed by reduction of Cu_2O with:
(a) FeS (b) CO (c) Cu_2S (d) SO_2

35. Which of the following pair is incorrectly matched?
(a) van Arkel method — Zirconium (b) Kroll's process — Titanium
(c) Froth Floatation — Cerussite (d) Distillation — Zinc

36. Most abundant metal in earth crust is:
(a) Al (b) O (c) Fe (d) Si

Extraction of Metals

37. Consider the following reactions :

$$2XS + 3O_2 \xrightarrow{\Delta} 2XO + 2SO_2$$

$$2XO + XS \xrightarrow{\Delta} 3'X' + SO_2$$

Then 'X' can not be :

(a) Hg (b) Pb (c) Zn (d) None

38. In the alumino-thermite process, Al metal acts as :

(a) Oxidising agent (b) Reducing agent
(c) Catalyst (d) Flux

39. Extraction of aluminium from bauxite ore, reduction is carried out by:

(a) carbon (b) magnesium
(c) electrolysis (d) hydrogen

40. Chromium is obtained by reducing concentrated chromite ore with:

(a) red hot coke (b) gaseous hydrogen
c) aluminium powder (d) carbon monoxide

41. The element which is recovered from electrolytic process is:

(a) iron (b) lead (c) aluminium (d) zinc

42. Magnesium is manufactured by electrolysing fused magnesium chloride using:

(a) a nickel cathode and a graphite anode
(b) the iron container as anode and a nickel cathode
(c) the iron container as cathode and a graphite anode
(d) the nickel container as cathode and iron anode

43. Copper is extracted from sulphide ore using the method :

(a) carbon reduction (b) carbon monoxide reduction
(c) auto reduction (d) none of these

44. In the extraction of copper, metal is formed in the Bassemer converter due to reaction :

(a) $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$ (b) $Cu_2S \rightarrow 2Cu + S$
(c) $Fe + Cu_2O \rightarrow 2Cu + FeO$ (d) $2Cu_2O \rightarrow 4Cu + O_2$

45. Silica is added to roasted copper ore during extraction in order to remove :

(a) cuprous sulphide (b) ferrous oxide (c) ferrous sulphide (d) cuprous oxide

46. Calcium is extracted by the electrolysis of :

(a) Fused mixture of $CaCl_2$ and CaF_2 (b) $CaCl_2$ fused salt solution
(c) Used mixture of $CaCl_2$ and NaF (d) $Ca_2(PO_4)_2$ fused salt solution

47. Lead is mainly extracted by:

(a) Carbon reduction method
(b) Self-reduction method
(c) Electrolytic reduction
(d) Leaching with aqueous solution of NaCN followed by reduction

48. In which of the following metallurgy, no reducing agent is required from out side?

(a) Mercury from cinnabar (b) Zinc from zinc blende
(c) Iron from haematite (d) Aluminium from Bauxite

49. Aluminium is used as a reducing agent in the reduction of :
(a) Cr_2O_3 (b) SnO_2 (c) ZnO (d) HgO

50. Bessemerisation is carried out for:
(a) Fe, Cu (b) Cu, Al (c) Al, Ag (d) Fe, Al

51. Silver can be separated from lead by :
(a) fractional crystallisation (b) amalgamation
(c) cupellation (d) addition of zinc (Parke's method)

52. A solution of Na_2SO_4 in water is electrolysed using inert electrodes. The products at cathode and anode are respectively:
(a) $O_2; H_2$ (b) $O_2; Na$ (c) $H_2; O_2$ (d) $O_2; SO_2$

53. The metal *X* is prepared by the electrolysis of fused chloride. It reacts with hydrogen to form a colourless solid from which hydrogen gas is released on treatment with water. The metal is :
(a) Al (b) Ca (c) Cu (d) Zn

54. The function of fluorspar in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is :
(a) as a catalyst
(b) to lower the temperature of the melt and to make the fused mixture very conducting
(c) to decrease the rate of oxidation of carbon at the anode
(d) none of the above

55. In the extraction of copper from copper pyrites, iron is removed as :
(a) $FeSO_4$ (b) $FeSiO_3$ (c) Fe_3O_4 (d) Fe_2O_3

56. The material mixed before ore is subjected for smelting in the extraction of iron are :
(a) coke and silica (b) coke and limestone
(c) limestone and silica (d) coke, limestone and silica

57. The maximum temperature 1550°C is obtained in the .... region of the blast furnace used in the extraction of iron.
(a) reduction (b) fusion
(c) combustion (d) slag formation

58. The iron obtained from the blast furnace is called :
(a) pig iron (b) cast iron (c) wrought iron (d) steel

59. Which metal can not obtained by electrolysis of their aqueous salt solution?
(a) Silver (b) Magnesium
(c) Copper (d) Platinum

Refining of Metals

60. Impure aluminium is purified by :
(a) Baeyer's process (b) Hall's process
(c) Hoop's process (d) Serpeck's process

61. Which is not correctly matched :
(a) Spiegleisan : Mn + Fe + C
(b) Dow's sea water process : $Ca(OH)_2$
(c) Parke's process : Ag
(d) Liquation : spelter (Impure Zn)

62. Incorrect match is :
(a) Purification of Al metal : Baeyer's method
(b) Polling : Reduction of Cu_2O
(c) $FeCr_2O_4$ (chromite ore) : $NaOH/Na_2CO_3$
(d) Ag : Mac Arthur cyanide process

63. Refining of tin cannot be done by:
(a) cupellation
(b) liquation
(c) poling
(d) electrorefining

64. Which method is not correct given for refining of crude metals?
(a) Distillation : zinc and mercury
(b) Liquation : tin
(c) van Arkel : Zirconium
(d) Mond process : lead

65. Aluminium metal is purified by :
(a) Hoope's process
(b) Hall's process
(c) Serpeck's process
(d) Baeyer's process

66. High purity copper metal is obtained by :
(a) carbon reduction
(b) hydrogen reduction
(c) electrolytic reduction
(d) thermite reduction

67. Poling process is used for:
(a) The removal of Cu_2O from Cu
(b) The removal of Al_2O_3 from Al
(c) The removal of Fe_2O_3 from Fe
(d) All of these

68. In zone refining method, the molten zone :
(a) consists of impurities only
(b) contains more impurity than the original metal
(c) contains the purified metal only
(d) moves to either side

69. Which of the following pair is correctly matched?
(a) Copper — Oxidative refining
(b) Nickel — Kroll's process
(c) Mercury — Distillation
(d) Lead — van Arkel method

70. Formation of $Ni(CO)_4$ and subsequent its decomposition into Ni and CO makes basis of Mond's process ;

$Ni + 4CO \xrightarrow{T_1} Ni(CO)_4 \xrightarrow{T_2} Ni + 4CO$, T_1 and T_2 are :
(a) 100°C, 50°C
(b) 50°C, 100°C
(c) 50°C, 230°C
(d) 230°C, 50°C

71. In the electrolytic refining of copper, Ag and Au are found :
(a) on anode
(b) in electrolyte solution
(c) in anode mud
(d) in cathode mud

72. Electrolyte solution in electrolytic refining of lead contains :
(a) H_2SiF_6 only
(b) $PbSiF_6$ only
(c) H_2SiF_6 in presence of gelatin
(d) H_2SiF_6 and $PbSiF_6$ in presence of gelatin

