Intermolecular Forces

Ion-Dipole attraction.	Dipole-Dipole attraction.	Ion-Indeced dipole attraction.	Instantaneous dipole-Instantaneous produced attraction.	Dipole-Induced dipole attraction.
Exists between ion & a polar molecule.	Electrostatic attractions between the oppositely charge ends of permanent dipole.	Exits between ion & non polar molecule.	Exits among the non-polar molecules like H_2, O_2, Cl_2 etc. Also know as london force.	Exists between polar & non polar molecules.

Solved Examples

JEE Main/Boards

Example 1: Classify the following bonds as ionic, polar covalent and give your reasons :

(i) SiSi bond in $Cl_3SiSiCl_3$

(ii) SiCl bond in $Cl_3SiSiCl_3$

(iii) CaF bond in CaF_2

(iv) NH bond in NH_3

Sol: Atoms having more electronegativity difference form ionic bond whereas atoms having similar electronegativity value forms covalent bond**.**

(i) Covalent, due to identical Electronegativity.

(ii) Covalent, due to less electronegativity difference.

(iii) Ionic, due to more electronegativity difference.

(iv) Covalent, due to nearly similar electronegativity

Example 2: (i) Which one has highest and lowest melting point and why? NaCl KCl RbCl   CsCl

(ii) Why does the melting point of cesium halide (CsX) decrease in the order given below? CsF > CsCl > CsBr > CsI.

**Sol:** Molecule having higher lattice energy show higher melting point.

Lattice energy can be defined as energy that is given out when infinitely-separated ions in gas phase come together to form a crystal.

(i) NaCl will have the highest lattice energy on account of the smaller Na^+ while CsCl has lowest lattice energy on account of the larger Cs^+. Hence, NaCl has the highest melting point and CsCl has the lowest melting point.

(ii) As the size of anions increases their polarisability increases, thus their covalent character increases and melting point decreases.

Example 3: Why does BeF_2 have a zero dipole moment whereas H_2O has some dipole moment ?

Sol: symmetrical stretching in BeF_2 causes cancelation of dipole moment whereas in H_2O, due to asymmetrical stretching net dipole gets added up.

$$F \longleftrightarrow Be \longleftrightarrow F$$
$$\mu = 0$$

$$\mu \neq 0$$
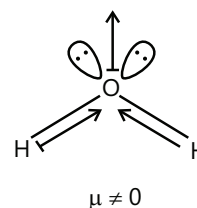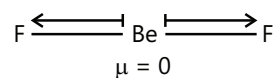
BeF_2 has linear molecule and H_2O has bent molecule.

Example 4: Which type of hybridization is found in H_3O^+?

Sol: According to steric no. rule Steric number = Number of bond pair(s) +number of lone pair(s) at central atom So, steric number = 3 + 1 = 4

$$H - \overset{\cdot\cdot}{\underset{|}{\overset{+}{O}}} \to H$$
$$H$$
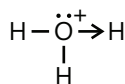
Thus the hybridization of oxygen in H_3O^+ is sp^3

Example 5: Why are crystals of hydrated calcium sulphate soft and easily cleaved, whereas anhydrous calcium sulphate is very hard and very difficult to cleave?

Sol: Hydrated calcium sulphate involves hydrogen bonding. Within the Ca^{2+}/SO_4^{2-} layer the ions are held together by strong electrovalent bonds but these separated Ca^{2+} / SO_4^{2-} layers are linked by relative weak H-bond. The weak H bonds link SO_4^{2-} ion in the intermediate region.

Example 6: Super oxides are coloured and paramagnetic. Why?

Sol: Super oxides contain on unpaired electron in anti-bonding molecular orbital and are coloured due to transition of HOMO orbital electron within the visible region.

Example 7: Of the species O_2^+, O_2^-, O_2 and O_2^{2-} which would have the maximum bond strength?

Sol: Bond strength is directly proportional to bond order.

O_2^+ has higher bond order i.e. 2.5 than

O_2 (2) and O_2^- (1.5) and bond strength is directly proportional to bond order.

Example 8: A diatomic molecule has a dipole moment of 1.2 D. If its bond distance is equal to 1.0 Å, then the fraction of an electronic charge on each atom is

(A) 25%   (B) 37%   (C) 52%   (D) 42%

Sol: (A) Assuming complete charge transfer dipole moment = $(4.8 \times 10^{-10} esu)(10^{-8} cm)$ = 4.8 D.

So % ionic character = $\dfrac{1.2}{4.8}$ × 100% = 25%

Example 9: The dipole moment of KCl is 3.336×10^{-29} coulomb meter. The interionic distance in KCl is 2.6 Å. Find the % ionic character in KCl.

Sol: First determine the theoretical dipole moment by using distance of separation and magnitude of charge.

% ionic character can be calculated as follows :

The theoretical dipole moment in

$KCl = e \times d = 1.602 \times 10^{-19} \times 2.6 \times 10^{-10}$

= 4.1652×10^{-29} C meter % ionic character

= $\dfrac{\text{experimental dipole moment}}{\text{The ratical dipole moment}} \times 100$

= $(3.336 \times 10^{-29} / 4.1652 \times 10^{-29})$ × 100

JEE Advanced/Boards

Example 1: Which of the compounds $MgCO_3$ and $ZnCO_3$ is thermally more stable? Explain.

Sol: Polarizing power of an ion affect the stability of its carbonate compound. More the polarizing power less stable is the carbonate compound.

Mg^{+2} has less polarising power due to inert gas configuration, while Zn^{+2} has higher polarising power due to pseudo inert gas configuration . A cation i.e. Zn^{2+} with a greater, polarizing power exercises a strong pull on the electron cloud of the neighbouring O-atom of the CO_3^{2-} ion, as such the metal carbonate ($ZnCO_3$) gets readily decomposed into CO_2 and the oxide of the metal, ZnO. Thus $ZnCO_3$ is less stable than $MgCO_3$.

Example 2: Why is anhydrous HCl predominantly covalent in the gaseous state but is ionic in its aqueous solution?

Sol: It exists as HCl (bond formed by equal sharing of electrons) but in an aqueous solution ionises as H^+ (or H_3O^+) and Cl^- due to polarity of HCl.
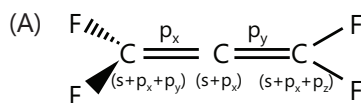
Example 3: Which is an incorrect statement?

(A) In $CF_2 = C = CF_2$ molecule all the four fluorine atoms are not in the same plane.

(B) Ka_2 of fumaric acid is more than Ka_2 of maleic acid due to intra molecular hydrogen bonding in maleic acid

(C) The O–O bond length in $O_2[AsF_4]$ is longer than KO_2.

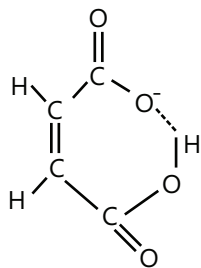(D) The bond angle order in halogen − S − halogen is $OSF_2 < OSCl_2 < OSBr_2$
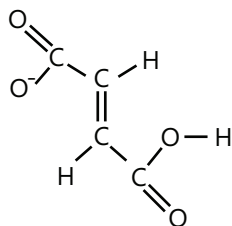
Sol: (C)

(A)

As both carbon atoms are in different planes, all the four fluorine atoms are not in the same plane.

(B) Maleic acid   Fumaric acid

Due to intramolecular hydrogen bonding the maleate ion gets stabilized and thus the removal of second hydrogen becomes quite difficult.

(C) $O_2[AsF_4] = O_2^+$ B.O = 2.5

   $KO_2 = O_2^-$ B.O = 1.5

Bond order $\propto \dfrac{1}{Bond\,length}$;

So, O_2^+ has smaller bond length than O_2^-

(D) Greater the size of the halogen atoms, greater will be the steric repulsions and thus larger will be the bond angles.

Example 4: The gaseous potassium chloride molecule has a measured dipole moment of 10.0 D, which indicates that is a very strong molecule. The separation between the nuclei in this molecule is 2.67×10^{-8} cm. Calculate the percentage ionic character in KCl molecule.

Sol: First determine the theoretical dipole moment by using distance of separation and magnitude of charge.

% ionic character can be calculated as follows :

$\dfrac{experimental\ dipole\ moment}{Theoretical\ dipole\ moment} \times 100$

Dipole moment of compound would have been completely ionic

$= (4.8 \times 10^{-10}\ esu)\ (2.67 \times 10^{-8}\ cm) = 12.8\ D$

So % ionic character $= \dfrac{10.0}{12.8} \times 100\% = 78.125\% \approx 78\%$

Example 5: There will be three different fluorine-fluorine distances in molecule $CF_2(C)_2CF_2$. Assuming ideal bond angles for a particular hybridisation (assume no distortion due to double bonds). Find out the two smaller fluoride-fluorine distances and fill the result (in pm) in the increasing order in your answer sheet. Round off your answer to the nearest whole number.

(Given that C – F bond length = 134 pm,
C = C bond length = 134 pm $\sqrt{3}$ = 1.73)

Sol:
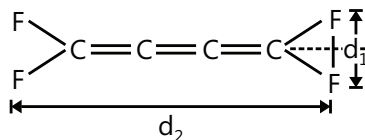
$d_1 = 2 \times 134 \times \sin 60° \ pm = 231.8\ pm = 232\ pm$

$d_2 = 134 \times 3 + 2 \times 134 \cos 60° \ pm = 536\ pm$

Example 6: For an ionic compound AX_3 (s) formed between a metal A and a non-metal X (outermost shell configuration of X = ns^2np^5). Find the enthalpy of formation (magnitude) of $AX_3(s)$ in k cal mol^{-1}, with the help of the following data. (Non-metal X is found to exist in nature as a diatomic gas)

$\Delta H_{Sublimation}$ A(s) = 100 Kcal/mol

ΔH_{IE1} , A(g) = 60 Kcal/mol

ΔH_{IE2} , A(g) = 150 Kcal/mol

ΔH_{IE3} , A(g) = 280 Kcal/mol

ΔH_{diss} $X_2(g)$ = 80 Kcal/mol

$\Delta H_{e.g.}$ X(g) = – 110 Kcal/mol

$\Delta H_{Lattice\ energy}$ A $X_3(s)$ = –470 Kcal/mol

Sol: This problem can be solved using born Heber cycle. Break the complete reaction to different step.
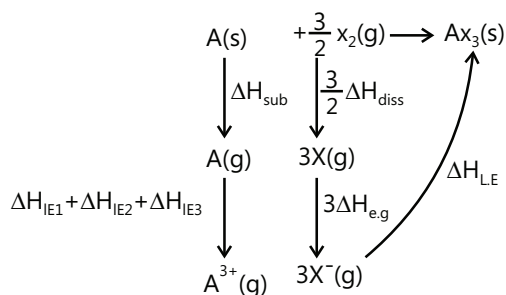
$\Delta H_f = \Delta H_{sub} + \Delta H_{IE1} + \Delta H_{IE2} + \Delta H_{IE3} + \dfrac{3}{2} + \Delta$

$H_{diss} + 3\Delta H_{e.g} + \Delta H_{LE}$

$\Delta H_f = \Delta H_{sub} + \Delta H_{IE1} + \Delta H_{IE2} + \Delta H_{IE3} + \dfrac{3}{2} \Delta$

$H_{diss} + 3\Delta H_{e.g} + \Delta H_{LE}$
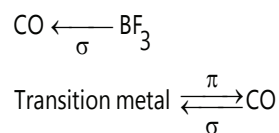
$= 100 + 60 + 150 + 280 + \dfrac{3}{2} \times 80 - 3 \times 110 - 470$

$= 100 + 60 + 150 + 280 + 120 - 330 - 470$

$= - 90$ Kcal/mol

Example 7: CO forms weak bonds to Lewis acid such as BF_3. In contrast, CO forms strong bonds to transition metals. Explain.

