

विध्न विचारत भीरु जन, नहीं आरम्भे काम, विपति देख छोड़े तुरंत मध्यम मन कर श्याम।
पुरुष सिंह संकल्प कर, सहते विपति अनेक, 'बना' न छोड़े ध्येय को, रघुबर राखे टेक।।

रचित: मानव धर्म प्रणेता
सद्गुरु श्री रणछोड़दासजी महाराज

STUDY PACKAGE This is TYPE 1 Package
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Subject : CHEMISTRY
Topic : Chemical Bonding

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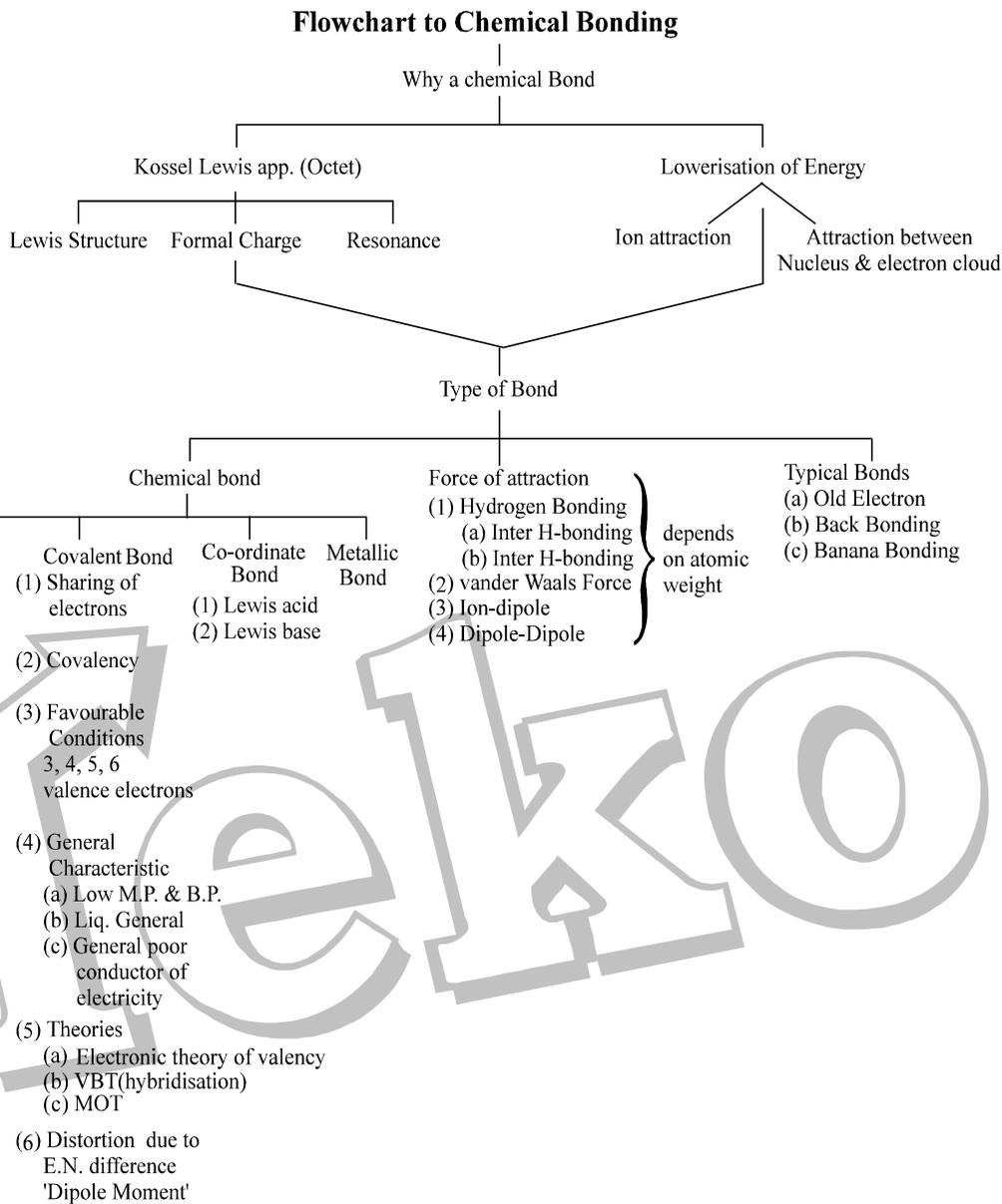
1. Key Concepts
2. Exercise I
3. Exercise II
4. Exercise III
5. Exercise IV
6. Answer Key
7. 34 Yrs. Que. from IIT-JEE
8. 10 Yrs. Que. from AIEEE

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KEY CONCEPT

Reasons for Bond formation:

- ✦ Lowerisation of energy due to attractions.
- ✦ Attainment of Octet [$ns^2 np^6$], assumed to be most stable.

Types of bonds : Ionic, covalent, co-ordinate

IONIC BOND [ELECTROVALENT]

- ✦ Complete loss of e^- to form ions.
 - ✦ Electrostatic attraction between ions.
 - ✦ Elements of 'p' & 'd' block may show variable electrovalency due to
- (a) **Inert Pair effect (for p block):** The reluctance of 's' electron pair to take part in bond formation on moving down a group in 'P' block elements.

Finds application in

- ✦ Stability of oxidation state of a particular metal atom.
 - ✦ Oxidizing & reducing power of compounds.
- (b) **Unstability of core:** For 'd' block elements the core may either have pseudo inert configuration (having 18 electrons in outermost shell) or any other.

Properties of Ionic compounds

- ✦ Ionic bonds are Non directional in nature
 - ✦ High Melting points / Boiling points.
 - ✦ In solid state they are conductor (due to absence of charge carrier) while in aqueous & molten state they are good conductor of electricity.
 - ✦ Soluble in Polar solvents
 - ✦ Show isomorphism.
- ⊙ No sp. theories to understand bond formation.
- ⊙ characteristics like various crystal lattices to be done in solid state.

COVALENT BOND

- ✦ Sharing of electrons
- ✦ Overlapping of orbitals
- ✦ Types : single, double, triple, polar, non-polar bonds.
- ✦ Variable covalency : Shown by elements having vacant 'd' orbitals (caused due to excitation of the electron.)

Properties:

- ✦ Covalent bonds are directional in nature
- ✦ Low melting point & boiling point. (except Diamond / Graphite, due to their peculiar structure)
- ✦ Electrical conductivity due to auto-protolysis or self ionisation.
- ✦ Show isomerism.