73. Blister copper is :
(a) pure copper
(b) ore of copper
(c) alloy of copper
(d) impure copper

74. Percentage of silver in the alloy german silver is :

(a) 2.5% (b) 1.5%

(c) 10% (d) 0%

75. AgCl on fusion with sodium carbonate, gives :

(a) Ag_2CO_3 (b) Ag_2O

(c) Ag (d) Ag_2C_2

76. An alloy which does not contain copper is :

(a) bronze (b) magnalium

(c) brass (d) bell metal

77. Stainless steel contains iron and :

(a) Zn (b) Cu

(c) Al (d) Cr

78. Axles are made by heating rods of iron embedded in charcoal powder. The process is known as :

(a) tempering (b) annealing

(c) nitriding (d) case hardening

79. Nitriding is a process of heating steel in atmosphere of :

(a) ammonia (b) oxygen

(c) carbon dioxide (d) air

80. Bassemer converter is used in the refining of :

(a) pig iron (b) steel

(c) wrought iron (d) cast iron

81. Which of the following elements constitutes a major impurity in pig iron?

(a) Carbon (b) Oxygen

(c) Sulphur (d) Silicon

Level 2

General Principal Involved in Metallurgy

1. Which of the following pair of ores can not be converted into corresponding metals by pyrometallurgy ?

(a) Ag_2S, ZnS (b) Cu_2S, HgS

(c) MnO_2, SnO_2 (d) None

2. $XCl_2\text{ (excess)} + YCl_2 \longrightarrow XCl_4 + Y\downarrow$;

$YO \xrightarrow[>400^\circ]{\Delta} \frac{1}{2}O_2 + Y$, Ore of Y would be :

(a) Siderite (b) Cinnabar

(c) Malachite (d) Hornsilver

3. A sulphide ore is first converted into its oxide before reduction. This is done because :

(a) a sulphide ore cannot be reduced to metal at all

(b) no reducing agent is found suitable for reducing a sulphide ore

(c) the enthalpy of formation of CO_2 is more than that of CS_2

(d) a metal oxide is generally less stable than the metal sulphide

4. Choose the correct code regarding Roasting process.

(I) It is the process of heating ore in air to obtain the oxide

(II) It is an exothermic process

(III) It is used for hydrated oxide and oxysalt ore

(IV) It is used after the concentration of ore

(a) I, II and III (b) I, II and IV

(c) I, III and IV (d) I, II, III and IV

5. Carbon cannot be used in the reduction of Al_2O_3 because :

(a) it is non-metal

(b) the heat of formation of CO_2 is more than that of Al_2O_3

(c) pure carbon is not easily available

(d) the heat of formation of Al_2O_3 is too high

6. On heating quick lime with coke in an electric furnace, we get :

(a) Ca and CO_2 (b) $CaCO_3$

(c) CaO (d) CaC_2

7. Boron can be obtained by various methods but not by :

(a) thermal decomposition of B_2H_6 (b) pyrolysis of BI_3 (van Arkel)

(c) reducing BCl_3 with H_2 (d) electrolysis of fused BCl_3

8. Select correct statement :

(a) The decomposition of an oxide into oxygen and metal vapour entropy increases

(b) Decomposition of an oxide is an endothermic change

(c) To make ΔG° negative, temperature should be high enough so that $T\,\Delta S^\circ > \Delta H^\circ$

(d) All are correct statements

9. The oxide of a metal (R) can be reduced by the metal (P) and metal (R) can reduce the oxide of metal (Q). Then the decreasing order of the reactivity of metal (P), (Q) and (R) with oxygen is:

(a) $P > Q > R$ (b) $P > R > Q$

(c) $R > P > Q$ (d) $Q > P > R$

10. Consider the following metallurgical processes :

(I) Heating impure metal with CO and distilling the resulting volatile carbonyl (b.p. 43°C) and finally decomposition at 150°–200°C to get the pure metal

(II) Heating the sulphide ore in air until a part is converted to oxide and then further heating in the absence of air to let the oxide react with unchanged metal sulphide

(III) Electrolysis of the molten electrolyte containing approximately equal amounts of the metal chloride and NaCl to obtained the metal

The processes used for obtaining magnesium, nickel and copper are respectively :

(a) (I), (II) and (III) (b) (II), (III) and (I)

(c) (III), (I) and (II) (d) (II), (I) and (III)

11. When alumina is heated with carbon in nitrogen atmosphere, the products are :

(a) Al + CO (b) Al + CO_2

(c) Al + CO + CO_2 (d) AlN + CO

12. MgO is used as a refractory material because :

(a) It has high melting point (b) It is a good conductor of heat

(c) It is a good electrical insulator (d) All of these

Ores and their Concentration

13. Among the following statements, the incorrect statement is :

(a) calamine and cerrusite are carbonate ores

(b) rutile and cuprite are oxide ores

(c) zinc blende and pyrites are sulphide ores

(d) malachite and azurite are sulphate ores of Cu

14. Give the correct order of initials **T** or **F** for following statements. Use **T** if statement is true and **F** if it is false.

(i) Every mineral is an ore but every ore is not a mineral

(ii) Slag is product formed during extraction of metal by combination of flux and impurities.

(iii) Highly pure metals can be obtained by zone refining.

(iv) Carnallite is an ore of magnesium and sodium.

(a) TTTF (b) FTTF

(c) FTTT (d) TFTF

15. Find the incorrectly matched pair?

Column-I (ores)	Column-II (metals)
(a) Sylvine	(1) Potassium
(b) Malachite	(2) Magnesium
(c) Cinnabar	(3) Mercury
(d) Fluorite (Flourspar)	(4) Calcium

16. Froth floatation process used for the concentration of sulphide ore :

(a) is based on the difference in wettability of different minerals

(b) uses sodium ethyl xanthate, $C_2H_5OCS_2Na$ as collector

(c) uses NaCN as depressant in the mixture of ZnS and PbS when ZnS forms soluble complex and PbS forms froth

(d) All are correct statements

17. When ZnS and PbS minerals are present together, then NaCN is added to separate them in the froth floatation process as a depressant, because :

(a) $Pb(CN)_2$ is precipitated while no effect on ZnS

(b) ZnS forms soluble complex $Na_2[Zn(CN)_4]$

(c) PbS forms soluble complex $Na_2[Pb(CN)_4]$

(d) They cannot be separated by adding NaCN

18. Leaching of Ag_2S is carried out by heating it with a dilute solution of :

(a) NaCN only (b) HCl

(c) NaOH (d) NaCN in presence of O_2

19. Leaching is commercially carried out for in the concentration of :

(a) Galena (b) Argentite

(c) Copper pyrites (d) Tin stone

20. NaCN is sometimes added in the forth flotation process as depressant when ZnS and PbS minerals are expected because :

(a) $Pb(CN)_2$ is precipitated while no effect on ZnS

(b) ZnS forms soluble complex $Na_2[Zn(CN)_4]$ while PbS forms froth

(c) PbS forms soluble complex $Na_2[Pb(CN)_4]$ while ZnS forms froth

(d) NaCN is never added in froth floatation process

21. Which of the following substance acts as collector in froth floatation method ?

(a) Sodium xenate (b) Sodium pyrophosphate

(c) Sodium nitroprusside (d) Sodium ethyl xanthate

Extraction of Metals

22. In which of the following pair of metals, both are commercially extracted from their respective ores by carbon reduction method?