Sol:

$$CO \xleftarrow[\sigma]{} BF_3$$

$$\text{Transition metal} \xrightleftharpoons[\sigma]{\pi} CO$$

This is called synergic interaction and because of it the bond between CO and transition metal is stronger.

Example 8: Which of the following will be the strongest Lewis base?

(A) CH_3CN (B) CH_3NH_2

(C) N_2 (D) None of these

Sol: Lewis base is a compound that donates lone pair of electron. Hybridization also play an important role. As s character increases the electronegativity of atom increases and electron donating ability decreases, (B) In CH_3NH_2 , hybridisation of N sp^3 while in CH_3CN hybridisation of N is sp. N_2 is also sp hybridised. We know that in hybridisation, as s-character increases the electronegativity of atom also increases. Due to this tendency the release of lone pair of electrons becomes somewhat difficult. In methyl amine, the nitrogen is in sp^3 hybridisation and therefore the donation of the lone pair of electron will be quite easier, so it is the strongest Lewis base.

JEE Main/Boards

Exercise 1

Q.1 Why do atoms of noble gases not react with other atoms to form compounds?

Q.2 Why ionic bond is called a non- directional bond but a covalent bond is a called directional bond

Q.3 Why is MgO more stable than NaCl?

Q.4 Why is NaCl more stable than CsCl?

Q.5 Why ionic compounds do not conduct electricity when they are in solid state?

Q.6 Why do elements show variable covalency?

Q.7 Why do covalent compounds consist of discrete molecules?

Q.8 Why are some covalent compounds good conductors of electricity?

Q.9 Why are covalent solids soluble in nonpolar solvents?

Q.10 Why do covalent solids have giant molecules insoluble in all solvents?

Q.11 Why is metallic bond weaker than covalent bond?

Q.12 Why only O, N and F are capable of forming H-bonds?

Q.13 Why is NH_3 a better electron donor than PH_3, H_2S & H_2O?

Q.14 Why do metals have a high density?

Q.15 Why are alkaline earth metals harder than alkali metals?

Q.16 Why does Ag^+ (cation) $4s^2p^6d^{10}$ have a greater polarising power than K^+ (cation) $3s^2p^6$?

Q.17 Why are Li^+ compounds soluble in non-polar solvents but not in polar solvents?

Q.18 Explain the following sequences of solubility? $AlF_3 > AlCl_3 > AlBr_3 > AlI_3$

Q.19 Why is a co-ordinate bond called a semi polar bond?

Q.20 Why is H - atom alone not capable of forming hydrogen bond?

Q.21 Methanoic acid, HCOOH, has one carbon-oxygen bond of length 123 pm, and another of 136 pm. Which bond has which length?

Q.22 Both carbon-oxygen bonds in the methanoate ion, HCOO, have the same length (127 pm). What does this tell about bonding?

Q.23 Water can react with hydrogen ion to make the oxonium ion, H_3O^+ What is present in water molecule that allows it to react with a hydrogen ion ? Describe the bonding in the oxonium ion. Draw a dot and cross diagram for the molecule?

Q.24 Why is $MgCl_2$ linear but $SnCl_2$ is angular?

Q.25 Why NCl_5 does not exist while PCl_5 does?

Q.26 The electronegativities of nitrogen and chlorine are same but NH_3 exists as liquid whereas HCl as gas. Why?

Q.27 Although CO_2 has no dipole moment, SO_2 and H_2O have considerable dipole moments. Why'?

Q.28 Nitrogen trifluoride (NF_3) and ammonia (NH_3) have identical shape and a lone pair of electrons on nitrogen and further the electronegativity difference between the elements is nearly the same but the dipole moment of NH_3 is very high in comparison to NF_3.Why?
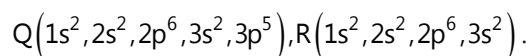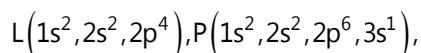
Q.29 Why three carbon-oxygen bonds are equal in carbonate ion?

Q.30 Why NF_3 is weaker base than NH_3, NCl_3, NBr_3 and NI_3?

Exercise 2

Single Correct Choice Type

Q.1 The electronic configuration of four elements L, P, Q and R given in brackets

$L\left(1s^2,2s^2,2p^4\right),P\left(1s^2,2s^2,2p^6,3s^1\right),$

$Q\left(1s^2,2s^2,2p^6,3s^2,3p^5\right),R\left(1s^2,2s^2,2p^6,3s^2\right).$

The formula of ionic compounds that can be formed between these elements are:

(A) L_2P,RL,PQ and R_2Q (B) LP, RL, PQ and RQ

(C) P_2L, RL, PQ and RQ_2 (D) LP, R_2L, P_2Q and RQ

Q.2 Lattice energy of an ionic compound depends upon:

(A) Charge on the ion only

(B) Size of the ion only

(C) Packing of ions only

(D) Both (A) and (B)

Q.3 The high melting point and insolubility in organic solvents of sulphanilic acid are due to its structure.

(A) Simple ionic   (B) Cubic

(C) Bipolar ionic   (D) Hexagonal

Q.4 What is the effect of more electronegative atom on the strength of ionic bond?

(A) Increases   (B) Decreases

(C) Remains the same   (D) None of these

Q.5 Which of the following hybrids are ionic?

I. CaH_2 II. BaH_2 III. SrH_2 IV. BeH_2

(A) I and IV   (B) II and IV

(C) III and IV   (D) I, II and III

Q.6 With which of the given pairs CO_2 resembles?

(A) $HgCl_2,C_2H_2$ (B) C_2H_2,NO_2

(C) $HgCl_2,SnCl_4$ (D) N_2O, NO_2

Q.7 Ionic and covalent bonds are present in:

(A) CCl_4 (B) $CaCl_2$ (C) H_2O (D) NH_4Cl

Q.8 Among the species $CO_2,CH_3COO^-,CO,CO_3^{2-},HCHO$ which has the weakest C – O bond?

(A) CO   (B) CO_2 (C) CO_3^{2-} (D) CH_3COO^-

Q.9 Number of electronic in the valence orbit of nitrogen in an ammonia molecule are:

(A) 5   (B) 6   (C) 7   (D) 8

Q.10 Which bond angle θ would result in the maximum dipole moment for the triatomic molecule yxy?

(A) $\theta = 90°$ (B) $\theta = 120°$

(C) $\theta = 150°$ (D) $\theta = 180°$

Q.11 The dipole moment of HBr is 1.6×10^{-30} C.m and interatomic spacing is 1 Å. The % ionic character of HBr is:

(A) 7   (B) 10   (C) 15   (D) 27

Q.12 In a polar molecule, the ionic charge is 4.8×10^{-10} esu. If the interionic distance is 1 Å unit, then the dipole moment is:

(A) 0.48 debye   (B) 4.18 debye

(C) 4.8 debye   (D) 41.8 debye

Q.13 If HCl molecule is completely polarized, so expected value of dipole moment is 6.12 (debye), but experimental value of dipole moment is 1.03 D. Calculate the percentage ionic character.

(A) 17   (B) 50   (C) 83   (D) Zero

Q.14 In which of the following there exists a $p\pi - d\pi$ bonding?

(A) Graphite   (B) Diamond

(C) Dimethyl amine   (D) Trisilyamine

Q.15 Number of sigma bonds in P_4O_{10} is:

(A) 6   (B) 9   (C) 16   (D) 20

Q.16 The correct order of hybridization of the central atom in the following species $NH_3, \left[PtCl_4\right]^{2-}, PCl_5$ and BCl_3 is:

(A) sp^3, dsp^2, dsp^3, sp^2 (B) dsp^2, dsp^3, sp^2, sp^3

(C) sp^2, sp^3, dsp^2, dsp^3 (D) sp^2, dsp^2, sp^3, dsp^3

Q.17 As the s-character of hybridization orbital increases, the bond angle.

(A) Increases   (B) Decreases

(C) Becomes zero   (D) Does not change

Q.18 Which has the least bond angle?

(A) NH_3 (B) H_2O (C) CH_4 (D) BeF_2

Q.19 The molecular shapes of SF_4, CF_4 and XeF_4 are:

(A) The same with 2, 0 and one lone pair of electron on the same central atom, respectively

(B) The same with 1, 1 and 1 lone pair of electrons on the central atoms, respectively

(C) Different with 0, 1 and 2 lone pair of electrons on the central atom, respectively

(D) Different with 1, 0 and 2 lone pair of electrons on the central atom, respectively

Q.20 The maximum number of 90° angles between bond pair-bond pair of electrons is observed in following hybridization:

(A) dsp^3 (B) dsp^2 (C) sp^3d (D) sp^3d^2

Q.21 When two atoms of chlorine combine to form one molecule of chlorine gas, the energy of the molecule:

(A) Equal to that of separate atoms

(B) Lower than that of separate atoms

(C) Greater than that of separate atoms

(D) None of the above

Q.22 Which of the following molecule has highest bond energy?

(A) C – C   (B) N – N   (C) O – O   (D) F – F

Q.23 According to MO theory which of the following statement about the magnetic character and bond order is correct regarding O_2^+ ?

(A) Paramagnetic and bond order $< O_2$

(B) Paramagnetic and bond order $> O_2$

(C) Diamagnetic and bond order $< O_2$

(D) Diamagnetic and bond order $> O_2$

Q.24 The bond order in NO is 2.5 while that in NO^+ is 3. Which of the following statements is true for those two species?

(A) Bond length in NO^+ is equal to that in NO

(B) Bond length in NO is greater than in NO^+

(C) Bond length is NO^+ is greater than in NO

(D) Bond length is unpredictable

Q.25 The reason for exceptionally high boiling point of water is:

(A) Its high specific heat

(B) Its high dielectric constant

(C) Low ionization of water molecule

(D) Intermolecular H-bonding

Q.26 The maximum possible number of hydrogen bonds in a H_2O molecule can participate is:

(A) 1   (B) 2   (C) 3   (D) 4

Q.27 The high density of water compare to ice is due to:

(A) Dipole-dipole interaction

(B) Dipole-induced dipole interaction

(C) Induced dipole-induced dipole interaction

(D) Hydrogen bonding interaction

Q.28 Which of the following hydrogen bonds are strongest in vapour phase?

(A) HF---HF   (B) HF---HCl

(C) HCl---HCl   (D) HF---HI

Q.29 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 %

Q.30 The number of electron that are paired in oxygen molecule is:

(A) 7   (B) 9   (C) 16   (D) 14

Q.31 Which combination is best explained by the coordinate covalent bond?

(A) $H^+ + H_2O$ (B) $Cl + Cl$

(C) $Mh + \dfrac{1}{2} O_2$ (D) $Mg + \dfrac{1}{2} O_2$

Q.32 In which of the following the central atom does not use sp^3 hybrid orbitals in its bonding?

(A) NH_2^- (B) OH_3^+ (C) BeF_3^- (D) NF_3

Q.33 Which of the following molecules/ions does not contain unpaired electrons?

(A) O_2^{2-} (B) B_2 (C) N_2^+ (D) O_2

Q.34 Among the following mixtures, dipole-dipole as the major interaction, is present in:

(A) Benzene and ethanol

(B) Acetonitrile and acetone

(C) KCl and water

(D) Benzene and carbon tetrachloride

Q.35 A metal, M forms chlorides in its +2 and +4 oxidation states. Which of the following statements about these chlorides is correct?