CO-ORDINATE BOND

Bonding between lewis acid & lewis base or electron deficient & electron rich species.

Lewis base: Species with lone pair on 'central atom' available for donation. eg. NH_3 , H_2O

Lewis acid: Electron deficient due to incomplete octal, vacant p or d orbital & high +ve $\frac{\text{charge}}{\text{size}}$ ratio.

Lewis Dot structures:

- ✦ Arrangement of various atoms & types of bonding present but no idea of geometry.
- ✦ Selection of central atom [least E.N. of all elements excluding hydrogen]
- ✦ In hydrogen containing proton donor oxy acids all 'H' atoms are attached to oxygen as -OH groups except in H_3PO_3 (dibasic), H_3PO_2 (monobasic) & $\text{H}_4\text{P}_2\text{O}_5$ (dibasic).

Applications:

- ✦ To know various linkages present
- ✦ To calculate O.S. of various elements.

Various Theories For Explaining Bonding

- ✦ Electronic theory of valency (Kossel, Lewis); Singlat linkages
- ✦ Valence bond theory (Heitler, London, Pauling, Slater).
- ✦ M.O.T. (Hund, Mulliken).

(will be discussed in class XII th)

DIPOLE MOMENT

Dipole moment is a vector quantity = $\mu = q \times d$. Units = col m (S.I.) or esu cm (cgs) or Debye (common unit) $1 \text{ D} = 10^{-18} \text{ esu cm} = 3.33 \times 10^{-30} \text{ col. m}$

$$\% \text{ ionic character} = \frac{\text{observed D.M.}}{\text{calculated D.M. for 100\% ionic}} \times 100 \%$$

$$\% \text{ ionic character} = [16(X_A - X_B) + 3.5(X_A - X_B)^2] \% \quad [\text{Hanny \& Smyth equation}]$$

Dipole moment depends on

- ✦ Electronegativity difference between atoms
- ✦ Angle between various bonds
- ✦ Magnetic of polarity of the molecule
- ✦ Direction of bond dipole moment
- ✦ Influence of unshared e^- pairs
- ✦ Symmetrical / Unsymmetrical shape.

Bond Moments:

H-F (1.9 D)	H-O (1.5 D)	C - C (0 D)	C-F (1.4 D)
H-Cl (1.1 D)	H-N (1.3 D)	C = O (2.3 D)	C-Cl (1.5 D)
H - Br (0.8 D)	H- C (0.4 D)		C - Br (1.4 D)
H - I (0.4 D)			C - I (1.2 D)

SHAPES OF MOLECULES BASED ON VSEPR THEORY

Total no. of hybrid orbitals	No. of b.p. (bond pairs)	No. of unshared pair i.e. l_p	General formula	Type of hybridisations	Stereo chemical formula	Shape	Exam.
2	2	0	AB_2	sp	B—A—B	linear	$BeCl_2$
3	3	0	AB_3	sp^2		Trigonal planar	BCl_3 , GaF_3
3	2	1	AB_2	sp^2		Bent or angular	GeF_2 , O_3
4	4	0	AB_4	sp^3		Tetrahedral	CH_4
4	3	1	AB_3	sp^3		Trigonal pyramid	NH_3
4	2	2	AB_2	sp^3		Bent or angular	H_2O
4	1	3	AB	sp^3		linear	HF
5	5	0	AB_5	sp^3d		Trigonal bipyramidal	PF_5 , $NbBr_5$
5	4	1	AB_4	sp^3d		Seesaw	SF_4
5	3	2	AB_3	sp^3d		T-shaped	ClF_3 , BrF_3
5	2	3	AB_2	sp^3d		Linear	ICl_2^- , XeF_2
6	6	0	AB_6	sp^3d^2		Octahedral	SF_6
6	5	1	AB_5	sp^3d^2		Square pyramidal	IF_5

6	4	2	AB ₄	sp ³ d ²		Square planar	IF ₄ XeF ₄
7	7	0	AB ₇	sp ³ d ³		Pentagonal bipyramidal	IF ₇

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HOW TO DECIDE THE TYPE OF HYBRIDISATION :

Type of hybridisation = (number of σ bonds + number of lone pairs)

RESONANCE

- ✦ Delocalisations of π electron cloud in between orbitals of various atoms in a molecule (provided all the atoms are in the same plane)
- ✦ Exists where more than one Lewis dot structure are possible for a molecule.
- ✦ Resonance causes stabilisation of the molecule & difference in the energies of hybrid & other structure is termed as Resonance energy.
- ✦ R.E. \rightarrow Experimental heat of formation-Theoretical heat of formation.
- ✦ The properties of the actual structure (Resonance hybrid) are decided by the weighed average (depending on stability) of the contributing molecule.
- ✦ More the resonating structure more stable the molecule becomes.

FORCES OF ATTRACTION (WEAKER BONDS)

- ✦ **Hydrogen bonding:** When a hydrogen atom is linked to a highly electronegative atom (like F, O or N) comes under the influence of another strongly electronegative atom, then a weak bond is developed between them, which is called as hydrogen bond.

Types of H-bonding:

- ✦ Intermolecular
- ✦ Intramolecular

Applications in:

- (a) Abnormal behaviour of water.
- (b) Association of a molecule as in carboxylic acid.
- (c) Dissociation of a polar species.
- (d) Abnormal melting point & boiling point.
- (e) Enhanced solubility in water.

✦ Ion dipole attraction

✦ Dipole-dipole attraction

✦ Ion-induced dipole attraction

✦ Dipole-Induced Dipole attraction

✦ Induced -dipole Induced Dipole attraction

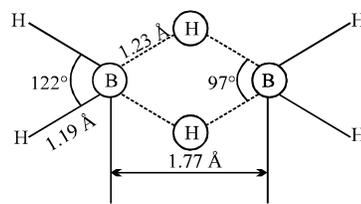
- ✦ **Metallic bonds:** Electron gas model or sea model, with metal atom existing as kernels along with less firmly held valence e^{-s} & bonds between various kernels (at the lattice site) & valence e^{-s} is known as metallic bonds.

SOME TYPICAL BOND

1. **Back bonding:**

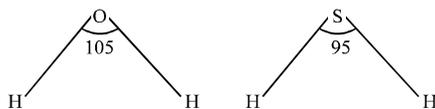
- ✦ If among the bonded atoms, one atom has a vacant orbital & another has excess of e^{-s} then a sort of π bonding takes place between he two. If this is between 'P' orbitals of the two, this is known as p π -p π back bonding.