(a) Zn, Cu (b) Fe, Cu

(c) Sn, Zn (d) Al, Ag

23. Formation of metallic copper from the sulphide ore in the commercial metallurgical process involves.

(a) $Cu_2S + \frac{3}{2}O_2 \longrightarrow Cu_2O + SO_2;$ $Cu_2O + C \longrightarrow 2Cu + CO$

(b) $Cu_2S + \frac{3}{2}O_2 \longrightarrow Cu_2O + SO_2;$ $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$

(c) $Cu_2S + 2O_2 \longrightarrow CuSO_4;$ $CuSO_4 + Cu_2S \longrightarrow 3Cu + 2SO_2$

(d) $Cu_2S + \frac{3}{2}O_2 \longrightarrow Cu_2O + SO_2;$ $Cu_2O + CO \longrightarrow 2Cu + CO_2$

24. There are following extraction process of silver but not :
(a) as a side product in electrolytic refining of copper
(b) Parke's process in which Zn is used to extract silver by solvent extraction from molten lead
(c) by reaction of silver sulphide with KCN and then reaction of soluble complex with Zn
(d) by heating $Na[Ag(CN)_2]$

25. In the extraction of aluminium
Process X : applied for red bauxite to remove iron oxide (chief impurity)
Process Y : (Serpeck's process) : applied for white bauxite to remove Z (chief impurity) then, process X and impurity Z are :
(a) X = Hall and Heroult's process and $Y = SiO_2$
(b) X = Baeyer's process and $Y = SiO_2$
(c) X = Serpeck's process and Y = iron oxide
(d) X = Baeyer's process and Y = iron oxide

26. Give the correct order of initials **T** or **F** for following statements. Use **T** if statement is true and **F** if it is false.
(i) In Gold schmidt thermite process aluminium acts as a reducing agent.
(ii) Mg is extracted by electrolysis of aq. solution of $MgCl_2$
(iii) Extraction of Pb is possible by carbon reduction method
(iv) Red Bauxite is purified by Serpeck's process
(a) TTTF (b) TFFT (c) FTTT (d) TFTF

27. $FeCr_2O_4$ (chromite) is converted to Cr by following steps :

$$\text{Chromite} \xrightarrow{\text{I}} NaCrO_4 \xrightarrow{\text{II}} Cr_2O_3 \xrightarrow{\text{III}} Cr$$

Reagents in I, II and III step might be :

	I-Step	II-Step	III-Step
(a)	Na_2CO_3/air, Δ	C	C
(b)	NaOH/air, Δ	C, Δ	Al, Δ
(c)	Na_2CO_3/air, Δ	C, Δ	C, Δ
(d)	conc. H_2SO_4, Δ	NH_4Cl, Δ	C, Δ

28. The electrolysis of pure alumina is not feasible because :
(a) it is bad conductor of electricity and its fusion temperature is high
(b) it is volatile in nature
(c) it is decomposed when fused
(d) it is amphoteric

29. Which of the following reaction does not occur in Bessemer's converter?
(a) $2Cu_2S + 5O_2 \longrightarrow 2CuSO_4 + 2CuO$
(b) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2 \uparrow$
(c) $2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$
(d) $FeO + SiO_2 \longrightarrow FeSiO_3$

30. What products are formed during, the electrolysis of a concentrated aqueous solution of NaCl?
(I) $Cl_2(g)$ (II) $NaOH(aq)$ (III) $H_2(g)$
(a) I only
(b) I and II only
(c) I and III only
(d) I, II and III

31. During the electrolysis of carnallite, $MgCl_2$ is decomposed and not KCl. This is because of :
(a) lower decomposition voltage of $MgCl_2$ than that of KCl
(b) reverse reaction $MgCl_2 + 2K \longrightarrow Mg + 2KCl$ if KCl is decomposed under other experimental condition
(c) both (a) and (b)
(d) none of the above

32. The reduction of an oxide by aluminium is called :
(a) Beeyer's process
(b) Goldschmidt's aluminothermite process
(c) Hall's process
(d) van Arkel process

33. Incorrect statement in electrolysis of Al_2O_3 by Hall-Heroult process is :
(a) Cryolite $Na_3[AlF_5]$ lowers the m.pt. of Al_2O_3 and increases its electrical conductivity
(b) Al is obtained at cathode and CO_2 at anode
(c) Li_2CO_3 can be used in place of cryolite (Na_3AlF_6)
(d) MgF_2 can be used in place of flourspare (CaF_2)

Refining of Metals

34. In the leaching of Ag_2S with NaCN, a stream of air is also passed. It is because of :
(a) reversible nature of reaction between Ag_2S and NaCN
(b) to oxide Na_2S formed into Na_2SO_4 and sulphur
(c) both (a) and (b)
(d) none of the above

35. In van Arkel method, if I_2 is introduced at 1700 K over impure metal, the product will be :
(a) Iodide of the metal
(b) No reaction takes place
(c) Impurities react with iodine
(d) None of these

36. The method of zone refining of metals is based on the principle of :
(a) Greater mobility of the pure metal than that of impurity
(b) Higher melting point of the impurity than that of the pure metal
(c) Greater noble character of the solid metal than that of the impurity
(d) Greater solubility of the impurity in the molten state than in the solid

37. Blister copper is refined by stirring molten impure metal with green logs of wood because such a wood liberates hydrocarbon gases (like CH_4). This process X is called .... and the metal contains impurities of Y is ....
(a) X = cupellation, $Y = CuO_2$
(b) X = polling, $Y = Cu_2O$
(c) X = polling, $Y = CuO$
(d) X = cupellation, $Y = CuO$

38. The anode mud in the electrolytic refining of silver contains :
(a) Zn, Cu, Ag, Au
(b) Zn, Ag, Au
(c) Cu, Ag, Au
(d) Au only

39. The method of electrolytic refining is not suitable in the extraction of :
(a) Aluminium
(b) Copper
(c) Mercury
(d) Silver

40. Match Column-I with Column-II

Column-I	Column-II
(P) Nitriding	(I) Process of heating steel to redness and then cooling it very slowly
(Q) Annealing	(II) Process of heating steel in presence of NH_3 and producing hard coating of Iron Nitride on the surface of steel
(R) Tempering	(III) Process of heating steel to redness and then cooling it suddenly by plunging it into water or oil
(S) Quenching	(IV) Process of heating quenched steel to a temperature well below redness and then cooling it slowly

	P	Q	R	S
(a)	II	I	III	IV
(b)	II	I	IV	III
(c)	I	II	IV	III
(d)	I	II	III	IV

41. 'Softening of lead' means :

(a) conversion of lead to PbO

(b) conversion of lead to Pb_3O_4

(c) removal of impurities (metallic) from lead

(d) washing lead with HNO_3 followed by alkali solution

42. In the purification of impure nickel by Mond's process, metal is purified by :

(a) Electrolytic reduction

(b) Vapour phase thermal decomposition

(c) Thermite reduction

(d) Carbon reduction

43. Correct match is :

(a) Bayer's method — Na_2CO_3

(b) Matte — 98% Cu_2S + 2% FeS

(c) van Arkel method — AgI

(d) Thomas slag — Raw material for cement industry

Level 3

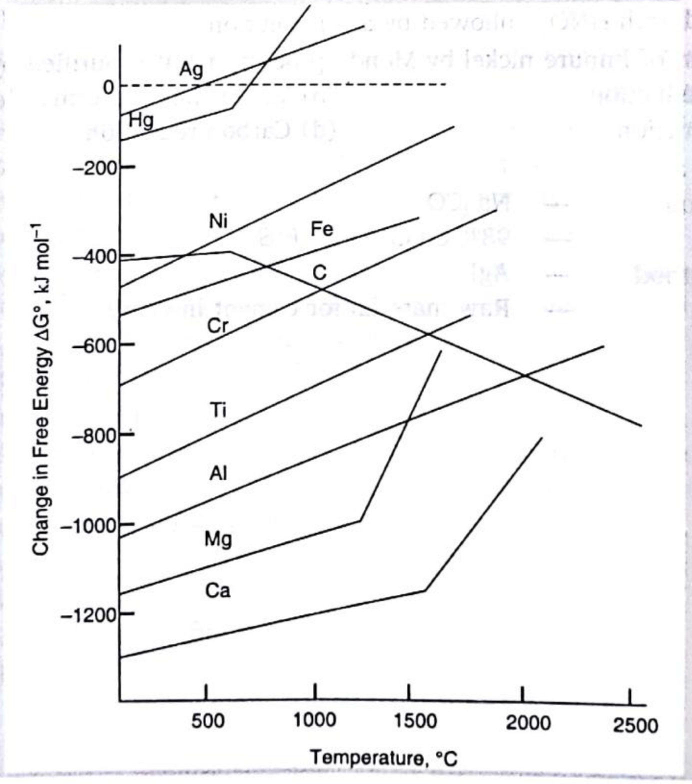
PASSAGE 1

For a spontaneous reaction, the free energy change must be negative. $\Delta G = \Delta H - T\Delta S$, ΔH is the enthalpy change during the reaction. T is the absolute temperature, and ΔS is the change in entropy during the reaction. Consider a reaction such as the formation of an oxide