(A) MCl_2 is more volatile than MCl_4

(B) MCl_2 is more soluble in anhydrous ethanol than MCl_4

(C) MCl_2 is more ionic than MCl_4

(D) MCl_2 is more easily hydrolysed than MCl_4

Q.36 In which of the following molecules/ions all the bonds are not equal?

(A) SF_4 (B) SiF_4 (C) XeF_4 (D) BF_4

Previous Years' Questions

Q.1 The common features among the species CN⁻, CO and NO⁺ are   *(2001)*

(A) Bond order three and isoelectronic

(B) Bond order three and weak field ligands

(C) Bond order two and acceptors

(D) Isoelectronic and weak field ligands

Q.2 The correct order of hybridisation of the central atom in the following species NH_3, $[PtCl_4]^{2-}$, PCl_5 and BCl_3 is   *(2001)*

(A) dsp^2, dsp^3, sp^2 and sp^3 (B) sp^3, dsp^2, sp^3d and sp^2

(C) dsp^2, sp^2, sp^3, dsp^3 (D) dsp^2, sp^3, sp^2, dsp^3

Q.3 Specify the coordination geometry around and hybridisation of N and B atoms in a 1: 1 complex of BF_3 and NH_3 *(2002)*

(A) N : tetrahedral, sp^3 ; B: tetrahedral, sp^3

(B) N : pyramidal, sp^3; B: pyramidal, sp^3

(C) N: pyramidal, sp^3 ; B: planar, sp^2

(D) N: pyramidal, sp^3; B: tetrahedral, sp^3

Q.4 The nodal plane in the π-bond of ethane is located in   *(2002)*

(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 bond at right angle

(D) A plane perpendicular to the molecular plane which contains the carbon-carbon σ bond

Q.5 Which of the following molecular species has unpaired electron(s)? *(2002)*

(A) N_2 (B) F_2 (C) O_2^- (D) O_2^{2-}
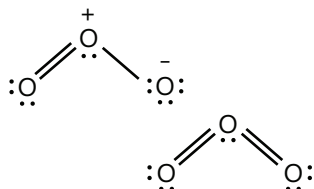
Q.6 Among the following, the molecule with the highest dipole moment is: *(2003)*

(A) CH_3Cl (B) CH_2Cl_2 (C) $CHCl_3$ (D) CCl_4

Q.7 Which of the following are isoelectronic and isostructural? $NO_3^-, CO_3^{2-}, ClO_3^-, SO_3$ *(2003)*

(A) NO_3^-, CO_3^{2-} (B) SO_3, NO_3^-,

(C) ClO_3^-, CO_3^{2-} (D) CO_3^{2-}, SO_3

Q.8 Statement-I: The electronic structure of O_3 is

Statement-II: Structure is not allowed because octet around O cannot be expanded. *(1998)*

Q.9 Statement-I: LiCl is predominantly a covalent compound

Statement-II: Electronegativity difference between Li and Cl is too small *(1998)*

Q.10 Based on VSEPR theory, the number of 90° F—Br—F angles in BrF_5 is: *(2010)*

Q.11 Which one of the following molecules is expected to exhibit diamagnetic behaviour ? *(2013)*

(A) C_2 (B) N_2 (C) O_2 (D) S_2

Q.12 Stability of the species Li_2, Li_2^- and Li_2^+ increases in the order of: *(2012)*

(A) $Li_2 < Li_2^+ < Li_2^-$ (B) $Li_2^- < Li_2^+ < Li_2$

(C) $Li_2 < Li_2^- < Li_2^+$ (D) $Li_2^- < Li_2 < Li_2^+$

Q.13 The intermolecular interaction that is dependent on the inverse cube of distance between the molecules is : *(2015)*

(A) Ion-ion interaction   (B) Ion-dipole interaction

(C) London force   (D) Hydrogen bond

JEE Advanced/Boards

Exercise 1

Q.1 In solid $NaCl^-$, one Na^+ is surrounded by six Cl^- ions. Find out total number of directional bonds formed by each Na^+ with Cl^- ions.

Q.2 Find out total number of $p\pi$–$d\pi$ bonds present in any one of its structures in case of PO_4^{3-}

Q.3 Find out total number of $p\pi$–$p\pi$ bonds present in ClO_3^-

Q.4 How many number of atomic orbitals are required, so that their mixing produces hybrid orbitals each having % of s-character equal to 17%?

Q.5 $AgNO_3$ gives a white precipitate with NaCl but not with CCl_4. Why?

Q.6 Using VSEPR theory identify the type of hybridisation and draw the structure of OF_2

Q.7 What should be the structure shape of the following as per VSEPR theory ?

(A) XeF_2 (B) XeF_4

(C) PBr_5 (D) OF_2

(E) I_3^- and   (F) I_3^+

Q.8 The percent ionic character in HCl is 18.08. The observed dipole moment is 1.08 D. Find the inter-nuclear distance in HCl.

Q.9 Assuming that all the four valences of carbon atoms in propane point towards the corners of a regular tetrahedron, calculate the distance between the terminal carbon atom in propane. Given, C–C single bond length is 1.54 Å

Q.10 The dipole moment of HBr is 7.95 Debye and the intermolecular separation is 1.94×10^{-10}m. Find the % ionic character in HBr molecule.

Q.11 HBr has dipole moment 2.6×10^{-30} C–m. If the ionic character of the bond is 11.5 %, Calculate the interatomic spacing

Q.12 Dipole moment of LiF was experimentally determined and was found to be 6.32 D. Calculate percentage ionic character in LiF molecule Li -F bond length is 156 pm.

Q.13 A diatomic molecule has a dipole moment of 1.2 D. If bond length is 1.0 A, what percentage of an electronic charge exists on each atom.

Q.14 Which will have a higher boiling point, Br_2 or ICl, & Why ?

Q.15 Arrange noble gases in the increasing order of b.p. Xe, Ar, Ne, Kr, He, Ra

Exercise 2

Multiple Correct Choice Type

Q.1 Shape of NH_3 is very similar to :

(A) SeO_3^{2-} (B) CH_3^- (C) BH_3 (D) CH_3^+

Q.2 Which of the following have same shape as NH_2^+ ?

(A) CO_2 (B) $SnCl_2$ (C) SO_2 (D) $BeCl_2$

Q.3
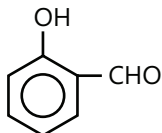
(A) Has intermolecular H - bonding

(B) Has intramolecular H- bonding

(C) Has low boiling point

(D) Is steam-volatile

Q.4 Which of the following bonds/forces is/are weakest?

(A) Covalent bond   (B) Vander Waals force

(C) Hydrogen bond   (D) London force

Q.5 Which of the following factors are responsible for van der Waals forces?

(A) Instantaneous dipole-induced dipole interaction

(B) Dipole-induced dipole interaction and ion-induced dipole interaction

(C) Dipole-dipole interaction and ion induced dipole interaction

(D) Small size of molecule

Q.6 Atoms combine so that

(A) They can always attain stable configuration to that of nearest noble gas.

(B) They can attain stable configuration if possible, to that of nearest noble gas.

(C) Their potential energy can increase and hence bond energy may increase.

(D) Their potential energy can decrease and hence bond energy may increase.

Q.7 Which of the following statement(s) is/are correct regarding ionic compounds?

(A) They are good conductors of electricity at room temperature in aqueous solution.

(B) They are generally soluble in polar solvents.

(C) They consist of ions.

(D) They generally have high melting and boiling points.

Q.8 Which of the following compounds contain ionic, covalent and coordinate bonds?

(A) NH_4Cl (B) KCN   (C) $NaBF_4$ (D) NaOH

Q.9 sp^3 hybridisation is in:

(A) AlH_4^- (B) CH_3^- (C) ClO_2^- (D)NH_2^-

Q.10 Which of the following has (have) regular octahedral geometry :

(A) $SbCl_6^-$ (B) $SnCl_6^{2-}$ (C)XCF_6 (D) IO_6^{5-}

Q.11 Which of the following species are linear?

(A) ICl_2^- (B) I_3^- (C) N_3^- (D) ClO_2

Q.12 Which of the following compounds possesses zero dipole moment?

(A) Water   (B) Benzene

(C) Carbon tetrachloride   (D) Boron trifluoride

Q.13 Which of the following statements are correct?

(A) The crystal lattice of ice is formed by covalent as well as hydrogen bonds

(B) The density of water increases when heated from 0°C to 4°C

(C) Above 4°C, the thermal agitation of water molecules increases. Therefore, intermolecular distance increases and water starts expanding

(D) The density of water decreases from 0°C to a maximum at 4°C

Q.14 Which of the following compounds has bond angle as nearly 90°?

(A) NH_3 (B) H_2S (C) H_2O (D) SF_6

Q.15 For propadiene $H_2C_1=C_2=C_3H_2$, correct statement(s) is/are:

(A) Molecule is non planar

(B) Molecule is nonpolar

(C) Nodal plane of π-bond formed by C_1 and C_2 is perpendicular to that of formed by C_2 and C_3

(D) Nodal plane of π-bond formed by C_1 and C_2 is coplanar with that of formed by C_2 and C_3.

Q.16 Molecule(s) having both polar and non- polar bonds is/are

(A) O_2F_2 (B) S_2Cl_2 (C) N_2H_4 (D) S_2F_{10}

Q. 17 Which of the following are true?

(A) Vander Waals forces are responsible for the formation of molecular crystals

(B) Branching lowers the boiling points of isomeric organic compounds due to weaker Vander Waals forces of attraction

(C) In graphite, Vander Waals forces act between the carbon layers

(D) In diamond, Vander Waals forces act between the carbon layers

Q.18 Intermolecular hydrogen bonding increases the enthalpy of vaporization of a liquid due to the:

(A) Decrease in the attraction between molecules

(B) Increase in the attraction between molecules

(C) Decrease in the molar mass of unassociated liquid molecules

(D) Increase in the effective molar mass of hydrogen - bonded molecules

Q.19 Which of the following molecules have intermolecular hydrogen bonds?

(A) KH_2PO_4 (B) H_3BO_3

(C) $C_6H_5CO_2H$ (D) CH_3OH

Q.20 Which of the following have dipole moment?

(A) Nitrobenzene   (B) p-chloronitrobenzene

(C) m-dichlorobenzene   (D) o-dichlorobenzene

Comprehension Type

Paragraph 1: During the formation of a covalent bond each participating atom usually acquires electronic configuration to that of nearest noble gas, and the shared electron pair remains localized between the bonded nuclei. Besides these shared electrons there are certain electron pairs which remain localized on C.A. or on substituent or both and are called nonbonding or lone pair electrons.

Q.21 Which of the following species does / do not follow octet rule:

(A) Hypovalent   (B) Hypervalent

(C) Odd electron molecules   (D) All of the above

Q.22 In SO_3^{2-} the total number of lone pairs and bond pairs are respectively

(A) 18 and 4   (B) 9 and 8   (C) 9 and 4   (D) 7 and 4

Paragraph 2: Hybridisation is a theoretical concept, as state of hybridisation cannot be detected even by spectroscopically; unlike intermediates or transition state in various reactions, but it corrects the predictions which are based on simple overlapping of pure atomic orbitals. VSEPR theory predicts precisely shape and bond angle in a given molecule.

Q.23 In which pair of molecules bond angles are not same:

(A) CCl_4 and $SiCl_4$ (B) NH_4^+ and NF_4^-

(C) ClF_6^- and SF_6 (D) None

Q.24 The molecules / ions which are planar as well as polar.

