Chemical Bonding and Molecular Structure

1. Which is a pair of paramagnetic species?

(a) KO_2, NO_2 (b) K_2O_2, KO_2 (c) K_2O, NO_2 (d) NO_2, N_2O_2

Answer: (a)

In KO_2, $O_2^- \rightarrow$ (superoxide) has one unpaired electron and NO_2 also has one unpaired electron. Thus, KO_2 and NO_2 are paramagnetic.

2. Hybridization involves:

(a) Addition of electron pair (b) Mixing of atomic orbitals

(c) Removal of electrons (d) Separation of orbitals

Answer: (b)

Hybridization is mixing up of orbitals of nearly same energy giving rise to the formation of entirely new orbitals (hybridized orbitals) equal in number of mixing orbitals and identical in shape and energy.

3. Among the interhalide species: $IF_2^{\oplus}$, IF_3, $IF_4^{\oplus}$ and IF_7

(a) All iodine centres are either sp^3d or sp^3d^2 hybridised

(b) The minimum angular separation between fluorine atoms is 60°

(c) The anionic species are both isoelectronic and isostructural to XeF_2 and XeF_4

(d) There is no species having a single lone pair of electrons

Answer: (c)

Hybridisation and structure of $IF_2^- \rightarrow sp^3d$ & linear

Hybridisation and structure of $XeF_2 \rightarrow sp^3d$ & linear

So Both XeF_2 and IF_2^- are isostructural and isoeletronic

Hybridisation and structure of $IF_4^- \rightarrow sp^3d^2$ & square Planar

Hybridisation and structure of $XeF_4 \rightarrow sp^3d^2$ & square Planar

$\Rightarrow$ Both XeF_4 and IF_4^- are isoelectronic and isostructural.

4. L In compound $O_2SC(NH_2)_2$, the geometry around the S, N, and number of resonating structure are respectively -

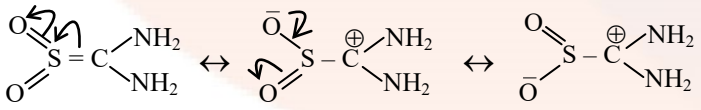
(a) trigonal planar, trigonal pyramidal and three

(b) tetrahedral, pyramidal and two

(c) trigonal planar, tetrahedral and three

(d) linear, pyramidal and three

Answer: (a)



5. LiF is least soluble among the fluorides of alkali metals, because

(a) smaller size Li^+ impart significant covalent character in LiF

(b) the hydration energies of Li^+ and F^- are quite higher

(c) lattice energy of LiF is quite higher due to the smaller size of Li^+ and F^-

(d) LiF have strong polymeric network in solid

Answer: (c)

The small size of both Li^+ and F^- ion leads to a very high value of lattice energy and thus crystal of LiF is very difficult to break.

6. Which of the following cannot represent the resonance forms for diamagnetic N_2O?

(a)  (b)  (c)  (d) 

Answer: (d)

In (d) the arrangement of the atom is different.

7. Most favourable conditions for the formation of ionic bonds are-

(a) large cation and small anion

(b) large cation and large anion

(c) small cation and small anion

(d) small cation and large anion

Answer: (a)

Large cation has lesser polarization power whereas small anion is lesser polarisable.

8. Barium ions, CN^- and Co^{+2} form an ionic complex. If this complex is 75% ionized in aqueous solution with Vant Hoff factor(i) equal to four and paramagnetic moment is found to be 1.73 BM(due to spin only) then hybridization state of Co(II) in the complex will be

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

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

Answer: (d)

as $\mu = 1.73$, no of unpaired $e^- = 1$, α of complex =0.75, i=4

Therefore no.of particles in the solution =5 $(i = 1 + (n-1)\alpha)$

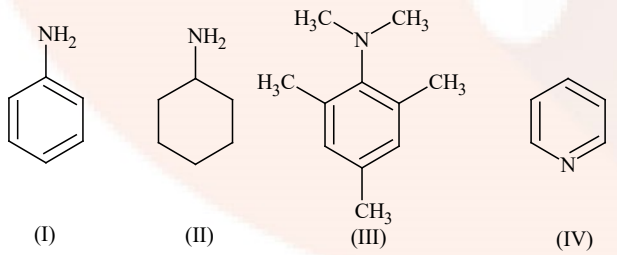
$Ba^{+2}\left[Co(CN)_y\right]^{-2} \Rightarrow Ba_x\left[Co(CN)_y\right]_2$

$\therefore x = 3$ and y=5

$Co^{+2}[Ar]4S^0 3d^7$; e^- get paired

$\therefore dSp^3$

9. The C – N bond length in the molecules:



(I) (II) (III) (IV)

is most correctly in the order

(a) II > III > I > IV (b) II > III = I > IV

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

Answer: (a)

As the s-character of the hybridized orbital of C-atom increases, the bond length decreases. A double bond is shorter than a single bond. Participation of lone pair on N atom in resonance induces partial double-bond character between C and N.