$$M + O_2 \longrightarrow MO$$

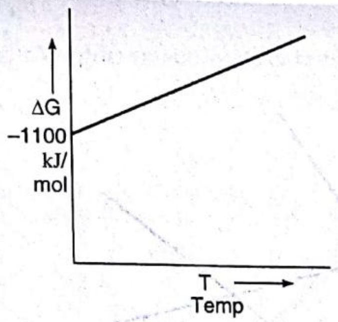
Dioxygen is used up in the course of this reaction. Gases have a more random structure (less ordered) than liquid or solids. Consequently gases have a higher entropy than liquids and solids. In this reaction S (entropy or randomness) decreases, hence ΔS is negative. Thus, if the temperature is raised then $T\Delta S$ becomes more negative. Since, $T\Delta S$ is substracted in the equation, then ΔG becomes less negative. Thus, the free energy change increases with the increase in temperature.

The free energy changes that occur when one mole of common reactant (in this case dioxygen) is used may be plotted graphically against temperature for a number of reactions of metals to their oxides. The following plot is called an Ellingham diagram for metal oxide. Understanding of Ellingham diagram is extremely important for the efficient extraction of metals.

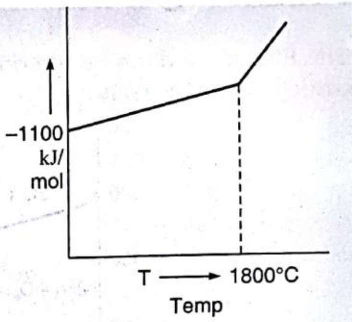


1. For the conversion of Ca(*s*) to CaO(*s*) which of the following represent the ΔG *vs*. T ?

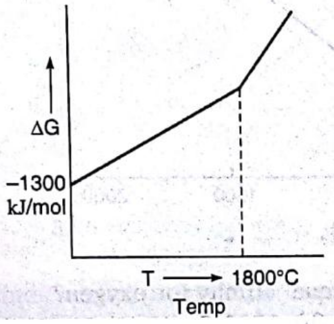
(a)



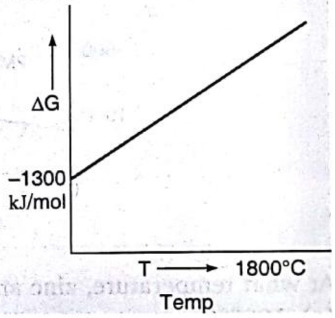
(b)



(c)



(d)



2. Free energy change of Hg and Mg for the convertion to oxides the slope of ΔG *vs*. T has been changed above the boiling points of the given metal because :

(a) above the boiling point of the metal entropy is increased
(b) above the boiling point of the metal the entropy is decreased
(c) above the boiling point of the metal the entropy change is equal to zero
(d) All of these

3. Which of the following elements can be prepared by heating the oxide above 400°C?

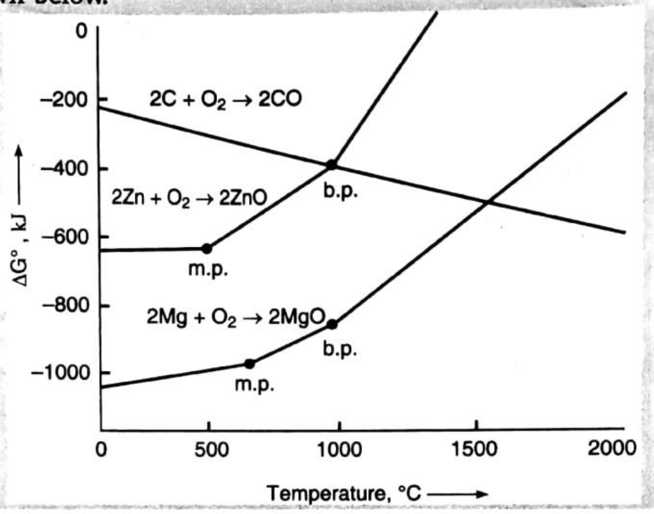
(a) Hg
(b) Mg
(c) Fe
(d) Al

4. As per the Ellingham diagram of oxides which of the following conclusion is true?

(a) Al reduces Fe_2O_3, whereas MgO cannot be reduced by Al at 1500°C
(b) Fe reduces Al_2O_3, whereas MgO cannot be reduced by Al at 1500°C
(c) Al reduces Fe_2O_3, whereas MgO cannot be reduced by Ca at 1500°C
(d) Al can reduce both Fe_2O_3 and MgO to the corresponding metal at 1500°C

PASSAGE 2

The Ellingham diagram for zinc, magnesium and carbon converting into corresponding oxides is shown below.



1. At what temperature, zinc and carbon have equal affinity for oxygen?

(a) 1000°C	(b) 1500°C
(c) 500°C	(d) 1200°C

2. To make the following reduction process spontaneous, temperature should be :

$$ZnO + C \longrightarrow Zn + CO$$

(a) 1000°C	(b) > 1100°C
(c) < 500°C	(d) < 1000°C

3. At 1100°C, which reaction is spontaneous to a maximum extent?

(a) $MgO + C \longrightarrow Mg + CO$

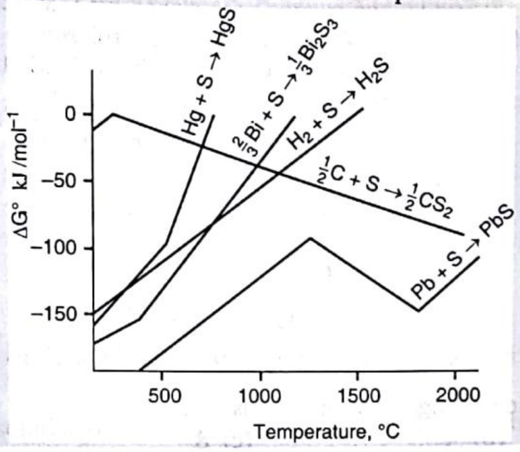
(b) $ZnO + C \longrightarrow Zn + CO$

(c) $MgO + Zn \longrightarrow Mg + ZnO$

(d) $ZnO + Mg \longrightarrow MgO + Zn$

PASSAGE 3

The Ellingham diagram for a number of metallic sulphides is shown below.



1. Formation of which of the sulphides is most spontaneous?
   (a) HgS (b) Bi_2S_3 (c) PbS (d) CS_2
2. Which sulphide occurs to minimum extent in nature?
   (a) HgS (b) H_2S (c) Bi_2S_3 (d) CS_2
3. Which of the following sulphides can not be reduced to metal by H_2 at about 1000°C ?
   (a) HgS (b) PbS (c) Bi_2S_3 (d) all of these

PASSAGE 4

Magnesium is a valuable, light weight metal used as a structural material as well as in alloys, batteries, and in chemical synthesis. Although magnesium is plentiful in Earth's crust, it is mainly found in the sea water (after sodium). There is about 1.3 g of magnesium in every kilogram of sea water. The process for obtaining magnesium from sea water employs all three types of reactions, *i.e.*, precipitation, acid-base, and redox-reactions.