(A) BF_3, H_2O, HF, NH_2^- (B) $SnCl_2, I_3^+, NH_2^-, IF_3$

(C) $CO_3^-, I_3^-, SF_2, XeF_2$ (D) $NO_2^-, XeF_4, ICl_4^-, NH_2^+$

Q.25 The correct order of energy levels of hybrid orbitals.

(A) $sp > sp^2 > sp^3$

(B) $sp < sp^2 < sp^3$

(C) $sp^2 > sp^3 > sp$

(D) $sp^3 > sp > sp^2$

Paragraph 3: As one moves from sp hybridisation to sp^3, % of s-character in hybrid orbital decreases from 50% to 25% and p-character increases from 50% to 75% and in any hybrid orbital total % of s and p-character remains 100%. By increasing p-character the hybrid orbitals become elongated hence, their overlapping extent decreases that is results into weak bond energy also bond angle decreases.

Q.26 Statement-I: On decreasing s-character in hybrid orbitals, bond angle decreases.

Statement-II: p-orbitals are at 90° to one another.

(A) Statement-I is true, statement-II is true and statement-II is correct explanation for statement-I.

(B) Statement-I is true, statement-II is true and statement-II is NOT the correct explanation for statement-I.

(C) Statement-I is true, statement-II is false.

(D) Statement-I is false, statement-II is true.

Q.27 The type of overlapping which produces bond of maximum bond energy is:

(A) sp^3 - 1s

(B) sp^2 - 1s

(C) sp - 1s

(D) All have same bond energy

Q.28 The molecule having bond pair in which % of s and p character is different from rest bond pairs.

(A) SiF_4 (B) BCl_3 (C) CF_3H (D) CCl_4

Q.29 State whether each statement is true or false. If false, write the correct statement.

(i) An element with low ionization potential is most likely to form a covalent bond with another element having a high electron gain enthalpy

(ii) Ionic interactions are always stronger than covalent bonds.

(iii) Two non-metal atoms are likely to form covalent

(iv) Ionic interactions are directional.

Q.30 State whether each statements is T or F, If F rectify

(i) All diatomic molecules are non-polar

(ii) All molecules having polar bonds are polar

(iii) The lone pairs of electrons do not contribute to the net dipole of a molecule.

(iv) The CH_2Cl_2 molecule may be polar or nonpolar depending on its geometry

(v) The net dipole in the water molecule is the resultant of its bond dipoles.

(vi) SO_2 is polar whereas CO_2 is non-polar.

(vii) NH_3 is less polar than NF_3

(viii) If a co-ordinate bond neutralizes charge separation of a polar bond, then dipole moment of the bond decreases.

Q.31 Fill in the blanks.

(i) π bonds are formed by the lateral overlap of a p-orbital with another ____ orbital in same phase.

(ii) Free rotation is possible if two atoms are bonded together only by a _____ bond.

(iii) The maximum number of σ bonds that can be formed between two atoms is ____

(iv) The repulsion between _____ is greater than the repulsion between two bonded pairs

(v) In nitro benzene the total number of bonded electrons equals _____

Paragraph 4: An ionic compound is formed by electrostatic attraction between gaseous cation(s) and gaseous anion(s) which are formed by complete removal and acceptance of electrons respectively

Q.32 The correct order of lattice energies of given ionic compounds is/are

(A) LiF<NaF<KF<RbF <CsF

(B) MgO>CaO>SrO>BaO

(C) LiF > LiCl> LiBr > LiI

(D) MgO > MgF_2> LiF > NaF

Q.33 The correct statement about ionic bond/compound is/are:

(A) One cation can attract more than one anion at a time and vice versa.

(B) One cation can attract only one anion at a time.

(C) Brittle character is caused by repulsion between same type of ions that come in contact by external force.

(D) They conduct electricity both in Molten & solid state.

Match the Columns

Q.34

Column I	Column II
(A) BrF_3	(p) One angle $\leq 90°$
(B) TeF_5	(q) Central atom is sp^3d^2 hybridised
(C) IF_7	(r) Non planar
(D) XeF_4	(s) Polar

Q.35

Column I	Column II
(A) $I(CN)_2^-$,	(p) Having $p\pi–p\pi$ bond and $\mu_D = 0$
(B) CO_3^{2-}	(q) Having $p\pi–d\pi$ bond and $\mu_D = 0$
(C) XeO_2F_2	(r) Planar
(D) SOF_4	(s) Central atom is sp^3d

Q.36

Column I	Column II
(A) $H_2S_2O_5$ sp^3 hybridised	(p) Central atom is S
(B) $H_6B_2O_7^{2-}$	(q) M-O-M i.e., oxo linkage is present
(C) $H_4P_2O_6$	(r) M-M i.e., oxo linkage is absent
(D) $H_6Si_2O_7$	(s) Non planar

Assertion Reasoning Type

(A) Statement-I is true, statement-II is true and statement-II is correct explanation for statement-I.

(B) Statement-I is true, statement-II is true and statement-II is NOT the correct explanation for statement-I.

(C) Statement-I is true, statement-II is false.

(D) Statement-I is false, statement-II is true.

Q.37 Statement-I: Higher the lattice energy greater will be the ease of formation of an ionic compound.

Statement-II: Lattice energy is evolved during formation of an ionic compound.

Q.38 Statement-I: Lattice energy of an ionic solid cannot be infinite

Statement-II: As inter ionic distance tends to zero, repulsive forces dominate over attractive forces.

Q.39 Statement-I: If all substituents and lone pairs are symmetrically placed around central atom, the molecule will be non- polar.

Statement-II: The direction of bond moment is from positive pole towards negative pole.

Q.40 Statement-I: During formation of coordinate bond, the acceptor accepts electron pair only when its octet has not been completed

Statement-II: Inspite of having completed octet, acceptor can accept electron pair provided it has empty 'd' orbitals.

Q.41 Statement-I: On the basis of overlapping of pure atomic orbital, the shape of NH_3 molecule will be trigonal pyramidal.

Statement-II: According to pure atomic orbital overlapping, each $\angle$ HNH is 90°.

Q.42 Statement-I: lone pair-lone pair repulsion is found to be greater than lone pair b.p. repulsion.

Statement-II: lone pair is under the influence of one nucleus while b.p. is under that of two nuclei.

Q.43 Statement-I: Phosphorus exists asP_4 not as P_2

Statement-II: Side wise overlapping between two 3p orbitals is less effective.

Q.44 Statement-I: Inorganic benzene ($B_3N_3H_6$) and organic benzene (C_6H_6) are isoelectronic & hence are iso-structural.

Statement-I: d_{C-C} in benzene is greater than d_{B-N} in inorganic benzene (borazine).

Q.45 Statement-I: Compounds, like graphite, H_3BO_3, boron nitride (inorganic graphite etc.), which are composed of layers in solid state have lubricating action.

Statement-II: Two dimensional layers are bonded to one another by weak Vander Waals forces.

Previous Years' Questions

Q.1 The species having bond order different from that in CO is **(2007)**

(A) NO^- (A) NO^+ (C) CN^- (D) N_2

Q.2 Hyper-conjugation involves overlap of the following orbitals **(2008)**

(A) $\sigma - \sigma$ (B) $\sigma - p$ (C) p - p   (D) $\pi - \pi$

Q.3 Assuming that Hund's rule is violated, the bond order and magnetic nature of the diatomic molecule B_2 is **(2010)**

(A) 1 and diamagnetic   (B) 0 and diamagnetic

(C) 1 and paramagnetic   (D) 0 and paramagnetic

Q.4 The species having pyramidal shape is **(2010)**

(A) SO_3 (B) BrF_3 (C) SiO_3^{2-} (D) OSF_2

Q.5 The linear structure assumed by **(1991)**

(A) $SnCl_2$ (B) CS_2 (C) NO_2^+ (D) NCO^- (E) SO_2

Q.6 Which of the following have identical bond order? **(1992)**

(A) CN^- (B) O_2^- (C) NO^+ (D) CN^+

Q.7 The molecules that will have dipole moment are **(1992)**

(A) 2, 2-dimethyl propane

(B) trans-2-pentene

(C) cis-3-hexene

(D) 2, 2, 3, 3-tetramethyl butane

Q.8 Match the reactions in column I with nature of the reactions/type of the products in column II **(2007)**

Column I	Column II
(A) $O_2^- \rightarrow O_2 + O_2^{2-}$	(p) Redox reaction
(B) $CrO_4^{2-} + H^+ \rightarrow$	(q) One of the products has trigonal planar structure
(C) $Mn\,O_4^- + NO_2^- + H^+$	(r) Dimeric bridged tetrahedral metal ion
(D) $NO_3^- + H_2SO_4 + Fe^{2+} \rightarrow$	(s) Disproportionation

Q.9 Draw the shape of XeF_4 and OSF_4 according to VSEPR theory. Show the lone pair of electrons on the central atom. **(2004)**

Q.10 On the basis of ground state electronic configuration arrange the following molecules in increasing O- O bond length order, $KO_2, O_2, O_2[AsF_6]$ **(2004)**

Q.11 Predict whether the following molecules are iso-structural or not. Justify your answer. **(2005)**

(i) NMe_3 (ii) $N(SiMe_3)_3$

Q.12 The shape of XeO_2F_2 molecules is **(2012)**

(A) trigonal bipyramidal   (B) square planar

(C) tetrahedral   (D) see – saw

Q.13 According to Molecular Orbital Theory, **(2016)**

(A) C_2^{2-} is expected to be diamagnetic

(B) O_2^{2+} is expected to have a longer bond length than O_2

(C) N_2^+ and N_2^- have the same bond order

(D) He_2^+ has the same energy as two isolated He atoms

MASTERJEE Essential Questions

JEE Main/Boards

Exercise 1

Q.2   Q.8   Q.16

Q.23   Q.27

Exercise 2

Q.1   Q.5   Q.10

Q.12   Q.29   Q.35

Previous Years' Questions

Q.1   Q.4   Q.10

JEE Advanced/Boards

EXERCISE 1

Q.2   Q.4   Q.10

Exercise 2

Q.9   Q.13   Q.19

Q.23   Q.26   Q.36

Q.38   Q.44

Previous Years' Questions

Q.2   Q.7   Q.8

Answer Key

JEE Main/Boards

Exercise 2

Single Correct Choice Type

Q.1 C	**Q.2** D	**Q.3** C	**Q.4** A	**Q.5** D	**Q.6** A
Q.7 D	**Q.8** C	**Q.9** D	**Q.10** A	**Q.11** B	**Q.12** C
Q.13 A	**Q.14** D	**Q.15** C	**Q.16** A	**Q.17** A	**Q.18** B
Q.19 D	**Q.20** D	**Q.21** B	**Q.22** B	**Q.23** B	**Q.24** B
Q.25 D	**Q.26** D	**Q.27** D	**Q.28** A	**Q.29** D	**Q.30** D
Q.31 A	**Q.32** C	**Q.33** A	**Q.34** B	**Q.35** C	**Q.36** A

Previous Years' Questions

Q.1 A	**Q.2** B	**Q.3** A	**Q.4** A	**Q.5** C	**Q.6** A
Q.7 A	**Q.8** A	**Q.9** C	**Q.11** C	**Q.12** B	**Q.13** B

JEE Advanced/Boards

Exercise 1

Q.1 6   **Q.2** 1   **Q.3** 0   **Q.4** 6

Q.5 NaCl ionic compound which dissociate to give Cl^- ions where as CCl_4 cannot be ionised to give Cl^-

Q.6 Hybridisation of O : sp^3

Q.7 (a) Linear, (b) square planar, (c) T.B.P (d) bent, (e) linear, (f) bent   **Q.8** 1.2 Å   **Q.9** 2.514 Å