- ✦ Most efficient when the atoms are very small & the orbitals involved of the two are of same energy level.
2. **Banana bond:**
- ✦ This type of bonding is present in B_2H_6 .
 - ✦ This structure shows that there are two types of hydrogen atom-Terminals and bridging.



MISCELLANEOUS CONCEPT

1. **Comparison of bond angles.**
- (a) In case central atoms are having different hybridisation then it can be compared.
 - (b) If same hybridisation but different central atom then bond angle would be more of the molecule in which C.A. is more E.N. eg. H_2S & H_2O .



- (c) If C.A. is same & bonded atoms different then bond angle increases as the attached atom size increases.
2. **Bond strength , Bond length & Paramagnetic nature**
- (a) Using concepts of resonance.
 - (b) Use of Lewis dot structure for the rest.

EXERCISE - I

IONIC BOND

- Q.1 The combination of atoms take place so that
(A) They can gain two electrons in the outermost shell
(B) They get eight electrons in the outermost shell
(C) They acquire stability by lowering of energy
(D) They get eighteen electrons in the outermost shell.
- Q.2 An ionic bond A^+B^- is most likely to be formed when :
(A) the ionization energy of A is high and the electron affinity of B is low
(B) the ionization energy of A is low and the electron affinity of B is high
(C) the ionization energy of A and the electron affinity of B is high
(D) the ionization energy of A and the electron affinity of B is low
- Q.3 Which of the following compounds of elements in group IV is expected to be most ionic ?
(A) $PbCl_2$ (B) $PbCl_4$ (C) CCl_4 (D) $SiCl_4$
- Q.4 The compound which contains ionic as well as covalent bonds is
(A) $C_2H_4Cl_2$ (B) CH_3I (C) KCN (D) H_2O_2
- Q.5 The hydration of ionic compounds involves :
(A) Evolution of heat (B) Weakening of attractive forces
(C) Dissociation into ions (D) All of these
- Q.6 In which of the following species the bonds are Non-directional ?
(A) NCl_3 (B) $RbCl$ (C) $BeCl_2$ (D) BCl_3
- Q.7 Which has the lowest anion to cation size ratio :
(A) LiF (B) NaF (C) CsI (D) CsF
- Q.8 Which of the following statement(s) is/are correct regarding ionic compounds?
(A) They are good conductors 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.9 Which of the following compounds contain/s both ionic and covalent bonds?
(A) NH_4Cl (B) KCN (C) $CuSO_4 \cdot 5H_2O$ (D) $NaOH$
- Q.10 Among the following isostructural compounds, identify the compound, which has the highest Lattice energy
(A) LiF (B) $LiCl$ (C) $NaCl$ (D) MgO
- Q.11 A bond formed between two like atoms cannot be
(A) ionic (B) covalent (C) coordinate (D) metallic
- Q.12 Which of the following, when dissolved in water forms a solution, which is Non-conductivity?
(A) Green Vitriol (B) Indian salt Petre
(C) Alcohol (D) Potash alum
- Q.13 Most ionic compounds have :
(A) high melting points and low boiling points
(B) high melting points and nondirectional bonds
(C) high solubilities in polar solvents and low solubilities in nonpolar solvents
(D) three-dimensional network structures, and are good conductors of electricity in the molten state

- Q.14 An electrovalent compound does not exhibit space isomerism because of
 (A) Presence of oppositely charged ions
 (B) High melting points
 (C) Non-directional nature of the bond
 (D) Crystalline nature
- Q.15 Which of the following have an $(18 + 2)$ electron configuration ?
 (A) Pb^{2+} (B) Cd^{2+} (C) Bi^{3+} (D) SO_4^{2-}
- Q.16 Which of the following contains (electrovalent) and non-polar (covalent) bonds ?
 (A) CH_4 (B) H_2O_2 (C) NH_4Cl (D) HCN

COVALENT BOND

- Q.17 A sigma bond may be formed by the overlap of 2 atomic orbitals of atoms A and B. If the bond is formed along as the x-axis, which of the following overlaps is acceptable ?
 (A) s orbital of A and p_z orbital of B (B) p_x orbital of A and p_y orbital of B
 (C) p_z orbital of A and p_x orbital of B (D) p_x orbital of A and s orbital of B
- Q.18 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.
- Q.19 How many bonded electron pairs are present in IF_7 molecule :
 (A) 6 (B) 7 (C) 5 (D) 8
- Q.20 PCl_5 exists but NCl_5 does not because :
 (A) Nitrogen has no vacant 2d-orbitals (B) NCl_5 is unstable
 (C) Nitrogen atom is much smaller than P (D) Nitrogen is highly inert
- Q.21 Which of the following has/have a strong covalent bond?
 (A) Cl-F (B) F-F (C) C-Cl (D) C-F
- Q.22 Which of the following statements is/are true?
 (A) Covalent bonds are directional
 (B) Ionic bonds are nondirectional
 (C) A polar bond is formed between two atoms which have the same electronegativity value.
 (D) The presence of polar bonds in a polyatomic molecule suggests that it has zero dipole moment
- Q.23 Rotation around the bond (between the underlined atoms) is restricted in :
 (A) \underline{C}_2H_4 (B) $H_2\underline{O}_2$ (C) \underline{Al}_2Cl_6 (D) \underline{C}_2H_6
- Q.24 The octet rule is not obeyed in :
 (A) CO_2 (B) BCl_3 (C) PCl_5 (D) SiF_4
- Q.25 Which of the following two substances are expected to be more covalent :
 (A) $BeCl_2$ (B) $SnCl_4$ (C) ZnS (D) $ZnCl_2$
- Q.26 To which of the following species octet rule is not applicable :
 (A) BrF_5 (B) SF_6 (C) IF_7 (D) CO

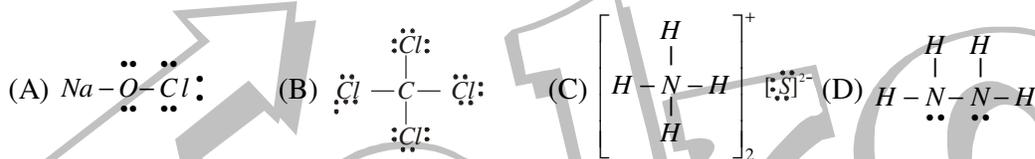
- Q.27 Which of the following species are hypervalent?
 1. ClO_4^- , 2. BF_3 , 3. SO_4^{2-} , 4. CO_3^{2-}
 (A) 1, 2, 3 (B) 1, 3 (C) 3, 4 (D) 1, 2
- Q.28 The types of bond present in N_2O_5 are
 (A) only covalent (B) only ionic
 (C) ionic and covalent (D) covalent & coordinate