1. Precipitation reaction involves formation of :
   (a) insoluble $MgCO_3$ by adding Na_2CO_3 (b) insoluble $Mg(OH)_2$ by adding $Ca(OH)_2$
   (c) insoluble in $MgSO_4$ by adding Na_2SO_4 (d) insoluble $MgCl_2$ by adding NaCl
2. Acid-base reaction involves reaction between :
   (a) $MgCO_3$ and HCl (b) $Mg(OH)_2$ and H_2SO_4
   (c) $Mg(OH)_2$ and HCl (d) $MgCO_3$ and H_2SO_4
3. Redox reaction takes place (in the extraction of Mg) :
   (a) in the electrolytic cell when fused $MgCl_2$ is subjected to electrolysis
   (b) when fused $MgCO_3$ is heated
   (c) when fused $MgCO_3$ is strongly heated
   (d) none of the above

PASSAGE 5

Dow's process of extraction of Mg involves extraction of Mg from sea water. Sea water is concentrated in sun-light and is then treated with slaked lime. Magnesium hydroxide is heated in a stream of HCl to give $MgCl_2$ which is electrolysed to discharge Mg. The mixture is in the ratio 35% $MgCl_2$ + 50% NaCl + 15% $CaCl_2$. NaCl and $CaCl_2$ are added to lower the fusion temperature and to increases the conductance.

$$Mg^{2+} + Ca(OH)_2 \longrightarrow Mg(OH)_2 + Ca^{2+}$$

$$Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O(l)$$

Electrolysis of fused $$MgCl_2 \rightleftharpoons Mg^{2+} + 2Cl$$

$$Mg^{2+} + 2e^- \longrightarrow Mg \text{ (At Cathode)}$$

$$2Cl^- \longrightarrow Cl_2 + 2e^- \text{ (At Anode)}$$

Mg electrolysed is protected from atmospheric oxidation by a blanket of inert gases.

1. In the hydrated chloride of Mg the value of x is :

(a) 6 (b) 4 (c) 8 (d) 10

2. Molten mixture contains Mg^{2+}, Na^+ and Ca^{2+} but at cathode only Mg^{2+} is discharged because :

(a) Standard reduction potential of Mg^{2+} is least among the three

(b) Standard oxidation potential of Mg is the least among the three

(c) Discharge potential of Mg^{2+} is highest

(d) None of these

3. Molten mixture of NaCl and $CaCl_2$ is added to the heated $MgCl_2$ because:

(a) $MgCl_2 \cdot xH_2O + \text{dry HCl} \xrightarrow{973-1223\text{ K}}$ Partially dehydrated $MgCl_2$ and molten mixture (NaCl + $CaCl_2$) makes it fully dehydrated

(b) $CaCl_2$ is dehydrating agent

(c) ($CaCl_2$ + NaCl) lowers the melting point of $MgCl_2$

(d) None of these

PASSAGE 6

$$FeCr_2O_4 + NaOH + air \longrightarrow (A) + Fe_2O_3$$

$$(A) + (B) \longrightarrow Na_2Cr_2O_7$$

$$Na_2Cr_2O_7 + X \xrightarrow{\Delta} Cr_2O_3$$

$$Cr_2O_3 + Y \xrightarrow{\Delta} Cr$$

1. Compound (*A*) and (*B*) are :

(a) Na_2CrO_4, H_2SO_4 (b) $Na_2Cr_2O_7$, HCl

(c) Na_2CrO_5, H_2SO_4 (d) $Na_4[Fe(OH)_6], H_2SO_4$

2. (*X*) and (*Y*) are :

(a) C and Al (b) Al and C (c) C in both (d) Al in both

3. Na_2CrO_4 and Fe_2O_3 are separated by :

(a) dissolving in conc. H_2SO_4 (b) dissolving in NH_3

(c) dissolving in H_2O (d) dissolving in dil. HCl

PASSAGE 7

Electrolysis is an important technique for extraction of metals, and each ion of the solution needs a minimum voltage to get discharged and this value is expressed in terms of discharge potential. For some metal ions the discharge potentials follow the order given below :

$Li^+ > K^+ > Ca^{2+} > Na^+ > Mg^{2+} > Al^{3+} > Zn^{2+} > Fe^{2+} > Ni^{2+} > H_3O^+ > Cu^{2+} > Hg_2^{2+} > Ag^+ > Au^{3+}$

For some anions the discharge potentials are in the order :

$SO_4^{2-} > NO_3^- > OH^- > Br^- > I^-$

1. When aqueous solution of cupric bromide is electrolyzed the product obtained at cathode will be:

(a) Cu (b) H_2 (c) Br_2 (d) O_2

2. The product formed at anode and cathode, when dilute H_2SO_4 is electrolysed are :

(a) SO_2, H_2 (b) SO_3, H_2 (c) $H_2S_2O_8, H_2$ (d) O_2, H_2

3. A mixture containing chlorides of sodium, calcium and zinc is electrolysed in presence of water. The product obtained at cathode will be :

(a) Na (b) H_2 (c) Ca (d) Cl_2

4. When conc. H_2SO_4 is electrolysed with high current using Pt electrodes, the product obtained at anode is :

(a) SO_2 (b) SO_3 (c) O_2 (d) $H_2S_2O_8$

ONE OR MORE ANSWERS IS/ARE CORRECT

1. Which of the following metal(s) is/are commercially extracted by self reduction method from their corresponding ore ?

(a) Cu (b) Fe (c) Pb (d) Hg

2. Which of the following process makes the ore porous?

(a) Roasting (b) Calcination (c) Reduction (d) Distillation

3. Which of the following ores is/are oxide ore(s)?

(a) Tinstone (b) Bauxite (c) Cryolite (d) Carnallite

4. Roasting of copper pyrites is done :

(a) to remove moisture (b) to oxidise free sulphur

(c) to decompose pyrite into Cu_2S and FeS (d) to remove volatile organic impurities

5. Which of the following is a correct statement?

(a) Calamine is the ore of zinc (b) Pyrolusite is the ore of manganese

(c) Cassiterite is the ore of tin (d) Calcite is the ore of calcium

6. In which of the following pairs, both the minerals are oxides?
(a) Sylvine, saltpetre (b) Casseterite, litharge
(c) Siderite, corundum (d) Cuprite, tinstone

7. Which of the following mineral does not contain sodium?
(a) Trona (b) Borax (c) Epsomite (d) Cerrusite

8. Which of the following pair consists of ore of the same metal?
(a) Bauxite, Limonite (b) Haematite, Siderite
(c) Cinnabar, Cassiterite (d) Galena, Cerrusite

9. The process(es) by which lighter earthy particles are freed from the heavier particles using water is/are :
(a) Gravity separation (b) Levigation (c) Hydraulic washing (d) Leaching

10. Roasting is carried out to :
(a) convert sulphide to oxide and sulphate (b) remove water of hydration
(c) melt the ore (d) remove arsenic and sulphur impurities

11. The chemical treatment of the ore for concentration is done in the case of :
(a) aluminium (b) silver
(c) copper (d) gold

12. Froth floatation :
(a) is a physical method of separating mineral from the gangue
(b) is a method to concentrate the ore depending on the difference in wetability of gangue and the ore
(c) is used for the sulphide ores
(d) is a method in which impurities sink to the bottom

13. Which of the following reaction(s) occur during calcination?
(a) $CaCO_3 \longrightarrow CaO + CO_2$ (b) $4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$
(c) $2Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$ (d) $CuS + CuSO_4 \longrightarrow 2Cu + 2SO_2$

14. Amphoteric nature of aluminium is employed in which of the following process for extraction of aluminium?
(a) Baeyer's process (b) Hall's process
(c) Serpek's process (d) Dow's process

15. Which of the following is true for calcination of a metal ore?
(a) It makes the ore more porous
(b) The ore is heated to a temperature when fusion just begins
(c) Hydrated salts lose their water of crystallisation
(d) Impurities of S, As and Sb are removed in the form of their volatile oxides