Q.10 85%   **Q.11** 1.4 Å   **Q.12** 84.5%   **Q.13** 25%   **Q.14** ICl

Exercise 2

Multiple Correct Choice Type

Q.1 A, B   **Q.2** B, C   **Q.3** B, C, D   **Q.4** B, D   **Q.5** A, B, C   **Q.6** B, D

Q.7 A, B, C, D   **Q.8** A, C   **Q.9** A, B, C, D   **Q.10** A, B, D   **Q.11** A, B, C   **Q.12** B, C, D

Q.13 A, B, C   **Q.14** B, D   **Q.15** A, D   **Q.16** A, B, C, D   **Q.17** A, B, C   **Q.18** B, D

Q.19 A, B, C, D   **Q.20** A, B, C, D

Comprehension Type

Q.21 A   **Q.22** C   **Q.23** D   **Q.24** B   **Q.25** B   **Q.26** D

Q.27 C   **Q.28** C   **Q.29** (i) F, (ii) T , (iii) T, (iv) F

Q.30 B (i) F, (ii) F, (iii) F, (iv) F, (v) F, (vi)T , (vii)F, (viii) T

Q.31 (i) p-orbital (ii) σ-bond. (iii) 1, (iv) lp.lp & lp-bp (v) 36

Q.32 B, C, D   **Q.33** A, C

Match the Columns

Q.34 A → p, s; B → p, q, r, s; C → p, r; D → p, q   **Q.35** A → p, r, s; B → p, r; C → q, s; D → q, s

Q.36 A → p, r, s ; B → p, q, s; C → p, r, s; D → p, q, s

Assertion Reasoning Type

Q.37 A   **Q.38** D   **Q.39** B   **Q.40** D   **Q.41** A   **Q.42** A

Q.43 A   **Q.44** C   **Q.45** A

Previous Years' Questions

Q.1 A   **Q.2** B   **Q.3** A   **Q.4** D   **Q.5** B, C, D   **Q.6** A, C

Q.7 B, C   **Q.8** A → p, s; B → r; C → p, q; D → p   **Q.12** D   **Q.13** A, C

Solutions

JEE Main/Boards

Exercise 1

Sol 1: Noble gases don't react with other atoms because of the stable $ns^2\, np^6$ outer shell configuration. (Octet).

Sol 2: Two ions can attract each other in any direction but that is not possible in case of covalent bonds.
Ex. F_2. The bond must be along the orbital containing the unpaired e^-.

Sol 3: Lattice energy $E \propto \dfrac{q_1 q_2}{r_+ + r_-}$.
$q_1 q_2 = 4$ for MgO, whereas it's 1 for NaCl.
So Lattice energy of MgO is high.

Sol 4: As lattice energy $\propto \dfrac{q_1 q_2}{r_+ + r_-}$ r_+ of Cs is very high compared to that of the Na. So, LE of NaCl is higher.

Sol 5: To conduct electricity, we need movement of charges. But in ionic solids. The ions are at fixed positions in a crystal lattice. So, it cannot conduct electricity.

Sol 6: Some elements show variable covalency because of presence of 2 or more stable O. S., some can show variable covalency because of presence of lone pairs. Ex. PCl_3, PCl_5

Sol 7: There is a force of attraction between ions of different molecules of ionic compounds. But there are no such interactions among most of covalent compounds.

Sol 8: Some covalent compounds are good conductors of electricity because of the presence of free e^-.

Sol 9: Ionic compounds are soluble in polar solvents where as covalent compounds are soluble in non-polar solvents.

Sol 10: Solubility depends on the interactions between solute and solvent. The large covalent molecules need not interact with all solvents. Ex. Starch is not soluble in water at normal temperature.

Sol 11: In metallic bond, the e^- are delocalized, so there isn't strong attraction between nucleus and those electrons. But, in covalent molecules, electrons are localised.

Sol 12: O, N, F are very highly electro-negative elements. So, they have partial –ve charge & H will have partial +ve charge.

$$-- \overset{\delta+}{H} - \overset{\delta-}{F} --- \overset{\delta+}{H} - \overset{\delta-}{F} --- \overset{\delta+}{H} - \overset{\delta-}{F} ---$$
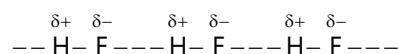
Another condition is that, the element size must be small, so that the H-bonding is significant.

Sol 13: NH_3 is a better electron donor than H_2O because the electro-negativity of H_2O is high. H_3O^+ is less stable than NH_4^+.

Sol 14: Metals atoms are closely packed in a crystal due to the presence of metallic bonding.

Sol 15: Alkaline earth metals are stronger as each atom contributes $2e^-$ for metallic bonding whereas in IA metals, each atom contributes only $1\,e^-$. So, metallic bonding is weaker in IA elements. So they are softer compared to II A elements.

Sol 16: Cations with pseudo noble gas configuration have higher polarization power compared to noble gas configuration element. (of similar sizes).

Sol 17: Due to high polarising power of Li^+, its compounds have high covalent character. So. solubility of Li^+ salts is high in non-polar solvents than in polar solvents.

Sol 18: The more the ionic character, more is the solubility in this case & hydration energy of $F^- > Cl^- > Br^- > I^-$. So, solubility of $AlF_3 > AlCl_3\ AlBr_3 > AlI_3$

Sol 19: $X: \to Y$ is equivalent to $X^+ - Y^-$ So, it's called as semi-polar bond. $X^{\delta+} - Y^{\delta-}$

Sol 20: To form H-bonding, we need an electronegative atom which has $\delta-$ charge on it to attract $H^{\delta+}$. In H_2, there are no partial charges.

Sol 21:
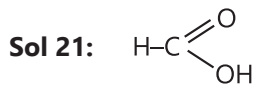
Single bond will be longer than double bond.

C–OH → 136pm.

C=O → 123pm.

double bond is shorter because of presence of 2e⁻pairs between 2 atoms.

Sol 22:
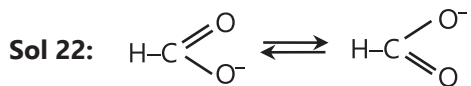
So, the resultant structure would be like
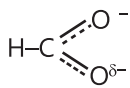
It is called Resonance

Sol 23: Lone pair on O.
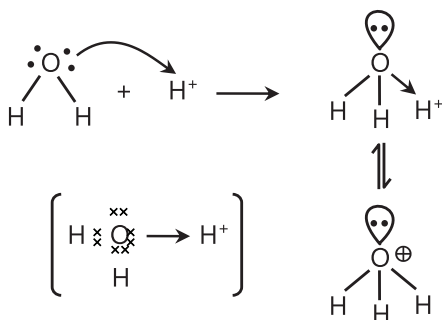
Sol 24: $MgCl_2$ has no lone pairs.

$Cl^- - Mg^{2+} - Cl^-$

In this structure, the repulsions would be minimum. But, Sn has a lone pair in $SnCl_2$
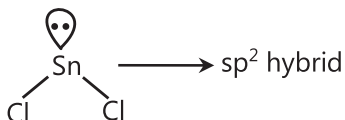
Sol 25: PCl_5 exists because of empty 3d orbitals of P.
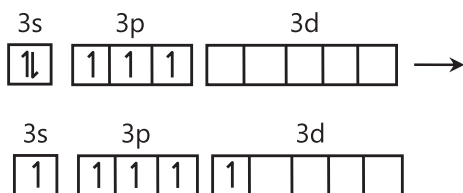
So, it can form 5 bonds.

But, outer orbit in N is 2. It doesn't have 2d orbitals.

Sol 26: NH_3 has H-bonding but not HCl. It because of large size of Cl. H-bonding is HCl is very-very –very weak.

Sol 27: CO_2 is linear O=C=O. So, no dipole moment
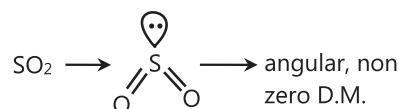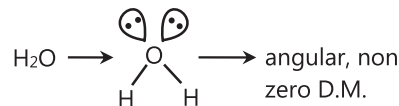
Sol 28:
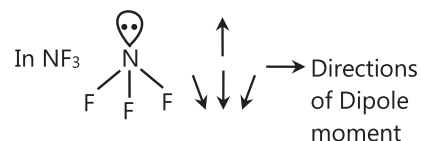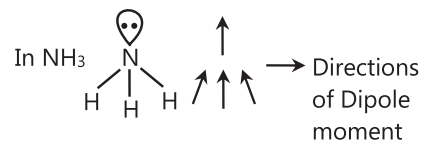
In NF_3, they are in opposite direction, so, they try to cancel each other.

In NH_3, all are in nearly same direction.

So, dipole moment of NH_3 is very high compared to NF_3.

Sol 29: Resonance
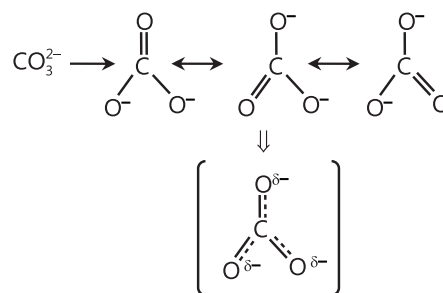
Sol 30: In NF_3, the highly electro negative F atom tries to take e⁻ toward it. So, N has δ+ charge. So, it's donation capacity decreases.

Exercise 2

Single Correct Choice Type

Sol 1: (C) Valencies of L, Q, P and R is -2, -1, +1, and +2 respectively so they will form P_2L, RL PQ, and RQ_2.

Sol 2: (D) The value of lattice energy depends on the charges present on the two ions and distance between

them. It shell be high if charges are high and ionic radii are small.

Sol 3: (C) Sulphanilic acids have dipolar structure so their, ionic bond strength increases.

Sol 4: (A) As soon as the electronegativity increases, ionic bond strength increases.

Sol 5: (D) CaH_2, BaH_2, SrH_2 are ionic hydride.

Sol 6: (A) All have linear structure.

$O = C = O, Cl - Hg - Cl, H - C \equiv C - H$
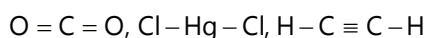
Sol 7: (D) NH_4Cl has covalent as well as ionic bond

$$\begin{bmatrix} & H & \\ & | & \\ H - & N & \rightarrow H^+ \\ & | & \\ & H & \end{bmatrix} Cl^-$$
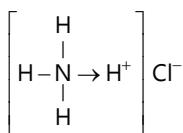
Sol 8: (C) Among the given species the bond dissociation energy of C – O bond is minimum in case of CO_3^{2-} by which C – O bond become more weaker in CO_3^{2-} or the bond order of CO_3^{2-} (1.33) is minimum so the bond become weaker.

Sol 9: (D) The electronic configuration of nitrogen is $N_7 = 1s^2, 2s^2, 2p^3$. It has 5 electrons in valency shell, hence in ammonia molecule it complete its octet by sharing of three electrons with three H-atoms, therefore, it has 8 electrons in its valence shell in ammonia molecule.

$$H \times \bullet \overset{\bullet\bullet}{\underset{\overset{\bullet}{\underset{x}{H}}}{N}} \bullet \times H$$
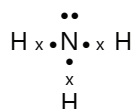
Sol 10: (A) The dipole moment of two dipole inclined at an angle θ is given by the equation $\mu = \sqrt{x^2 + y^2 + 2xy \cos \theta}$, cos 90 = 0, Since, the angle increases from 90-180, the value of cos θ becomes more and more –ve and hence resultant decreases. Thus dipole moment is maximum, when $\theta = 90°$.