10. For a metal ion M^{3+} the ionic radius $= 0.5$ Å

Therefore the nature of M_2O_3 is-

(a) Acidic (b) Alkaline (c) Amphoteric (d) Neutral

Answer: (c)

The ionic potential $\phi_{M^{3+}} = \frac{3}{0.5} = 6$

$$\sqrt{\phi_{M^{3+}}} = 2.45$$

Since $2.2 < \sqrt{\phi_{M^{3+}}} < 3.2$, hence M_2O_3 is an amphoteric oxide.

11. Which of the following hydrated salts most likely exist at normal temperature?

(a) $LiCl.2H_2O$ (b) $NaCl \cdot 2H_2O$ (c) $KCl \cdot 2H_2O$ (d) All of these

Answer: (a)

Because of the greater ϕ value of Li^+, Li^+ most likely form hydrated salts.

12. Among the following the strongest hydrogen bond is

(a) O–H - - - - - S (b) S–H- - - - -O

(c) F–H- - - - -F (d) O–H- - - - -O

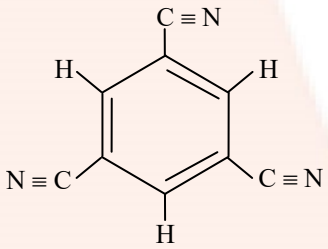
Answer: (c)

F being most electronegative will yield strongest H–bond.

13. The difference of number of sigma bonds and □ bonds in 1, 3, 5-tricyanobenzene is –

(a) 5 (b) 3 (c) 6 (d) zero

Answer: (c)



Total no. of π bonds = 9

Total no. σ bonds = 15

14. I_4O_9 is an -

(a) covalent compound (b) coordinate compound

(c) ionic compound (d) double salt

Answer: (c)

I_4O_9 actually exist as $I(IO_3)_3 \equiv I^{3+} + 3IO_3^-$

15. $N(SiH_3)_3$ has -

(a) sp^3 hybridisation, pyramidal shape

(b) sp^2 hybridisation, planar shape

(c) sp^3 hybridisation, tetrahedral shape

(d) $d\,sp^2$ hybridisation, square planar shape

Answer: (b)

lp of e^-s of nitrogen is donated to the vacant d-orbital of Si.

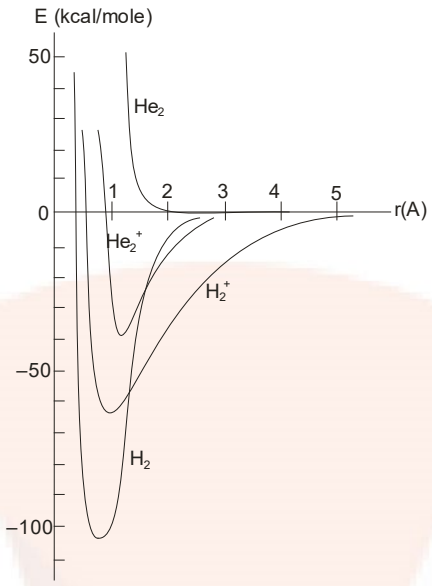
16. Which of the following is/are coloured?

(a) SnF_4 (b) $SnCl_4$ (c) $SnBr_4$ (d) SnI_4

Answer: (d)

Because of the charge transfer spectra, SnI_4 is orange in colour.

17. The following graph is given, between total energy and distance between the two nuclei for species H_2^+, H_2, He_2^+ & He_2, which of the following statements is correct :



(a) He_2^+ is more stable than H_2^+.

(b) Bond dissociation energy of H_2^+ is more than bond dissociation energy of He_2^+.

(c) Since bond orders of He_2^+ and H_2^+ are equal hence both will have equal bond dissociation energy.

(d) Bond length of H_2^+ is less than bond length of H_2.

Answer: (b)

More the negative energy, more is the stability of the ion/molecule.

H_2^+ is more stable than He_2^+.

Bond dissociation energy of H_2^+ is more than bond dissociation energy of He_2^+ as more energy is released when H_2^+ is formed.