CO-ORDINATE BOND

- Q.29 NH_3 and BF_3 combine readily because of the formation of:
 (A) a covalent bond (B) a hydrogen bond (C) a coordinate bond (D) an ionic bond
- Q.30 Which of the following species contain covalent coordinate bond :
 (A) AlCl_3 (B) CO (C) $[\text{Fe}(\text{CN})_6]^{4-}$ (D) N_3^-
- Q.31 Which of the following molecules does not have coordinate bonds?
 (A) $\text{CH}_3\text{-NC}$ (B) CO (C) O_3 (D) CO_3^{2-}

LEWIS STRUCTURE

- Q.32 Which of the following Lewis diagrams is(are) incorrect ?



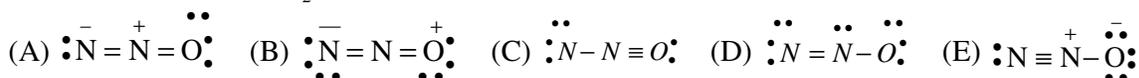
- Q.33 The possible structure(s) of monothiocarbonate ion is :



- Q.34 The valency of sulphur in sulphuric acid is :
 (A) 2 (B) 8 (C) 4 (D) 6
- Q.35 The total number of valence electrons in 4.2g of N_3^- ion are :
 (A) 2.2 N (B) 4.2 N (C) 1.6 N (D) 3.2 N
- Q.36 No $X-X$ bond exists in which of the following compounds having general form of X_2H_6 ?
 (A) B_2H_6 (B) C_2H_6 (C) Al_2H_6 (D) Si_2H_6
- Q.37 Pick out among the following species isoelectronic with CO_2 :
 (A) N_3^- (B) $(\text{CNO})^-$ (C) $(\text{NCN})^{2-}$ (D) NO_2^-
- Q.38 Which of the following have a three dimensional network structure ?
 (A) SiO_2 (B) $(\text{BN})_x$ (C) P_4 (white) (D) CCl_4
- Q.39 Which of the following oxyacids of sulphur contain $S-S$ bonds ?
 (A) $\text{H}_2\text{S}_2\text{O}_8$ (B) $\text{H}_2\text{S}_2\text{O}_6$ (C) $\text{H}_2\text{S}_2\text{O}_4$ (D) $\text{H}_2\text{S}_2\text{O}_5$

RESONANCE

- Q.40 Resonating structures of a molecule should have:
(A) identical bonding (B) identical arrangement of atoms
(C) nearly the same energy content (D) the same number of paired electrons
- Q.41 Which of the following conditions apply to resonating structures ?
(A) The contributing structures should have similar energies
(B) The contributing structures should be represented such that unlike formal charges reside on atoms that are far apart
(C) The more electropositive element should preferably have positive formal charge and the more electronegative element have negative formal charge
(D) The contributing structures must have the same number of unpaired electrons
- Q.42 N_2O has a linear, unsymmetrical structure that may be thought of as a hybrid of two resonance forms. If a resonance form must have a satisfactory Lewis structure, which of the five structures shown below are the resonance forms of N_2O ?



- Q.43 Resonance occurs due to the
(A) delocalization of a lone pair of electrons (B) delocalization of sigma electrons
(C) delocalization of pi electrons (D) migration of protons

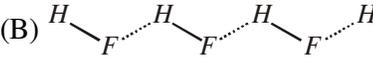
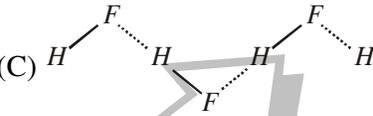
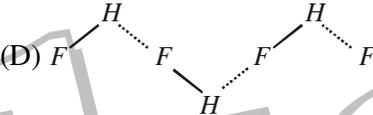
V.B.T. & HYBRIDISATION

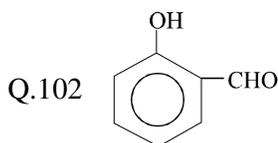
- Q.44 The strength of bonds by $s-s$, $p-p$, $s-p$ overlap is in the order :
(A) $s-s < s-p < p-p$ (B) $s-s < p-p < s-p$
(C) $s-p < s-s < p-p$ (D) $p-p < s-s < s-p$
- Q.45 In the following compound $\overset{1}{\text{C}}\text{H}_2 = \overset{2}{\text{C}}\text{H} - \overset{3}{\text{C}}\text{H}_2 - \text{C} \equiv \text{CH}$, the $\text{C}_2 - \text{C}_3$ bond is of the type :
(A) $sp-sp^2$ (B) sp^3-sp^3 (C) $sp-sp^3$ (D) sp^2-sp^3
- Q.46 Which of the following has a geometry different from the other three species (having the same geometry)?
(A) BF_4^- (B) SO_4^{2-} (C) XeF_4 (D) PH_4^+
- Q.47 Maximum bond energy is in :
(A) F_2 (B) N_2 (C) O_2 (D) equal
- Q.48 Among the following species, identify the isostructural pairs : $\text{NF}_3, \text{NO}_3^-, \text{BF}_3, \text{H}_3\text{O}^+, \text{HN}_3$
(A) $[\text{NF}_3, \text{NO}_3^-]$ and $[\text{BF}_3, \text{H}_3\text{O}^+]$ (B) $[\text{NF}_3, \text{HN}_3]$ and $[\text{NO}_3^-, \text{BF}_3]$
(C) $[\text{NF}_3, \text{H}_3\text{O}^+]$ and $[\text{NO}_3^-, \text{BF}_3]$ (D) $[\text{NF}_3, \text{H}_3\text{O}^+]$ and $[\text{HN}_3, \text{BF}_3]$
- Q.49 Number and type of bonds between two carbon atoms in CaC_2 are :
(A) one sigma (σ) and one pi (π) bond (B) one σ and two π bonds
(C) one σ and one and a half π bond (D) one σ bond
- Q.50 In $\text{C}-\text{C}$ bond in C_2H_6 undergoes heterolytic fission, the hybridisation of two resulting carbon atoms is/are
(A) sp^2 both (B) sp^3 both (C) sp^2, sp^3 (D) sp, sp^2