Sol 11: (B) Charge of $e^- = 1.6 \times 10^{-19} C$

Dipole moment of HBr $= 1.6 \times 10^{-30}$ C.m

Interionic spacing = 1 Å = 1×10^{-10} m

% of ionic character in

$$HBr = \frac{\text{Dipole moment of HBr} \times 100}{\text{Interspacing distance} \times q}$$

$$= \frac{1.6 \times 10^{-30} \times 100}{1.6 \times 10^{-19} \times 10^{-10}}$$

$$= 10^{-30} \times 10^{29} \times 100 = 0.1 \times 100 = 10\%$$

Sol 12: (C) Given, ionic charge $= 4.8 \times 10^{-10}$ esu and, ionic distance = 1 Å $= 10^{-8}$ cm

We know that

Dipole moment = Ionic charge $\times$ ionic distance

$= 4.8 \times 10^{-10} \times 10^{-8}$

$= 4.8 \times 10^{-18}$ esu cm^{-1}

= 4.8 debye

Sol 13: (A) % of ionic character =

$\frac{\text{Experimental value of dipole moment}}{\text{Expected value of dipole moment}} = \frac{1.03}{6.12} \times 100$

$= 16.83\% \approx 17\%$

Sol 14: (D) We know that trisilylamine is sp^2 hybridized, therefore, $p\pi - d\pi$ bonding is possible due to the availability of vacant d-orbitals with silicon.

Sol 15: (C) Structure of P_4O_{10} is:
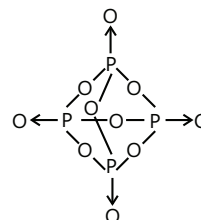
Each phosphorus is attached to 4-oxygen atoms.

Sol 16: (A) Hybridization of N in NH_3 is sp^3 that of Pt in $\left[PtCl_4\right]^{2-}$ is dsp^2 that of P in PCl_5 is sp^3d and that of B in BCl_3 is sp^2.

Sol 17: (A) s-character increases with increase in bold angle.

Hybridization	s %	Angle
sp	50	180°
sp²	33.3	120°
sp³	25	109°28'
sp³d¹	20	90° and 120°

Sol 18: (B) Due to lp-lp repulsion, bond angle in H_2O is lower (145°5') than that in NH_3 (107°) and CH_4 (109°28'). BeF_2 on the other hand, has sp-hybridization and hence has a bond angle of 180°.

Sol 19: (D) The molecular shapes of SF_4, CF_4 and XeF_4 are different with 1, 0 and 2 lone pair of electrons on the central atom, respectively.

Sol 20: (D)
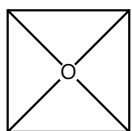
dsp^2 hybridization
(Four 90° angles
between bp-bp)
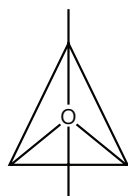
sp^2 hybridization
(Six 90° angles
between bp-bp)
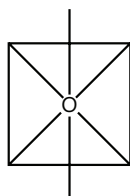
sp^2 hybridization
(Twelve 90° angles
between bp-bp)

Sol 21: (B) when bond forms between two atoms then their energy get lower than that of separate atoms because bond formation is an exothermic process.

Sol 22: (B) Nitrogen molecule has highest bond energy due to presence of triple bond.

Sol 23: (B)

$$O_2 = \sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, \sigma 2p_x^2, \pi 2p_y^2 = \pi 2p_z^2$$

$$\pi^*2p_y^1 = \pi^*2p_z^1$$
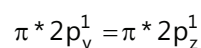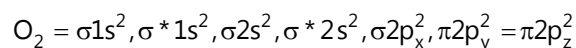
Bond order $= \dfrac{N_b - N_a}{2} = \dfrac{10-6}{2} = 2$

Paramagnetic (Two unpaired electrons)

$$O_2^+ = \sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, \sigma^*2s^2, \sigma 2p_x^2, \pi 2p_y^2 = \pi 2p_z^2$$
$$\pi^*2p_y^1 = \pi^*2p_z^0.$$
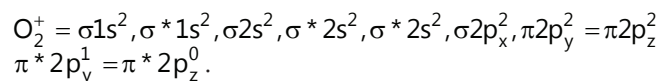
BO $= = \dfrac{N_b - N_a}{2} = \dfrac{10-5}{2} = 2.5$

Paramagnetic (One unpaired electron)

Sol 24: (B) Higher the bond order, shorter will be the bond-length, thus NO^+ having the higher bond order that is 3 as compared to NO having bond order 2, so NO^+ has shorter bond length.

Sol 25: (D) Hydrogen bonding increases the boiling point of compound.

Sol 26: (D) In case of water, five water molecules are attached together through four hydrogen bonding.

Sol 27: (D) Water is dense than ice because of hydrogen bonding interaction and structure of ice.

Sol 28: (A) A compound having maximum electronegative element will form strong hydrogen bond.

Sol 29: (D) We know that:

Ionic character $= 16\left[E_A - E_B\right] + 3.5 \times \left[E_A - E_B\right]^2$

Or ionic characters = 72.24 %

Sol 30: (D)

$$O_2 : \sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, \sigma 2p_x^2, \pi 2p_y^2 = \pi 2p_z^2$$
$$\pi^*2p_y^1 = \pi^*2p_z^1$$
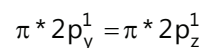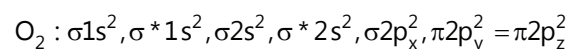
Total number of paired electrons = 14

Sol 31: (A)

$$H-\ddot{O}: + H^+ \longrightarrow H-\ddot{O} \rightarrow H$$
$$\quad\ |\qquad\qquad\qquad |$$
$$\quad\ H\qquad\qquad\qquad H$$
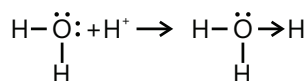
Sol 32: (C) BeF_2^- does not show sp^3 hybridization because this compound is not formed.

Sol 33: (A) O_2^{2-} (total number of electrons = 18)

$$\sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, \sigma 2p_z^2, \pi 2p_x^{1+1} = \pi 2p_y^{1+1}$$
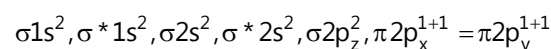
Sol 34: (B)

Molecules	Interaction
Benzene and ethanol	Dispersion force
Acetonitrile and acetone	dipole-dipole
KCl and water	ion-dipole
Benzene and carbon tetrachloride	Dispersion (London) force

Sol 35: (C) MCl_2 oxidation state M = +2

MCl_4 oxidation state of M = + 4

Higher the oxidation state, smaller the size.

Greater the polarizing power, greater the covalent characteristics.

Hence, MCl_4 is more covalent and MCl_2 is more ionic.

Sol 36: (A) SF_4 has distorted trigonal bipyramidal geometry, lone pair of electrons repels the axial bond pair and decreases the bond angle to 89° and 177° (from 90° and 180°)

SF_4

Trigonal bipyramidal (distorted)

SiF_4 Regular tetrahedral

XeF_4 — Square planar
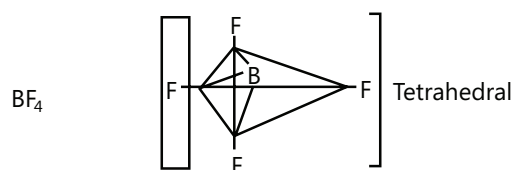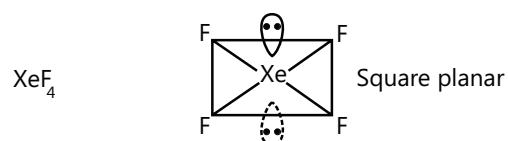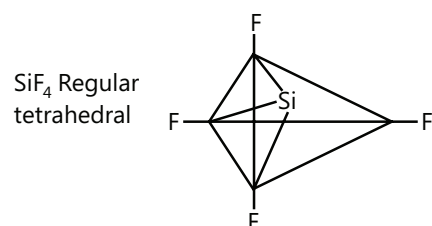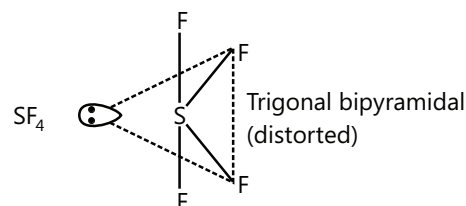
BF_4 — Tetrahedral

Previous Years' Questions

Sol 1: (A) All three have 14 electrons (iso-electronic) with bond order of three.

Sol 2: (B) $NH_3 = sp^3$, $[PtCl_4]^{2-} = dsp^2$,

$PCl_5 = sp^3d$, $BCl_3 = sp^2$

Sol 3: (A)

$$F-\overset{\overset{\displaystyle F}{|}}{\underset{\underset{\displaystyle F}{|}}{B^-}} \leftarrow \overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{N^+}}-H$$
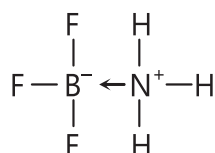
Both 'B' and 'N' are sp^3 tetrahedral

Sol 4: (A)
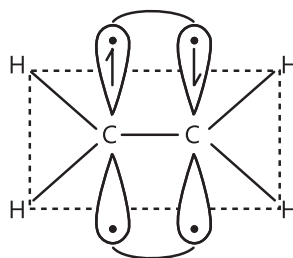
Pi bond is formed by the p-orbitals whose lobes have minima in the plane of molecule, hence molecular plane is the nodal plane of pi-bond.

Sol 5: (C) O_2^- has odd number (17) of electrons, therefore it must contain at least one unpaired electron.

Sol 6: (A) CH_3Cl has the highest dipole moment

Sol 7: (A) NO_3^- and CO_3^{2-} both have 32 electrons, central atom sp^2 hybridised, triangular planar.

Sol 8: (A) Assertion is correct, given structure is one of the resonance structure of ozone
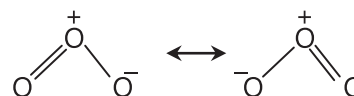
Sol 9: (C) Assertion is correct but reason is wrong. The covalency in LiCl is due to small size of Li^+ ion which brings about large amount of polarization in bond.

Sol 10:
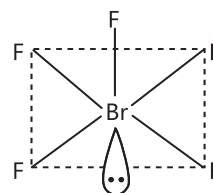
Lone pair would push the Br—F bond pairs in upward directions and all Br—F bond angles will contract.

Sol 11: (C) O_2 is expected to diamagnetic in nature but actually it is paramagnetic.

Sol 12: (B) B.O. of $Li_2^+ = 0.5$

B.O. of $Li_2^- = 0.5$

Hence stability order $= Li_2^- < Li_2^+ < Li_2$

Sol 13: (B) Conceptual fact.

JEE Advanced/Boards

Exercise 1

Sol 1: In the lattice, each Na^+ & Cl^- ion is surrounded by 6 oppositely charged ions. But, ionic bond is non-directional. So, no. of directional bonds = 6

Sol 2:
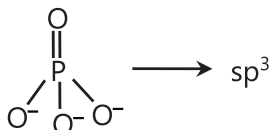
$p\pi - d\pi$ is in P =O as P is sp^3 hybridised.

So, s and p will from σ bonds

$\therefore$ No. of $p\pi$-$d\pi$ bonds = 1

Sol 3: ClO_3^-

Cl $\longrightarrow$ sp^3 hybrid
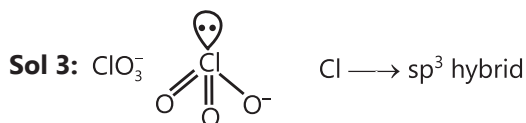
Sol 4: Let the total no. of orbital's be x.

% of s character = $\dfrac{1}{x} \times 100\%$ $\Rightarrow$ $\dfrac{100}{x}$ = 17

$\Rightarrow$ x = 6.