18. The value of electronegativity of atoms A and B are 1.20 and 4.0 respectively. The percentage of ionic character of $A-B$ bond is:

(a) 43% (b) 50% (c) 55.3% (d) 72.24%

Answer: (d)

$\Delta EN = 4.0 - 1.2 = 2.8$

% Ionic Character $= 16\Delta EN + 3.5(\Delta EN)^2 = 16 \times 2.8 + 3.5(2.8)^2 = 72.24$ %

19. Which compound is highest covalent?

(a) LiF (b) LiCl (c) LiBr (d) LiI

Answer: (d)

LiF LiCl LiBr LiI →

Size of Anion ↑

Convalent Character ↑

20. As compared to covalent compounds, electrovalent compounds generally have:

(a) low melting points and low boiling points

(b) high melting points and high boiling points

(c) low melting points and high boiling points

(d) high melting points and low boiling points

Answer: (b)

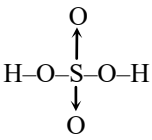
Ionic compound has high M.P. and B.P.

21. A simple example of a coordinate covalent bond is exhibited by:

(a) HCl (b) NH_3 (c) C_2H_2 (d) H_2SO_4

Answer: (d)

H_2SO_4



22. Which of the following does not conduct electricity?

(a) Molten NaOH (b) Molten KOH

(c) Solid NaCl (d) Aqueous NaCl

Answer: (c)

In solid state, ionic compounds are bad conductor of electricity.

23. The geometry of IF_7 is

(a) heptagonal (b) octahedral

(c) trigonal bipyramidal (d) Pentagonal bipyramidal

Answer: (d)

b. p. = 7

l.p. = 0

sp^3d^3 pentagonal bipyramidal.

24. The correct order of the strength of H-bonds is

(a) H……F > H……O > H……N

(b) H……N > H……O > H……F

(c) H……O > H……N > H……F

(d) H……F > H……N > H……O

Answer: (a)

[Strength of H-bond ∝ E.N. of Z atom]

25. Phosphorous hydride's bond angle is closer to 90° while the bond angle of ammonium hydride is closer to 104.5°. Among the following, which one explains this structural feature correctly?

(a) Nitrogen bond pair electron cloud concentrates near the central atom because of its higher electronegativity, thus the bond pair – bond pair repulsion increases which in turn decreases the bond angle in NH_3.

(b) Due to larger size of the lone pair electron cloud, there is larger lone pair – bond pair repulsion in PH_3 compared to NH_3.

(c) Due to quite high energy difference between 3s and 3p orbitals, the lone pair on phosphorous prefers to occupy unhybridized s-orbital rather than hybridized sp^3 hybridized orbital which causes its s-orbital energy to increase.

(d) Phosphorous forms pπ - dπ bonds while nitrogen doesn't.

Answer: (c)

The energy difference between 3s and 3p orbitals is quite hi gh in group 15 and group 16 hydrides (except for NH3 and H2O).

The orbital energy of 3s increases so much by hybridization so lone pair tends to occupy an unhybridized s orbital. . For example in PH3, 600 kJ mol-1 of energy is required to hybridize the central atom. In order to avoid such energy demanding hybridization, by leaving the lone pair in the spherical s orbital, P forms bonds with unhybridized p orbitals.

Thus, the bond angle in PH3 is closer to 90° while that in NH3 is 104.5°.

26. Decreasing order of size of various hybrid orbitals is -

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

Answer: (b)

An increase is s-character give rise to a decrease in size of orbitals.

27. The bond angle and hybridization in ether (CH_3OCH_3) is -

(a) $106°51', sp^3$ (b) $104°31', sp^3$

(c) $110°, sp^3$ (d) None of these

Answer: (c)

The bond angle in CH_3OCH_3 is $110°$ in spite of sp^3 hybridization of O and two lone pair due to steric hindrance.

28. Maleic acid is stronger than fumaric acid because-

(a) Fumaric acid shows intermolecular H-bonding

(b) Fumaric acid shows intramolecular H-bonding

(c) Maleic acid is dibasic acid

(d) Maleic acid shows chelation or intramolecular H-bonding

Answer: (d)

Maleic acid shows intramolecular H-bonding (chelation) and thus–COOH is stabilized.

29. Dipole moment of the hydrides of group 15 elements decreases in the order -

(a) $AsH_3 > BiH_3 > SbH_3 > NH_3 > PH_3$ (b) $BiH_3 > SbH_3 > AsH_3 > PH_3 > NH_3$

(c) $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$ (d) $PH_3 > NH_3 > AsH_3 > SbH_3 > BiH_3$

Answer: (c)

Dipole moment of MH_3 decreases down the group as the electronegativity of the central atom M decreases.

30. The hybridization of central metal ion and shape of Wilkinson's catalyst is -

(a) dsp^2, square planar (b) sp^3, tetrahedral

(c) sp^3d, trigonal bipyramidal (d) d^2sp^3, octahedral

Answer: (a)

In Wilkinson's catalyst-(a homogeneous catalyst), $(Ph_3P)_3RhCl$, Rh is dsp^2 hybridized giving a square planar shape to the compound.