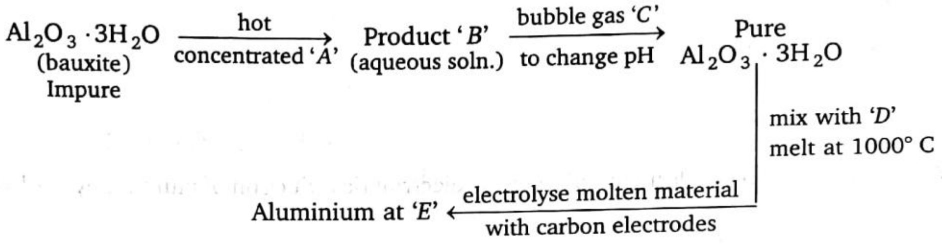
16. The difference(s) between roasting and calcination is/are :
(a) roasting is highly endothermic while calcination is not
(b) partial fusion occurs in calcination but not in roasting
(c) calcination is performed in limited amount of air but roasting employs excess air
(d) combustion reaction occur in roasting but not in calcination

17. The extraction of metals from oxide ores involve :
(a) Reduction with carbon (b) Reduction with aluminium
(c) Electrolyte reduction (d) Reduction with CO

18. Metals which can be extracted by smelting process are :
(a) Pb (b) Fe (c) Zn (d) Al

19. Of the following reduction processes, correct processes are :
(a) $Fe_2O_3 + C \longrightarrow Fe$ (b) $ZnO + C \longrightarrow Zn$
(c) $Ca_3(PO_4)_2 + C \longrightarrow P$ (d) $PbO + C \longrightarrow Pb$

20. In the extraction of aluminium metal, one of the process is summarised as follows :



Which of the following entries correctly summarises reagents, electrodes & products of the process?

	I	II	III	IV	V
(a)	NaOH	Al^{3+}	HF	Na_3AlF_6	Cathode
(b)	NaOH	$NaAlO_2$	CO_2	NaF	Anode
(c)	H_2SO_4	$Al_2(SO_4)_3$	NH_3	Na_3AlF_6	Cathode
(d)	NaOH	$NaAlO_2$	CO_2	Na_3AlF_6	Cathode

21. During the production of iron and steel.
(a) The oxide ore is primarily reduced to iron by solid coke according to the reaction

$$2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$$

(b) The oxide ore is reduced by the carbon monoxide according to the reaction

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

(c) Major silica impurities are removed as calcium silicate slag by addition of a fluxing agent limestone
(d) The silicate slag is used in manufacturing cement

22. The smelting of iron in a blast furnace involves the following processes :
(a) combustion (b) reduction (c) slag formation (d) sublimation

23. Which one of the following metals can be extracted by aluminothermic process?
(a) Manganese (b) Iron (c) Chromium (d) Magnesium

24. For which of the following metal, the carbon reduction cannot be used?
(a) Lead (b) Manganese (c) Tungsten (d) Iron

25. The advantage(s) of using carbon to reduce a number of oxides and other compounds are :
(a) easy availability of coke
(b) low cost of carbon
(c) tendency of carbon to show catenation
(d) presence of carbon lowers the melting point of the oxides

26. The disadvantage of carbon reduction method are :
(a) high temperature needed which is expensive and requires the use of a blast furnace
(b) many metals combine with carbon forming carbides

(c) carbon combines with oxygen to form poisonous CO
(d) carbon cannot be used with highly electropositive metals

27. Which of the following metals are extracted from its ore by using self-reduction method?
(a) Copper (b) Mercury (c) Lead (d) Silver

28. Which of the following is/are correctly matched?

Column-I (Metals)	Column-II (Process used for extraction)
(a) Titanium	Kroll process
(b) Aluminium	Baeyer process
(c) Chromium	Thermite process
(d) Silver	Mac-Arthur cyanide process

29. The function of adding cryolite in the electrolytic reduction of alumina by Hall-Heroult process is to :
(a) dissolve alumina
(b) lower the melting point of alumina
(c) lower the fuel bill
(d) increase the electrical conductivity of alumina

30. Which of the following reduction reactions are actually employed in commercial extraction of metals?
(a) $Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$
(b) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$
(c) $2Na[Au(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Au$
(d) $Cu_2S + Pb \longrightarrow Cu + PbS\downarrow$

31. The chief reaction(s) occurring in blast furnace during extraction of iron from haematite is/are :
(a) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$ (b) $FeO + SiO_2 \longrightarrow FeSiO_3$
(c) $Fe_2O_3 + C \longrightarrow 2Fe + 3CO$ (d) $CaO + SiO_2 \longrightarrow CaSiO_3$

32. Which of the following are true for electrolytic extraction of aluminium?
(a) Cathode material contains graphite
(b) Anode material contains graphite
(c) Cathode reacts away forming CO_2
(d) Anode reacts away forming CO_2

33. Select correct statement regarding silver extraction process.
(a) When the lead-silver alloy is rich in silver, lead is removed by the cupellation process
(b) When the lead-silver alloy is rich in lead, lead is removed by parke's or pattinson's process
(c) Zinc forms an alloy with lead, from which lead is separated by distillation
(d) Zinc forms an alloy with silver, from which zinc is separated by distillation

34. Aluminothermy used for the spot welding of large iron structures is based upon the fact that :
(a) As compared to iron, aluminium has greater affinity for oxygen
(b) As compared to aluminium, iron has greater affinity for oxygen
(c) Reaction between aluminium and oxygen is endothermic
(d) Reaction between iron oxide and aluminium is exothermic

35. Highly electropositive metals can not be extracted by carbon reduction process because these :
(a) Metals combine with carbon to form carbides
(b) Metals do not react with carbon
(c) Metal oxides are not reduced by carbon
(d) Loss of metal is more by vaporisation

36. Which of the following reaction in the blast furnace is/are endothermic?
(a) $C(s) + O_2(g) \rightleftharpoons CO_2(g)$
(b) $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$
(c) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
(d) $Fe_2O_3(s) + 3CO(g) \rightleftharpoons 2Fe(l) + 3CO_2(g)$

37. The furnace lining in steel manufacture consists of :
(a) CaO (b) SiO_2
(c) MgO (d) $CaCO_3$

38. Pick up the correct statement(s) :
(a) All minerals are ores
(b) All minerals cannot be an ore
(c) All ores are minerals
(d) The minerals from which metals can be extracted profitably are called ores

MATCH THE COLUMN

Column-I and **Column-II** contains four entries each. Entries of column-I are to be matched with some entries of column-II. Each entry of column-I may have the matching with one or more than one entries of column-II.

1.

Column-I (Main ore of metal)	**Column-II (Process involved in commercial extraction pure metal)**
(A) Cinnabar	(P) Froth floatation method
(B) Chalcopyrite	(Q) Roasting
(C) Bauxite	(R) Distillation
(D) Argentite	(S) Leaching
	(T) Calcination

2.

Column-I (Statements)	Column-II (Corresponding metals)
(A) Hydrometallurgy applied in commercial extraction of metal	(P) Ag
(B) Carbon reduction applied in commercial extraction in metal	(Q) Zn
(C) Aqueous salt solution is used in electrolytic Refining method	(R) Sn
(D) Metal present in anode mud of refining of crude copper	(S) Au
	(T) Cu

3.

Column-I	Column-II
(A) Haematite	(P) Self reduction
(B) Copper pyrites	(Q) Roasting
(C) Carnalite	(R) Electrolytic reduction
(D) Bauxite	(S) Calcination
	(T) Reduction by carbon monoxide (mainly) as well as carbon at different temperature.

4.

Column-I	Column-II
(A) Ca	(P) Found as its native state
(B) Zn	(Q) Found as its sulphide
(C) Cr	(R) Found as its carbonate
(D) Ag	(S) Found as its oxide

5.

Column-I	Column-II
(A) Ilmentie	(P) Iron
(B) Dolomite	(Q) Magnesium
(C) Carnallite	(R) Potassium
(D) Chromite	(S) Titanium
	(T) Calcium

6.