Sol 5: $AgNO_3$ + NaCl $\rightarrow$ AgCl $\downarrow$ + $NaNO_3$

AgCl is formed because of the presence of Ag^+ & Cl^- Ions in the solution.

CCl_4 is covalent, So Ag^+ will not have Cl^- ion to form the precipitate.

Sol 6: $OF_2 \rightarrow$ x = $\dfrac{1}{2}$(V + M – C + A) = $\dfrac{1}{2}$(6 + 2) = 4

i.e. sp^3.
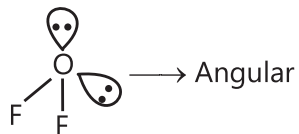
$\longrightarrow$ Angular

Sol 7: (A) XeF_2 x = $\dfrac{1}{2}$(V + M –C + A) = $\dfrac{1}{2}$(8 + 2)

= 5(sp^3d)

linear $\longrightarrow$
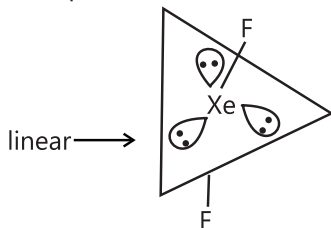
(B) XeF_4 x = $\dfrac{1}{2}$ (V + M – C + A) = $\dfrac{1}{2}$ (8 + 4) planar, 2 LP.

= 6 $\rightarrow$ sp^3d^2

(C) PBr_5 x = $\dfrac{1}{2}$ (5 + 5) = 5 $\rightarrow$ sp^3d Trigonal

Bipyramidal

(D) $OF_2 \rightarrow$ $\dfrac{1}{2}$(6 + 2) = 4 $\rightarrow$ sp^3

Angular

(E) $I_3^- \rightarrow$ $\dfrac{1}{2}$(7 + 2 + 1) = 5 $\rightarrow$ sp^3d

linear
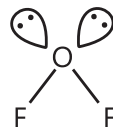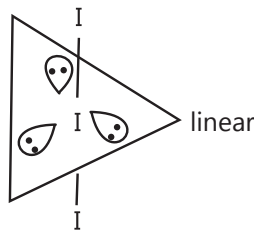
(F) $I_3^+ \rightarrow$ $\dfrac{1}{2}$(7 + 2 + 0 –1) = 4 $\rightarrow$ sp^3

Sol 8: Partial charge = 4. 8 $\times$ $\dfrac{18.08}{100}$ $\times$ 10^{-18}

= 0. 86 $\times$ 10^{-18}

$\therefore$ Distance (A°) = $\dfrac{DP}{\delta C}$ = $\dfrac{1.08}{0.86}$ = 1. 2 A°

Sol 9:
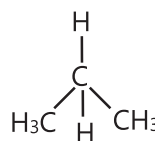
d_{c-c} = 1. 54 A°

d_1 = d_{c-c} Cos(109. 28° – 90°).

d_2 = $\sqrt{3}\ d_1$ = 2. 517 A°
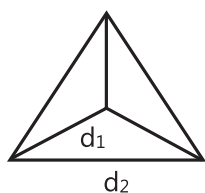
Sol 10: $\delta C = \dfrac{DM}{R} = \dfrac{7.95}{1.94\,A°} = 4.097.$

$\therefore$ % of Ionic character $= \dfrac{4.098}{4.8} = 8.5$ i. e. 85%

Sol 11: $\Delta C = \dfrac{11.5}{100} \times 1.67 \times 10^{-17} = \mathbf{1.92 \times 10^{-20}}$

$d = \dfrac{2.6 \times 10^{-30}}{1.92 \times 10^{-20}} = 1.35\ A°$

Sol 12: $\Delta C = \dfrac{6.32}{1.56} = 4.05.$

% of Ionic Character $= \dfrac{4.05}{4.8} = 0.844$ i. e. 84. 4%

Sol 13: $\Delta C = \dfrac{1.2}{1} = 1.2$

% of Ionic character $= \dfrac{1.2}{4.8} = 0.25$ i. e. 25%

Sol 14: ICl. Because of Vander waal's inductions between ICl molecular

$$\overset{\delta+}{I}-\overset{\delta-}{CI} \; --- \; \overset{\delta+}{I}-\overset{\delta-}{CI}$$

Sol 15: Vander waal's forces $\propto$ Surface Area.

So, BP of He < Ne < Ar < Kr < Xe < Ra

Exercise 2

Multiple Correct Choice Type

Sol 1: (A, B) NH_3 similar to CH_3^-, SeO_3^{2-} [Pyramidal]

Sol 2: (B, C) $CO_2 \rightarrow$ Linear

Sn $\rightarrow$ Has a lone pair $\rightarrow$ Angular

$SO_2 \rightarrow$ Angular.

$BeCl_2 \rightarrow$ Linear.
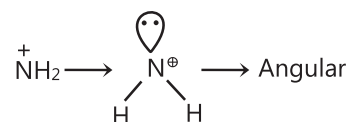
Sol 3: (B, C, D)
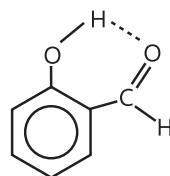
Intramolecular H-bonding.

So Low BP and steam volatile

Sol 4: (B, D) Vander waal's forces & London forces are very weak. They are due to induced charges.

Sol 5: (A, B, C) Possible chances for Vander waal's forces is interaction between Instantaneous, induced dipoles, Ion-induced dipoles. It's not due to sizes of molecules.

Sol 6: (B, D) Atoms combine to decrease their potential energy. In order to do this, they try to attain stable configurations (closest inert gas configuration).

Sol 7: (A, B, C, D) In case of ionic compounds

$\rightarrow$ They are soluble in polar solvent.

$\rightarrow$ Good conductors in aqueous state

$\rightarrow$ They have ions.

$\rightarrow$ High BP and MP due to stable crystal lattice.

Sol 8: (A, C)
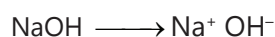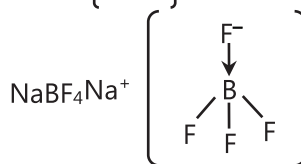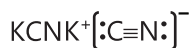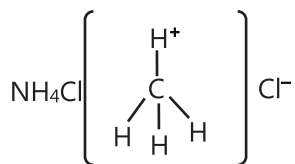
Sol 9: (A, B, C, D) $sp^3 \rightarrow AlH_4$

sp^3 CH_3^- $\longrightarrow$

sp^3 NH_3^- $\longrightarrow$
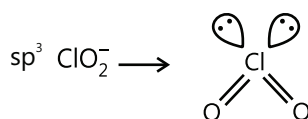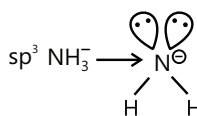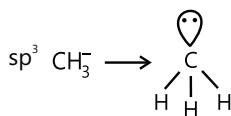
Sol 10: (A, B, D) $Sb \rightarrow$ 5A group

$SbCl_6^-$ ✓ Sb has $6e^-$

$SnCl_6^{2-}$ ✓

XeF_6 ✓ It has a lone pair

IO_6^{5-} ✓

Sol 11: (A, B, C)

ICl_2^- $\longrightarrow$
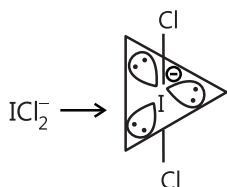
I_3^- $\rightarrow$ linear.

$N_3^- \rightarrow \overset{-}{N} = \overset{+}{N} = \overset{-}{N} \rightarrow$ linear.

ClO_2 $\longrightarrow$

 not linear
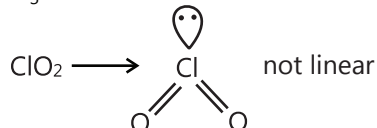
Sol 12: (B, C, D) Benzene. CCl_4, BF_3 NO dipole moment.
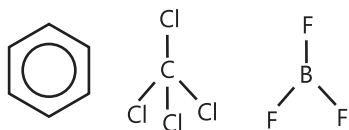
Sol 13: (A, B, C)
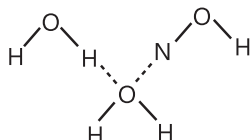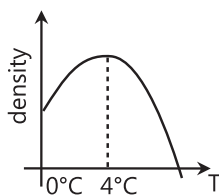
Above 4°C thermal agitation of H_2O, molecules increase.

$\therefore$ Intermolecular distance increases and water starts expanding.

Sol 14: (B, D) H_2O, $NH_3 \rightarrow Sp^3 \rightarrow$ nearly 109°

$SF_6 \rightarrow Sp^3d^2 \rightarrow 90°$.

$H_2S \rightarrow$ no hybridization $\rightarrow$ Bond angle is the angle b/w 2 bond-forming p-orbital's i. e. 90°.

Sol 15: (A, D) Molecule is non-planar.

Nodal planes for $C_1 - C_2$ and $C_2 - C_3$ are perpendicular.
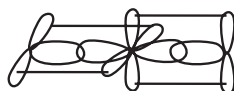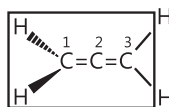
Sol 16: (A, B, C, D) $O_2F_2 \rightarrow F - O - O - F$

$S_2Cl_2 \rightarrow Cl - S - S - Cl$

N_2H_4 $\longrightarrow$


S_2F_{10} $\longrightarrow$
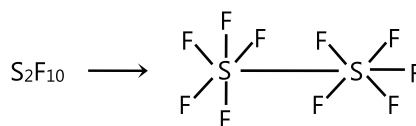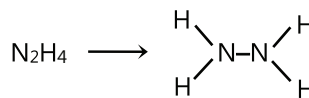
Sol 17: (A, B, C) In graphite, Vander waal's forces act b/w carbon layers. Linear compounds have larger surface area and large Vander waals forces.

Sol 18: (B, D) Intermolecular H-bonding, increases the attraction b/w the molecules.

So, it increases the effective molar mass of H-bonded molecules.

Sol 19: (A, B, C, D)

$H_3BO_3 \longrightarrow$

Sol 20: (A, B, C, D)

These 2 groups will not cancel each other exactly
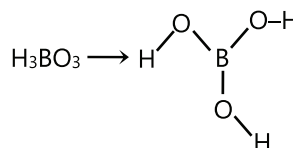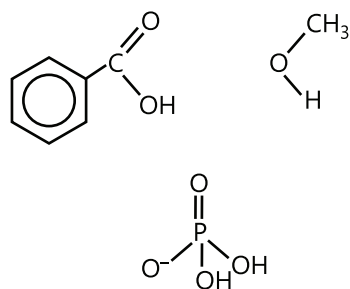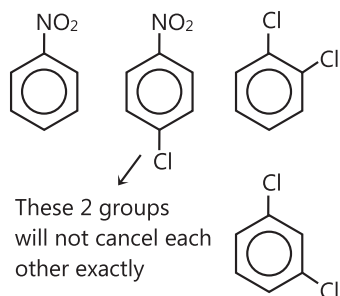
Comprehension Type

Sol 21: (A) Hypovalent → less than octet.

(E.g. $BeCl_2$)

Hyper valent → more than octet

(E.g. PCl_5)

Odd e^- → there will be unpaired e^-.

Sol 22: (C) SO_3^{2-}
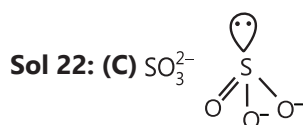
LP = 1 + 2 + 3 + 3 = 9

BP = 4

Sol 23: (D) CCl_4, $SiCl_4$ → Tetrahedral.

NH_4^+, NF_4^+ → Tetrahedral.

ClF_6, SF_6 → Octahedral.