31. The correct order of hybridization of the central atom in the following species NH_3, $[PtCl_4]^{2-}$, PCl_5 and BCl_3 is

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

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

Answer: (b)

There is only one option with sp^3 hybridization of NH_3 and sp^2 hybridization of BCl_3.

32. The nodal plane in the $\pi-$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 $\sigma-$bond at right angle

(d) a plane perpendicular to the molecular plane which contains the carbon–carbon $\sigma-$bond.

Answer: (a)

Nodal plane is a plane where probability of finding electron is almost zero. In ethene molecule the $\pi-$bond is a discontinuous bond. It is above and below the plane of the molecule. Thus the nodal plane in the $\pi-$bond of ethene is the molecular plane itself.

33. Among LiCl, $BeCl_2$, BCl_3 and CCl_4, the covalent bond character follows the order

(a) $LiCl > BeCl_2 > BCl_3 > CCl_4$ (b) $LiCl < BeCl_3 < BCl_3 < CCl_4$

(c) $LiCl > BeCl_2 > CCl_4 > BCl_3$ (d) $LiCl < BeCl_2 < BCl_3 > CCl_4$

Answer: (b)

Smaller cation causes more polarization of anion.

34. PCl_5 exists but NCl_5 does not because

(a) nitrogen has no vacant 2 d-orbitals

(b) NCl_5 is unstable

(c) nitrogen atom is much smaller than P

(d) nitrogen is highly inert

Answer: (a)

Excitation of 2s electron in N is not possible.

35. The pair of species having identical shape is

(a) CFl_4, SF_4 (b) PCl_3, BF_3 (c) XeF_2, CO_2 (d) PF_5, IF_5

Answer: (c)

Both are linear molecules.

36. The hybridization of P in phosphate ion (PO_4^{3-}) is the same as in

(a) in ICl_4^- (b) S in SO_3 (c) N in NO_3^- (d) S in SO_3^{2-}

Answer: (d)

P in PO_4^{3-} has sp^3 hybridization like S in SO_3^{2-}.

37. Which molecule is T-shaped?

(a) BeF_2 (b) BCl_3 (c) NH_3 (d) ClF_3

Answer: (d)

ClF_3 has sp^3d hybridization with two lone pairs of electron on central Cl atom.

38. The species which does not show paramagnetism is

(a) O_2 (b) O_2^+ (c) O_2^{2-} (d) H_2^+

Answer: (c)

O_2^{2-} has no unpaired electron.

39. Which ion has the highest polarizing power?

(a) Mg^{2+} (b) Al^{3+} (c) Ca^{2+} (d) Na^+

Answer: (b)

Small cation has more polarizing power.

40. Which one of the following species is diamagnetic in nature?

(a) He_2^+ (b) H_2 (c) H_2^+ (d) H_2^-

Answer: (b)

Molecular orbital configuration for H_2 is $s1s^2$ in which all the electrons are paired.

41. The number and type of bonds between two carbon atoms in calcium carbide are

(a) One sigma, one pi (b) One sigma, two pi

(c) Two sigma, one pi (d) Two sigma, two pi

Answer: (b)

Calcium carbide is ionic carbide having $[:C \equiv C:]^{2-}$. In $C \equiv C$ bond there are one sigma and two pi bonds.

42. Which of the following statements is wrong regarding ionic compounds -

(a) These are generally in solid state at room temperature.

(b) The force of attraction between ions is non directional.

(c) Ionic compounds soluble in all solvents.

(d) They conduct electricity in molten and solution state.

Answer: (c)

Ionic compounds are not always soluble in any polar solvent. It depends on the solvent.

43. The maximum covalency is equal to -

(a) The number of unpaired p-electrons

(b) The number of paired d-electrons

(c) The number of unpaired s-and p-electrons

(d) The actual number of s-and p-electrons in the outermost shell.

Answer: (d)

The maximum covalency is equal to the actual number of s- and p-electrons in the outermost shell.

44. The combination of atoms occur because they want -

(a) To decrease number of electrons in the outermost orbit.

(b) To attain an inert gas configuration.

(c) To increase number of electrons in the outermost orbit.

(d) To attain 18 electrons in the outermost orbit.

Answer: (b)

The combination of atoms occur because they want to attain an inert gas configuration.

45. In an antibonding molecular orbital, electron density is minimum -

(a) Around one atom of the molecule

(b) Between the two nuclei of the molecule

(c) At the region away from the nuclei of the molecule

(d) at no place

Answer: (b)

In an antibonding molecular orbital, electron density is minimum between the two nuclei of the molecule.