- Q.51 The hybridisation and geometry of BrF_3 molecules are :
 (A) sp^3d and T shaped (B) sp^2d^2 and tetragonal
 (C) sp^3d and bent (D) none of these
- Q.52 The shape of methyl cation (CH_3^+) is likely to be:
 (A) linear (B) pyramidal (C) planar (D) spherical
- Q.53 The structure of XeF_2 involves hybridization of the type :
 (A) sp^3 (B) dsp^2 (C) sp^3d (D) sp^3d^2
- Q.54 In the XeF_4 molecule, the Xe atom is in the
 (A) sp^2 -hybridized state (B) sp^3 -hybridised state (C) sp^2d -hybridized state (D) sp^3d^2 -hybridized state
- Q.55 How many σ - and π - bonds are there in salicylic acid?
 (A) $10\sigma, 4\pi$ (B) $16\sigma, 4\pi$ (C) $18\sigma, 2\pi$ (D) $16\sigma, 2\pi$
- Q.56 Which of the following statements are not correct?
 (A) Hybridization is the mixing of atomic orbitals of large energy difference.
 (B) sp^2 – hybrid orbitals are formed from two p - atomic orbitals and one s - atomic orbitals
 (C) dsp^2 – hybrid orbitals are all at 90° to one another
 (D) d^2sp^3 – hybrid orbitals are directed towards the corners of a regular octahedron
- Q.57 Which of the following has been arranged in increasing order of size of the hybrid orbitals ?
 (A) $sp < sp^2 < sp^3$ (B) $sp^3 < sp^2 < sp$ (C) $sp^2 < sp^3 < sp$ (D) $sp^2 < sp < sp^3$
- Q.58 In the context of carbon, which of the following is arranged in the correct order of electronegativity :
 (A) $sp > sp^2 > sp^3$ (B) $sp^3 > sp^2 > sp$ (C) $sp^2 > sp > sp^3$ (D) $sp^3 > sp > sp^2$
- Q.59 When $2s-2s, 2p-2p$ and $2p-2s$ orbitals overlap, the bond strength decreases in the order :
 (A) $p-p > s-s > p-s$ (B) $p-p > p-s > s-s$ (C) $s-s > p-p > p-s$ (D) $s-s > p-s > p-p$
- Q.60 The shapes of IF_5 and IF_7 are respectively :
 (A) square pyramidal and pentagonal bipyramidal (B) octahedral and pyramidal
 (C) trigonal bipyramidal and square antiprismatic (D) distorted square planar and distorted octahedral
- Q.61 Carbon atoms in $C_2(CN)_4$ are :
 (A) sp -hybridized (B) sp^2 -hybridized
 (C) sp - and sp^2 hybridized (D) sp, sp^2 and sp^3 - hybridized
- Q.62 CO_2 has the same geometry as :
 (I) $HgCl_2$ (II) NO_2 (III) $SnCl_4$ (IV) C_2H_2
 (A) I and III (B) II and IV (C) I and IV (D) III and IV
- Q.63 Strongest bond is formed by the head on overlapping of :
 (A) $2s$ - and $2p$ - orbitals (B) $2p$ - and $2p$ - orbitals
 (C) $2s$ - and $2s$ - orbitals (D) All

- Q.64 The ratio of σ and π bonds in benzene is :
 (A) 2 (B) 6 (C) 4 (D) 8
- Q.65 The bond angle and hybridization in ether (CH_3OCH_3) is :
 (A) $106^\circ 51'$, sp^3 (B) $104^\circ 31'$, sp^3 (C) $109^\circ 28'$ sp^3 (D) None of these
- Q.66 The enolic form of acetone contains :
 (A) 9 sigma, 1 pi bond and 2 lone pairs (B) 8 sigma, 2 pi bond and 2 lone pairs
 (C) 10 sigma, 1 pi bond and 1 lone pairs (D) 9 sigma, 2 pi bond and 1 lone pairs
- Q.67 The shape of a molecule which has 3 bond pairs and one lone pair is :
 (A) Octahedral (B) Pyramidal (C) Triangular planar (D) Tetrahedral
- Q.68 which molecule is T shaped :
 (A) BeF_2 (B) BCl_3 (C) NH_3 (D) ClF_3
- Q.69 Maximum s-character is in bonds formed by () atom:
 (A) CH_4 (B) XeO_3 (C) XeO_6^{4-} (D) SF_4
- Q.70 Which of the following species is (are) isostructural with XeF_4 ?
 (A) ICl_4^- (B) I_5^- (C) BrF_4^- (D) XeO_4
- Q.71 A hydrazine molecule is split in NH_2^+ and NH_2^- ions. Which of the following statements is/are correct ?
 (A) NH_2^+ shows sp^2 - hybridisation whereas NH_2^- shows sp^3 - hybridisation
 (B) $Al(OH)_4^-$ has a regular tetrahedral geometry
 (C) sp^2 - hybridized orbitals have equal s- and p- character
 (D) Hybridized orbitals always form σ - bonds
- Q.72 There is change in the type of hybridisation when:
 (A) NH_3 combines with H^+ (B) AlH_3 combines with H^-
 (C) NH_3 forms NH_2^- (D) SiF_4 forms SiF_6^{2-}
- Q.73 Which of the following statement is/are correct
 (A) Hybridisation is the mixing of atomic orbitals prior to their combining into molecular orbitals :
 (B) sp^3d^2 - hybrid orbitals are at 90° to one another
 (C) sp^3d - hybrid orbitals are directed towards the corners of a regular tetrahedron
 (D) sp^3d^2 - hybrid orbitals are directed towards the corners of a regular octahedron
- Q.74 A σ -bond may form between two p_x orbitals containing one unpaired electron each when they approach each other appropriately along :
 (A) x - axis (B) y - axis (C) z - axis (D) any direction
- Q.75 Indicate the wrong statement :
 (A) A sigma bond has no free rotation around its axis
 (B) p-orbitals always have only sideways overlap
 (C) s-orbitals never form π - bonds
 (D) There can be more than one sigma bond between two atoms