Sol 24: (B) BF_3 → Non polar

$SnCl_2$ → Angular, polar.

I_3^+ → Angular, polar.

NH_2^- → Angular, polar.

$IF_3 \rightarrow$
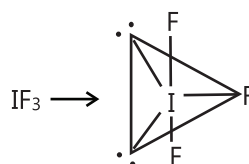
T-shaped, polar

All of the above are planar

Sol 25: (B) P are more energetic than S.

(higher ℓ value for P).

∴ More is % of P, more is energy.

$sp < sp^2 < sp^3$.

Sol 26: (D) Generally, as s-character increases, the bond-angle increases. But few hybridizations have multiple bond-angles, where this rule becomes false.

Sol 27: (C) 1S sp, sp is more circular compared to sp^2,sp^3. So, overlap will be stronger.

Sol 28: (C) $SF_4 \rightarrow sp^3d$ $BCl_3 \rightarrow sp^2$

$CF_3H - sp^3$, $CCl_4 \rightarrow sp^3$

Sol 29: (i) False. Low IP → metals

High EA → Non-metals.

They tend to form Ionic bonds
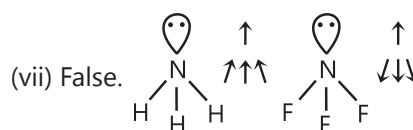
(ii) True.

(iii) True.

(iv) False. Ionic interactions are non-directional.

Sol 30: (i) False. E.g. HCl.

(ii) False. E.g. CCl_4. C-Cl is polar, CCl_4 is non-polar.
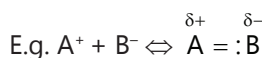
(iii) False. Net Dipole moment depends on both BP & LP.

(iv) False. CH_2Cl_2 is polar because of H it's tetrahedral structure. It can't be planar.

(v) False. Net dipole moment is due to BP and LP also

(vi) True. SO_2 is angular, CO_2 is linear
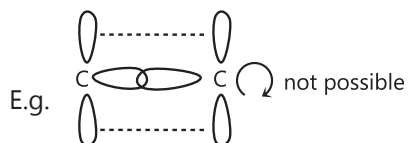
(vii) False.

DM of NH_3 = NF_3

(viii) True. As the amount of charges on adjacent atoms decrease, the dipole moment also decrease.

E.g. $A^+ + B^- \Leftrightarrow \overset{\delta+}{A} = \overset{\delta-}{:B}$

Sol 31: (i) π–bond $\rightarrow$ between 2p orbitals

(ii) Sigma bond.

If there are both σ & π bond, the due to the formation of π – bond, the 2 atoms become rigid.

E.g.

not possible

possible rotation

(iii) 1. 2 atoms can't form 2 sigma bonds between each other because σ bond is formed along the inter-nuclear axis.

(iv) Repulsions between LP – LP > LP – BP > BP – BP. Because LP are closer to atom then BPs.

(v)
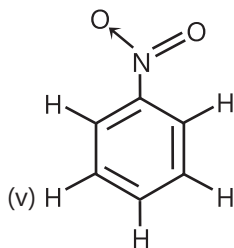
bond pairs so 36 bonded e^-

Sol 32: (B, C, D) Lattice energy $\propto \dfrac{q_1 q_2}{r_+ + r_-}$

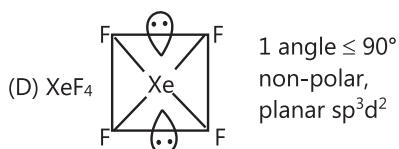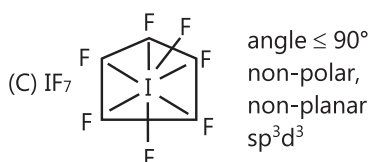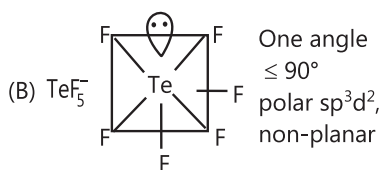$\therefore$ LE of MgO > CaO > SrO > BaO
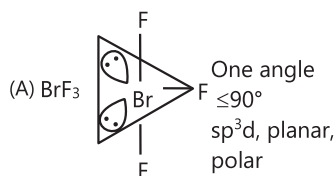
LiF > LiCl > LiBr > LiI

MgO > MgF$_2$ > LiF > NaF and
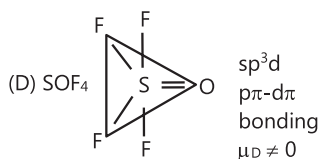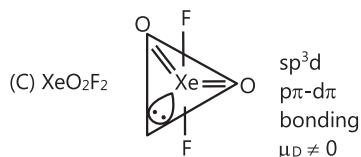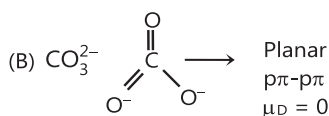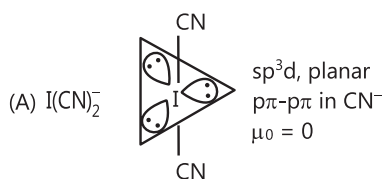
LiF > NaF > KF > RbF > CsF.

Sol 33: (A, C) Cation can attract more than 1 anion at a time (Ex. MgCl$_2$) Brittleness is due to repulsions between same charges. They don't conduct electricity in solid state (no charge movement).
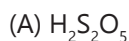
Match the Columns

Sol 34: A $\rightarrow$ p, s; B $\rightarrow$ p, q, r, s; C $\rightarrow$ p, r; D $\rightarrow$ p, q

(A) BrF$_3$

One angle ≤90°
sp^{3}d, planar, polar

(B) TeF$_5^-$

One angle ≤ 90°
polar sp^{3}d^2, non-planar

(C) IF$_7$

angle ≤ 90°
non-polar, non-planar
sp^{3}d^3

(D) XeF$_4$

1 angle ≤ 90°
non-polar, planar sp^{3}d^2

Sol 35: A $\rightarrow$ p, r, s; B $\rightarrow$ p, r; C $\rightarrow$ q, s; D $\rightarrow$ q, s

(A) I(CN)$_2^-$

sp^{3}d, planar
pπ-pπ in CN$^-$
μ_0 = 0

(B) CO$_3^{2-}$

Planar
pπ-pπ
μ_D = 0

(C) XeO$_2$F$_2$

sp^{3}d
pπ-dπ
bonding
$\mu_D \neq 0$

(D) SOF$_4$

sp^{3}d
pπ-dπ
bonding
$\mu_D \neq 0$

Sol 36: A $\rightarrow$ p, r, s; B $\rightarrow$ p, q, s; C $\rightarrow$ p, r, s; D $\rightarrow$ p, q, s

(A) H$_2$S$_2$O$_5$

O. S. of S $\rightarrow$+4

So, M-O-M might not be present, s-sp³, non polar

(B) $H_6B_2O_6^{2-}$ O. S. of B = $\dfrac{12-6}{2}$ = +3 So, there must be

M–O–M present, B → sp³ non-polar

(C) $H_2P_2O_6$ M-O-M is absent, sp³, non-polar

(D) $H_6Si_2O_7$ M-O-M is present, sp³, non-polar

Assertion Reasoning Type

Sol 37: (A) As lattice energy is evolved during the formation of ionic bond, more is the lattice energy, more is the stability of the compound.

Sol 38: (D) When the atoms of opposite sign comes too close, their nucleus-nucleus repulsions & inter-electronic repulsions also increase. So, lattice energy cannot tend to Infinity.

Sol 39: (B) Direction of Bond moment is from positive pole towards negative pole. But it is not the reason for statement-I which is Symmetries molecular has no polarity.

Sol 40: (D) Statement-I is false because some acceptors accept e⁻ pairs when there are empty d-orbitals. Ex. Complexes.

Sol 41: (A)
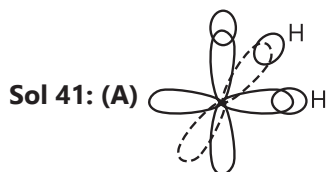
All bond angles with 90° as angle b/w p orbitals is 90°.

Sol 42: (A) Repulsions of $\angle LP - \angle LP > \angle LP - BP$, because both $\angle LP'S$ on single atom are close to each whereas BP will be shared by two atoms.

Sol 43: (A) The size of 3p orbitals is large compared to 2p. So, triple bond in P will be weaker compared to N. So, P_2 is not possible.

Sol 44: (C) d_{c-c} in benzene is not greater than
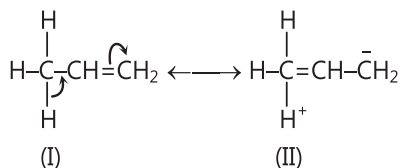
d_{B-N}

d_{c-c} = 1. 39 A°

d_{B-N} = 1. 43 A° (factual knowledge).

Sol 45: (A) Most of the compared having layered structure have Vander waal's forces acting between the layers.
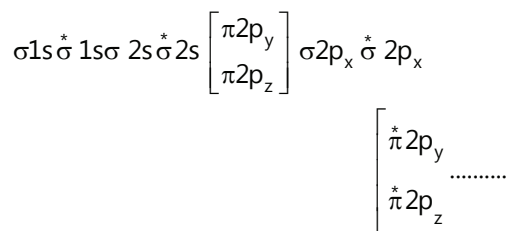
Previous Years' Questions

Sol 1: (A) The bond order of CO=3. NO⁺, CN⁻ and N_2 are isoelectronic with CO, have the same bond orders as CO. NO⁻ (16e⁻) has bond order of 2.

Sol 2: (B)

I and II are hyperconjugating structures of propene and involves σ-electrons of C–H bond and p-orbitals of pi bond in delocalization.

Sol 3: (A) For molecules lighter than O_2, the increasing order of energies of molecular orbitals is:

$$\sigma 1s \; \overset{*}{\sigma} \; 1s\sigma \; 2s \overset{*}{\sigma} 2s \begin{bmatrix} \pi 2p_y \\ \pi 2p_z \end{bmatrix} \sigma 2p_x \; \overset{*}{\sigma} \; 2p_x$$

$$\begin{bmatrix} \overset{*}{\pi} 2p_y \\ \overset{*}{\pi} 2p_z \end{bmatrix} ....$$

Where, $\pi 2p_y$ and $\pi 2p_z$ are degenerate molecular orbitals, first singly occupied and then pairing starts if Hund's rule is obeyed. If Hund's rule is violated in B_2, electronic arrangement would be:
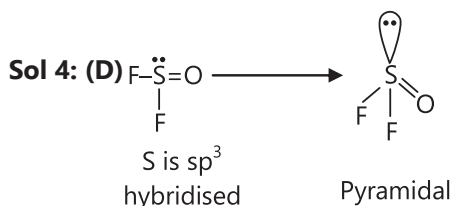
$$\sigma 1s^2 \; \overset{*}{\sigma} \; 1s^2\sigma \; 2s^2 \; \overset{*}{\sigma} 2s^2 \begin{bmatrix} \pi 2p^2_y \\ \pi 2p_z \end{bmatrix} ....$$
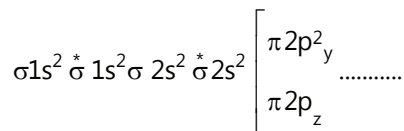
No unpaired electron-diamagnetic.

Bond-order

$$= \dfrac{\text{bonding electrons} - \text{anit bonding electrons}}{2}$$

$$= \dfrac{6-4}{2} = 1$$

Sol 4: (D)

S is sp³ hybridised

Pyramidal

SO_3 is planar (S is sp² hybridised), BrF_3 is T-shaped and SiO_3^{2-} is planar (Si is sp²hybridised)