Column-I	Column-II
(A) Cuprite	(P) Sulphate ore
(B) Cerussite	(Q) Carbonate ore
(C) Kainite	(R) Oxide ore
(D) Calamine	(S) Chloride ore

7.

Column-I	Column-II
(A) Poling	(P) Titanium
(B) Cupellation	(Q) Copper
(C) Electro-refining	(R) Silver
(D) van Arkel method	(S) Tin

8.

Column-I	Column-II
(A) Metal which occur in the native state in nature is	(P) Hg
(B) The oxides of metal that can be commercially reduced by Aluminothermic reduction process is	(Q) Ti
(C) van Arkel method is used for preparing ultrapure metal of	(R) Cr
(D) Auto reduction process is employed for the sulphide ore of	(S) Ag

9.

Column-I	Column-II
(A) Mond's process	(P) $Cr_2O_3 + 2Al \xrightarrow{\Delta} 2Cr + Al_2O_3$
(B) van Arkel process	(Q) $TiCl_4 + 2Mg \xrightarrow{\Delta} Ti + 2MgCl_2$
(C) Thermite process	(R) $Ni(CO)_4 \xrightarrow{\Delta} Ni + 4CO$
(D) Kroll's process	(S) $ZrI_4 \xrightarrow{\Delta} Zr + 2I_2$

10.

Column-I (Metal)	Column-II (Process involved in commercial extraction from their ore)
(A) Pb	(P) Bessemerisation
(B) Cu	(Q) Roasting
(C) Zn	(R) Pyrometallurgy
(D) Fe (Steel)	(S) Self-reduction method

ASSERTION-REASON TYPE QUESTIONS

The questions given below consist of "Assertion" and their "Reason". Use the following key to choose the appropriate answer.

(A) If both assertion and reason are CORRECT, and reason is the CORRECT explanation of the assertion
(B) If both assertion and reason are CORRECT, but reason is NOT the CORRECT explanation of the assertion
(C) If assertion is CORRECT but reason is INCORRECT
(D) If assertion is INCORRECT but reason is CORRECT

1. **Assertion** : $PbSiF_6 + H_2SiF_6$ + gelatine is taken as electrolyte in electrolytic refining of lead.
Reason : Discharge potential of Pb^{2+} is less than H^+.
2. **Assertion** : Nitriding is the process of heating steel in presence of N_2 to form iron nitrides.
Reason : The surface of steel becomes hard after nitriding process.
3. **Assertion** : Ores are generally converted into oxides, prior to reduction.
Reason : Metal oxides can be easily reduced.
4. **Assertion** : In the extraction of Ag, complex $Na[Ag(CN)_2]$ is reacted with Zn.
Reason : Zn is *d*-block transition metal.
5. **Assertion** : Thermite mixture $Fe_2O_3 + Al$ (powder) is used in the welding.
Reason : Al is a good reductant.
6. **Assertion** : In froth floatation process sodium ethyl xanthate is used as collector.
Reason : Sulphide ores are water soluble.
7. **Assertion** : Cryolite is used in electrolytic extraction of Al from alumina.
Reason : It dissolves alumina.
8. **Assertion** : $CuFeS_2$ is concentrated by froth floatation method.
Reason : $CuFeS_2$ is main ore of copper.
9. **Assertion** : In the electrolytic reduction of Al_2O_3, cryolite is used.
Reason : Cryolite is an ore of aluminium.
10. **Assertion** : Wrought iron is more malleable and ductile than steel.
Reason : It contains slightly less percentage of carbon.
11. **Assertion** : Lead, tin and bismuth are purified by liquation method.
Reason : Lead, tin and bismuth have low m.p. as compared to impurities.
12. **Assertion** : Al_2O_3 is converted into Al by reduction with carbon at high temp.
Reason : Carbon has greater affinity for oxygen than aluminium.
13. **Assertion** : Reduction of ZnO with carbon is done at 1100°C.
Reason : $\Delta G°$ is negative at this temperature thus, process is spontaneous.
14. **Assertion** : Desilverisation of lead is done by Parke's method.
Reason : When lead-silver alloy is poor in silver, zinc is added to molten ore.
15. **Assertion** : All the ores are mineral.
Reason : Ores contains metals in combined state.

ANSWERS

Level 1

1. (b)	2. (b)	3. (a)	4. (a)	5. (a)	6. (a)	7. (d)	8. (d)	9. (b)	10. (b)
11. (d)	12. (a)	13. (b)	14. (b)	15. (b)	16. (d)	17. (c)	18. (c)	19. (b)	20. (c)
21. (d)	22. (d)	23. (a)	24. (c)	25. (a)	26. (a)	27. (d)	28. (a)	29. (c)	30. (b)
31. (b)	32. (d)	33. (c)	34. (c)	35. (c)	36. (a)	37. (c)	38. (b)	39. (c)	40. (c)
41. (c)	42. (c)	43. (c)	44. (a)	45. (b)	46. (a)	47. (b)	48. (a)	49. (a)	50. (a)
51. (d)	52. (c)	53. (b)	54. (b)	55. (b)	56. (b)	57. (c)	58. (a)	59. (b)	60. (c)
61. (d)	62. (a)	63. (a)	64. (d)	65. (a)	66. (c)	67. (a)	68. (b)	69. (c)	70. (c)
71. (c)	72. (d)	73. (d)	74 (d)	75. (c)	76. (b)	77. (d)	78. (d)	79. (a)	80. (b)
81. (a)									

Level 2

1. (a)	2. (b)	3. (d)	4. (b)	5. (d)	6. (d)	7. (d)	8. (d)	9. (b)	10. (c)
11. (d)	12. (d)	13. (d)	14. (b)	15. (b)	16. (d)	17. (b)	18. (d)	19. (b)	20. (b)
21. (d)	22. (c)	23. (b)	24. (d)	25. (b)	26. (d)	27. (b)	28. (a)	29. (c)	30. (d)
31. (c)	32. (b)	33. (d)	34. (c)	35. (a)	36. (d)	37. (b)	38. (d)	39. (c)	40. (b)
41. (c)	42. (b)	43. (b)							

Level 3

Passage–1	1. (c)	2. (a)	3. (a)	4. (a)
Passage–2	1. (a)	2. (b)	3. (d)	
Passage–3	1. (c)	2. (d)	3. (b)	
Passage–4	1. (b)	2. (c)	3. (a)	

Passage–5	**1.** (a)	**2.** (b)	**3.** (c)	
Passage–6	**1.** (a)	**2.** (a)	**3.** (c)	
Passage–7	**1.** (a)	**2.** (d)	**3.** (b)	**4.** (d)

One or More Answers is/are correct

1.	(a,c,d)	**2.**	(a,b)	**3.**	(a,b)	**4.**	(a,b,c,d)	**5.**	(a,b,c,d)	**6.**	(b,d)
7.	(c,d)	**8.**	(b,d)	**9.**	(a,b,c)	**10.**	(a,b,d)	**11.**	(a,b,d)	**12.**	(a,b,c,d)
13.	(a,c)	**14.**	(a,b)	**15.**	(a,c)	**16.**	(c,d)	**17.**	(a,b,c,d)	**18.**	(a,b,c)
19.	(a,b,c,d)	**20.**	(d)	**21.**	(b,c,d)	**22.**	(a,b,c)	**23.**	(a,b,c)	**24.**	(b,c)
25.	(a,b)	**26.**	(a,b)	**27.**	(a,b,c)	**28.**	(a,c,d)	**29.**	(a,b,c,d)	**30.**	(b,c)
31.	(a,d)	**32.**	(a,b,d)	**33.**	(a,b,d)	**34.**	(a,d)	**35.**	(a,d)	**36.**	(b,c)
37.	(a,c)	**38.**	(b,c,d)								

Match the Column

1. A → P, Q, R; B → P, Q; C → S, T; D → P, S
2. A → P, S; B → Q, R; C → P, Q, R, S, T; D → P, S
3. A → Q, S, T; B → P, Q; C → R, S; D → R, S
4. A → R; B → Q, R, S; C → S; D → P, Q
5. A → P, S; B → Q, T; C → Q, R; D → P
6. A → R; B → Q; C → P, S; D → Q
7. A → Q, S; B → R; C → Q, R, S; D → P
8. A → S; B → R, C → Q; D → P
9. A → R; B → S; C → P; D → Q
10. A → Q, R, S; B → P, Q, R, S; C → Q, R; D → P, Q, R

Assertion-Reason Type Questions

1. (C) **2.** (D) **3.** (C) **4.** (C) **5.** (B) **6.** (C) **7.** (A) **8.** (B) **9.** (B) **10.** (A)
11. (A) **12.** (C) **13.** (A) **14.** (A) **15.** (C)

Hints and Solutions

Level 1

2. (b) From given reactions, Free energy of the reaction : $ZnO(g)+C(s) \xrightarrow[1000°C]{\Delta} Zn(g)+CO(g)$, is negative.