- Q.76 sp^3 hybridisation is in :
 (A) AlH_4^- (B) CH_3^- (C) ClO_2^- (D) NH_2^-
- Q.77 Which of the following pairs is (are) isostructural?
 (A) SF_4 and SiF_4 (B) SF_6 and SiF_6^{2-} (C) SiF_6^{2-} and SeF_6^{2-} (D) XeO_6^{4-} and TeF_6^{2-}
- Q.78 Which of the following has (have) octahedral geometry :
 (A) $SbCl_6^-$ (B) $SnCl_6^{2-}$ (C) XeF_6 (D) IO_6^{5-}
- Q.79 Shape of NH_3 is very similar to :
 (A) SeO_3^{2-} (B) CH_3^- (C) BH_3 (D) CH_3^+
- Q.80 Which of the following have same shape as NH_2^+ ?
 (A) CO_2 (B) $SnCl_2$ (C) SO_2 (D) $BeCl_2$
- Q.81 Which of the following is (are) linear ?
 (A) I_3^- (B) I_3^+ (C) $PbCl_2$ (D) XeF_2
- Q.82 Which of the following species are linear ?
 (A) ICl_2^- (B) I_3^- (C) N_3^- (D) ClO_2
- Q.83 The structure of XeF_6 is:
 (A) pentagonal bipyramidal (B) distorted octahedral (C) capped octahedral (D) square pyramidal
- OTHER FORCES**
- Q.84 Which of the following models best describes the bonding within a layer of the graphite structure ?
 (A) metallic bonding (B) ionic bonding
 (C) non-metallic covalent bonding (D) van der Waals forces
- Q.85 The critical temperature of water is higher than that of O_2 because the H_2O molecule has :
 (A) fewer electrons than O_2 (B) two covalent bonds
 (C) V - shape (D) dipole moment
- Q.86 Ethanol has a higher boiling point than dimethyl ether though they have the same molecular weight. This is due to :
 (A) resonance (B) coordinate bonding (C) hydrogen bonding (D) ionic bonding
- Q.87 Arrange the following in order of decreasing boiling point :
 (I) *n*-Butane (II) *n*-Butanol (III) *n*-Butyl chloride (IV) Isobutane
 (A) IV > III > II > I (B) IV > II > III > I (C) I > II > III > IV (D) II > III > I > IV
- Q.88 Which of the following compounds would have significant intermolecular hydrogen bonding ?
 HF, CH_3OH, N_2O_4, CH_4
 (A) HF, N_2O_4 (B) HF, CH_4, CH_3OH (C) HF, CH_3OH (D) CH_3OH, CH_4
- Q.89 For H_2O_2, H_2S, H_2O and HF , the correct order of increasing extent of hydrogen bonding is :
 (A) $H_2O > HF > H_2O_2 > H_2S$ (B) $H_2O > HF > H_2S > H_2O_2$
 (C) $HF > H_2O > H_2O_2 > H_2S$ (D) $H_2O_2 > H_2O > HF > H_2S$

- Q.90 Iron is harder than sodium because
 (A) iron atoms are smaller (B) iron atoms are more closely packed
 (C) metallic bonds are stronger in sodium (D) metallic bonds are stronger in iron
- Q.91 Which one of the following does not have intermolecular H-bonding?
 (A) H_2O (B) *o*-nitro phenol (C) HF (D) CH_3COOH
- Q.92 The order of strength of hydrogen bonds is:
 (A) $CIH \dots Cl > NH \dots N > OH \dots O > FH \dots F$ (B) $CIH \dots Cl < NH \dots N < OH \dots O < FH \dots F$
 (C) $CIH \dots Cl < NH \dots N > OH \dots O > FH \dots F$ (D) $CIH \dots Cl < NH \dots N < OH \dots O > FH \dots F$
- Q.93 Which of the following exhibit/s H-bonding?
 (A) CH_4 (B) H_2Se (C) N_2H_4 (D) H_2S
- Q.94 Among the following, van der Waals forces are maximum in
 (A) HBr (B) LiBr (C) LiCl (D) AgBr
- Q.95 The H bond in solid HF can be best represented as:
 (A) $H - F \dots H - F \dots H - F$ (B) 
 (C) 
 (D) 
- Q.96 The volatility of HF is low because of :
 (A) its low polarizability (B) the weak dispersion interaction between the molecules
 (C) its small molecular mass (D) its strong hydrogen bonding
- Q.97 The melting point of AlF_3 is $104^\circ C$ and that of SiF_4 is $-77^\circ C$ (it sublimes) because :
 (A) there is a very large difference in the ionic character of the $Al - F$ and $Si - F$ bonds
 (B) in AlF_3 , Al^{3+} interacts very strongly with the neighbouring F^- ions to give a three dimensional structure but in SiF_4 no interaction is possible
 (C) the silicon ion in the tetrahedral SiF_4 molecule is not shielded effectively from the fluoride ions whereas in AlF_3 , the Al^{3+} ion is shielded on all sides
 (D) the attractive forces between the SiF_4 molecules are strong whereas those between the AlF_3 molecules are weak
- Q.98 Two ice cubes are pressed over each other and unite to form one cube. Which force is responsible for holding them together :
 (A) van der Waal's forces (B) Covalent attraction
 (C) Hydrogen bond formation (D) Dipole-dipole attraction
- Q.99 Intramolecular hydrogen bonding is found in :
 (A) Salicylaldehyde (B) Water (C) Acetaldehyde (D) Phenol
- Q.100 The pairs of bases in DNA are held together by :
 (A) Hydrogen bonds (B) Ionic bonds (C) Phosphate groups (D) Deoxyribose groups
- Q.101 In dry ice there are :
 (A) Ionic bond (B) Covalent bond (C) Hydrogen bond (D) None of these



- (A) has intermolecular H - bonding (B) has intramolecular H- bonding
(C) has low boiling point (D) is steam-volatile

Q.103 Which of the following bonds/forces is/are weakest?
(A) covalent bond (B) vander Waals force (C) hydrogen bond (D) london force

Q.104 Compare O–O bond energy among O_2 , H_2O_2 and O_3 with reasons.

Q.105 Which of the following is/are observed in metallic bonds ?
(A) Mobile valence electrons (B) Overlapping valence orbitals
(C) Highly directed bond (D) Delocalized electrons

Q.106 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.107 Which of the following are true ?
(A) Van der Waals forces are responsible for the formation of molecular crystals
(B) Branching lowers the boiling points of isomeric organic compounds due to van der Waals forces of attraction
(C) In graphite, van der Waals forces act between the carbon layers
(D) In diamond, van der Waals forces act between the carbon layers

Q.108 Intermolecular hydrogen bonding increases the enthalpy of vapourization 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.109 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

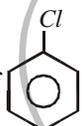
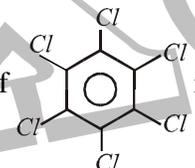
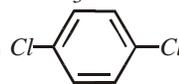
Q.110 Which of the following have dipole moment ?
(A) nitrobenzene (B) *p*-chloronitrobenzene
(C) *m*-dichlorobenzene (D) *o*-dichlorobenzene

Q.111 In which of the following compounds, breaking of covalent bond takes place?
(A) Boiling of H_2O (B) Melting of KCN (C) Boiling of CF_4 (D) Melting of SiO_2

MISCELLENEOUS

Q.112 Among KO_2 , AlO_2^- , BaO_2 and NO_2^+ unpaired electron is present in :
(A) KO_2 only (B) NO_2^+ and BaO_2 (C) KO_2 and AlO_2^- (D) BaO_2 only

Q.113 Cyanogen, $(CN)_2$, has a ____ shape/structure :
(A) Linear (B) Zig-zag (C) Square (D) Cyclic

- Q.114 In which of the following solvents, KI has highest solubility? The dielectric constant (ϵ) of each liquid is given in parentheses.
 (A) C_6H_6 ($\epsilon=0$) (B) $(CH_3)_2CO$ ($\epsilon=2$) (C) CH_3OH ($\epsilon=32$) (D) CCl_4 ($\epsilon=0$)
- Q.115 The formal charges on the three O-atoms in O_3 molecule are
 (A) 0, 0, 0 (B) 0, 0, -1 (C) 0, 0, +1 (D) 0, +1, -1
- Q.116 The types of bonds present in $CuSO_4 \cdot 5H_2O$ are
 (A) electrovalent and covalent (B) electrovalent and coordinate covalent
 (C) covalent and coordinate covalent (D) electrovalent, covalent and coordinate covalent
- Q.117 For which of the following crystalline substances does the solubility in water increase upto $32^\circ C$ and then decrease rapidly?
 (A) $CaCl_2 \cdot 2H_2O$ (B) $Na_2SO_4 \cdot 10H_2O$ (C) $FeSO_4 \cdot 7H_2O$ (D) Alums
- Q.118 Which of the following has been arranged in order of decreasing dipole moment?
 (A) $CH_3Cl > CH_3F > CH_3Br > CH_3I$ (B) $CH_3F > CH_3Cl > CH_3Br > CH_3I$
 (C) $CH_3Cl > CH_3Br > CH_3I > CH_3F$ (D) $CH_3F > CH_3Cl > CH_3I > CH_3Br$
- Q.119 Which of the following has the least dipole moment
 (A) NF_3 (B) CO_2 (C) SO_2 (D) NH_3
- Q.120 The experimental value of the dipole moment of HCl is $1.03 D$. The length of the $H-Cl$ bond is 1.275 \AA . The percentage of ionic character in HCl is:
 (A) 43 (B) 21 (C) 17 (D) 7
- Q.121 The dipole moment of  is $1.5 D$. The dipole moment of  is:
 (A) $0 D$ (B) $1.5 D$ (C) $2.86 D$ (D) $2.25 D$
- Q.122 In the cyanide ion the formal negative charge is on
 (A) C (B) N
 (C) Both C and N (D) Resonate between C and N
- Q.123 Which has (have) zero value of dipole moment?
 (A) $[Xe(CN)_4]^{2-}$ square planar (B) $CHCl_3$
 (C) CO_2 (D) 
- Q.124 Which of the following compounds possesses zero dipole moment?
 (A) Water (B) Benzene (C) Carbon tetrachloride (D) Boron trifluoride
- Q.125 Hypervalent compound is (are):
 (A) SO_3^{2-} (B) PO_4^{3-} (C) SO_4^{2-} (D) ClO_4^-

- Q.126 Which of the following statements are correct?
 (A) The crystal lattice of ice is mostly formed by covalent as well as hydrogen bonds
 (B) The density of water increases when heated from 0°C to 4°C due to the change in the structure of the cluster of water molecules
 (C) Above 4°C the thermal agitation of water molecules increases. Therefore, intermolecular distance increases and water starts expanding
 (D) The density of water increases from 0°C to a maximum at 4°C because the entropy of the system increases

BONDS ANGLES & BOND LENGTH

Q.127 The correct order of increasing $X-O-X$ bond angle is ($X = H, F$ or Cl) :

- (A) $H_2O > Cl_2O > F_2O$ (B) $Cl_2O > H_2O > F_2O$
 (C) $F_2O > Cl_2O > H_2O$ (D) $F_2O > H_2O > Cl_2O$

Q.128 Which of the following is true ?

- (A) Bond order $\propto \frac{1}{\text{bond length}} \propto \text{bond energy}$ (B) Bond order $\propto \text{bond length} \propto \frac{1}{\text{bond energy}}$
 (C) Bond order $\propto \frac{1}{\text{bond length}} \propto \frac{1}{\text{bond energy}}$ (D) Bond order $\propto \text{bond length} \propto \text{bond energy}$

Q.129 Which of the following has been arranged in order of decreasing bond length ?

- (A) $P-O > Cl-O > S-O$ (B) $P-O > S-O > Cl-O$
 (C) $S-O > Cl-O > P-O$ (D) $Cl-O > S-O > P-O$

Q.130 If a molecule MX_3 has zero dipole moment, the sigma bonding orbitals used by M (atm. no. < 21) are :

- (A) pure p (B) sp hybrid (C) sp^2 hybrid (D) sp^3 hybrid

Q.131 How many sigma and pi bonds are present in tetracyanoethylene ?

- (A) Nine σ and nine π (B) Five π and nine σ (C) Nine σ and seven π (D) Eight σ and eight π

Q.132 Among the following species, which has the minimum bond length ?

- (A) B_2 (B) C_2 (C) F_2 (D) O_2^-

Q.133 Which has higher bond energy :

- (A) F_2 (B) Cl_2 (C) Br_2 (D) I_2

Q.134 The bond angle in PH_3 is :

- (A) Much lesser than NH_3 (B) Equal to that in NH_3
 (C) Much greater than in NH_3 (D) Slightly more than in NH_3

Q.135 $H-B-H$ bond angle in BH_4^- is :

- (A) 180° (B) 120° (C) 109° (D) 90°

Q.136 In the series ethane, ethylene and acetylene, the $C-H$ bond energy is :

- (A) The same in all the three compounds (B) Greatest in ethane
 (C) Greatest in ethylene (D) Greatest in acetylene

Q.137 Which one of the following compounds has bond angle as nearly 90° ?