37. (c) Zn is extracted from its sulphide ore by roasting followed by carbon reduction
Hg, Pb and Cu are extracted by self reduction from their sulphide ores.

40. (c) Cr metal is commercially extracted by Al-reduction method.

61. (d) From spelter pure zinc is obtained either by distillation or by electrolytic refining.

62. (a) Purification of Al metal : Hoop's Method

65. (a) Others are purification methods of bauxite ore.

67. (a) When impure metal has impurity of its own metal oxide, then Poling process is used, *e.g.*, impure Cu and Sn are purified by this method.

75. (c) $2AgCl + Na_2CO_3 \longrightarrow 2NaCl + Ag_2CO_3 \xrightarrow{\Delta} 2Ag + \frac{1}{2}O_2 + CO_2\uparrow$

Level 2

2. (b) $\underset{(XCl_2)}{SnCl_2} + \underset{(YCl_2)}{HgCl_2} \longrightarrow \underset{(XCl_4)}{SnCl_4} + \underset{(Y)}{Hg}$

$HgO \xrightarrow[>400°C]{\Delta} Hg + \frac{1}{2}O_2$

HgS : Cinnabar

8. (d) See Ellingham diagram.

10. (c) (I) $\underset{(impure)}{Ni} + 4CO \xrightarrow{50°C} \underset{(volatile)}{[Ni(CO_4)]} \xrightarrow{230°C} \underset{(pure)}{Ni} + 4CO\uparrow$

(II) $Cu_2S + \frac{3}{2}O_2 \xrightarrow{\Delta} Cu_2O + SO_2$

$Cu_2S + 2Cu_2O \xrightarrow[temp.]{high} 6Cu + SO_2$

(III) $MgCl_2(s) \xrightarrow{electrolysis} Mg^{2+}(l) + 2Cl^-(l)$

At cathode : $Mg^{2+} + 2e^- \longrightarrow Mg(s)$

At anode : $2Cl^-(l) \longrightarrow Cl_2(g) + 2e^-$

17. (b) $ZnS + 4NaCN \rightleftharpoons 4Na^+ + \underset{\text{water soluble}}{[Zn(CN)_4]^{2-}} + S^{2-}$

18. (d) $Ag_2S + 4NaCN \xrightarrow{Air} 2Na[Ag(CN)_2] + Na_2S$

$2Na[Ag(CN)_2] + \left(\begin{matrix}Zn\\dust\end{matrix}\right) \longrightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$

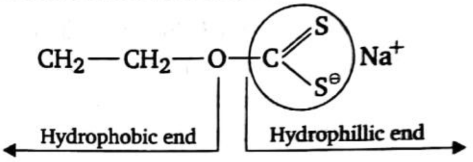
19. (b) Leaching is carried out for the concentration of argentite (Ag_2S).

(i) $$Ag_2S + 4NaCN \xrightarrow{Air} 2Na[Ag(CN)_2]^- + Na_2S \xrightarrow{Air} Na_2SO_4 + S$$

20. (b) Depressant is a substance that is added to suppress the floating characteristic of metal sulphide present as an impurity.

$$PbS + \underset{\text{(Impurity)}}{ZnS} \xrightarrow{4NaCN} \underset{\text{Soluble complex}}{Na_2[Zn(CN)_4]} + PbS$$

21. (d) Sodium ethyl xanthate acts as collector for sulphide ore.



26. (d) (i) $Cr_2O_3 + 2Al\ (R.A.) \xrightarrow{\Delta} Al_2O_3 + 2Cr;\ \Delta H = -ve$

(ii) Mg is extracted by electrolysis of fused $MgCl_2$ and NaCl

(iii) $PbS + \frac{3}{2}O_2 \longrightarrow PbO + SO_2$

$PbO + C \longrightarrow Pb + CO$

(iv) Red Bauxite is purified by Baeyer's process

27. (b) Chromite $\xrightarrow{NaOH/air,\ \Delta} NaCrO_4 \xrightarrow{C,\ \Delta} Cr_2O_3 \xrightarrow{Al,\ \Delta} Cr$

32. (b) The reduction of metal oxides by aluminium powder is called Gold schmidt's aluminothermite process.

$$\underbrace{\underset{\text{(3 part)}}{Cr_2O_3} + \underset{\text{(1 part)}}{Al\ powder}}_{\text{Thermite mixture}} \xrightarrow[\text{Ignition mixture}]{\text{Mg powder+BaO}_2} \underset{\text{(Molten)}}{2Cr} + Al_2O_3 + Heat$$

33. (d) Mg^{2+} cation will be preferentially discharged than Al^{3+} at cathode.

38. (d) Metals, which are less reactive than Ag, remain in anode mud, and metals which are more reactive than Ag metal will be in electrolyte solution.

42. (b) $\underset{\text{(Impure)}}{Ni} + 4CO \xrightarrow{50°\text{ to }60°C} \underset{\text{Volatile compound}}{[Ni(CO)_4]\uparrow} \xrightarrow[\text{Thermal decompotion}]{200\text{ to }230°C} \underset{\text{Pure}}{Ni} + 4CO\uparrow$

43. (b) Roasted mass obtained from roasting step is called **matte**. (98% Cu_2S + 2% FeS)

Level 3

One Ore More Answers is/are Correct

21. (b, c, d)

The oxide ore (Fe_2O_3) is primarily reduced to iron by carbon monoxide

$$SiO_2 + CaO \longrightarrow CaSiO_3\ (Slag)$$

31. (a, d)

In extraction of Fe, Fe_2O_3 is primary reduced by CO below 710°C and acidic impurity of SiO_2 is removed in the form of $CaSiO_3$ (slag).

Match The Column

5. Ilmenite $FeTiO_3$ or $FeO \cdot TiO_2$
   Dolomite $CaCO_3 \cdot MgCO_3$
   Carnaollite $KCl \cdot MgCl_2 \cdot 6H_2O$
   Chromite $FeCr_2O_4$ or $FeO \cdot Cr_2O_3$
6. Cuprite Cu_2O (oxide ore)
   Cerussite $PbCO_3$ (carbonate ore)
   Kainite $KCl \cdot MgSO_4 \cdot 3H_2O$ (chloride and sulphate ore)
   Calamine $ZnCO_3$ (carbonate ore)
7. **Poling :** Impure molten metal is stirred with green wood poles, oxide impurities are removed, mainly used for Cu and Sn.

   Cupellation is used when impurities are of other metals, mainly used for silver.

   Electro-refining : Cu, Ag, Au, Cr, Zn, Ni, etc., are mainly purified by removing insoluble impurities as anode mud.

   van Arkel method : (vapour phase refining) Metals like titanium, zirconium, thorium and uranium are purified by this method.