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

- Q.138 **State whether each statement is true or false. If false, write the correct statement.**
- The polarising power of a cation is directly proportional to its charge.
 - The polarising power of a cation is directly proportional to its size.
 - The polarisability of an anion is directly proportional to its charge.
 - The polarisability of an anion is directly proportional to its size.
 - For a given anion, greater the polarising power of the cation, more the ionic character.
 - For a given cation, greater the polarisability of the anion, more the covalent character.
 - An element with low ionization potential is most likely to form a covalent bond with an other element having a high electron affinity.
 - Ionic interactions are stronger than covalent bonds.
 - Two non-metal atoms are likely to form covalent bonds on combination.
 - Ionic interactions are directional.

Q.139 **State whether each statements is T or F, if F rectify.**

- All diatomic molecules are non-polar.
- All molecules having polar bonds are polar (i.e., have a net dipole)
- The lone pairs of electrons do not contribute to the net dipole of a molecule.
- The CH_2Cl_2 molecule may be polar or nonpolar depending on its geometry.
- The net dipole in the water molecule is the resultant of its bond dipoles.
- SO_2 is polar whereas CO_2 is non-polar.
- NH_3 is less polar than NF_3 .
- If all bonds in a molecule are polar, the molecule as a whole must be polar.

Q.140 **Fill in the blanks.**

- π -bonds are formed by the lateral overlap of a p-orbital with another _____ orbital.
- Free rotation is possible if two atoms are bonded together only by a _____ bond.
- The maximum number of σ bonds that can be formed between two atoms is _____.
- The repulsion between _____ is greater than the repulsion between two bonded pairs
- A lone pair is _____ polarisable compared to a σ bonded pair which in turn is _____ polarisable compared to a π - bonded pair.
- In nitro benzene the total number of bonded electrons equals _____.

Q.141 AgNO_3 gives a white precipitate with NaCl but not with CCl_4 . Why ?

Q.142 Using *VSEPR* theory identify the type of hybridisation and draw the structure of OF_2 .

Q.143 What should be the structure 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.144 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.145 In the hydrides of group VI elements the central atoms involve sp^3 hybridisation but the bond angles decrease in the order, H_2O , H_2S , H_2Si , H_2Te . How would you account for this ?

- Q.146 Assuming that all the four valency of carbon atom in propane pointing towards the corners of a regular tetrahedron. Calculate the distance between the terminal carbon atoms in propane. Given, $C - C$ single bond length is 1.54 \AA .
- Q.147 The dipole moment of HBr is 7.95 debye and the intermolecular separation is $1.94 \times 10^{-10} \text{ m}$. Find the % ionic character in HBr molecule.
- Q.148 HBr has dipole moment $2.6 \times 10^{-30} \text{ cm}$. If the ionic character of the bond is 11.5% , calculate the interatomic spacing.
- Q.149 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 0.156 pm .
- Q.150 A diatomic molecule has a dipole moment of $1.2 D$. If bond length is 1.0 \AA , what percentage of an electronic charge exists on each atom.

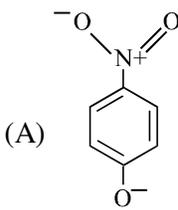
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EXERCISE - II

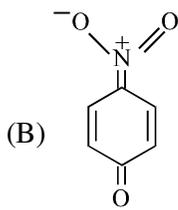
Choose the correct alternative (only one correct answer).

- Q.1 The bond between carbon atom(1) & carbon atom(2) in compound
 $N \equiv \underset{1}{C} - \underset{2}{C}H = CH_2$ involves the hybrids as : [JEE '87]
(A) sp^2 & sp^2 (B) sp^3 & sp (C) sp & sp^2 (D) sp & sp
- Q.2 Hydrogen bonding is maximum in [JEE '87]
(A) Ethanol (B) Diethylether (C) Ethylchloride (D) Triethylamine
- Q.3 The species which the central atom uses sp^2 hybrid orbitals in its bonding is [JEE '88]
(A) PH_3 (B) NH_3 (C) CH_3^+ (D) SbH_3
- Q.4 The molecule that has linear structure is [JEE '88]
(A) CO_2 (B) NO_2 (C) SO_2 (D) SiO_2
- Q.5 The compound which has zero dipole moment is [JEE '89]
(A) CH_2Cl_2 (B) BF_3 (C) NF_3 (D) ClO_2
- Q.6 Which of the following is paramagnetic [JEE '89]
(A) O_2^- (B) CN^- (C) CO (D) NO^+
- Q.7 The molecule which has pyramidal shape is [JEE '89]
(A) PCl_3 (B) SO_3 (C) CO_3^{2-} (D) NO_3^-
- Q.8 The compound in which C uses its sp^3 hybrid orbitals for bond formation is : [JEE '89]
(A) $H\overset{*}{C}OOH$ (B) $(H_2N)\overset{*}{C}O$ (C) $(CH_3)_3\overset{*}{C}OH$ (D) $CH_3\overset{*}{C}HO$
- Q.9 The C - H bond distance is the longest in [JEE '89]
(A) C_2H_2 (B) C_2H_4 (C) C_2H_6 (D) $C_2H_2Br_2$
- Q.10 Which one of the following is the smallest in size [JEE '89]
(A) N^{3-} (B) O^{2-} (C) F^- (D) Na^+
- Q.11 The number of sigma and pi bonds in 1-butene-3-yne are [JEE '89]
(A) 5 sigma 5 pi (B) 7 sigma 3 pi (C) 8 sigma 2 pi (D) 6 sigma 4 pi
- Q.12 Amongst the following the one having highest I.E. is [JEE '90]
(A) $[Ne] 3s^2 3p^1$ (B) $[Ne] 3s^2 3p^3$ (C) $[Ne] 3s^2 3p^2$ (D) $[Ar] 3d^0 4s^2 4p^3$
- Q.13 The hybridisation of C atoms in C - C single bond of $HC \equiv C - CH = CH_2$ is [JEE '91]
(A) $sp^3 - sp^3$ (B) $sp^2 - sp^3$ (C) $sp - sp^2$ (D) $sp^3 - sp$
- Q.14 The type of hybrid orbitals used by the chlorine atom in ClO_2^- is [JEE '92]
(A) sp^3 (B) sp^2 (C) sp (D) none
- Q.15 The CN^- & N_2 are isoelectronic. But in contrast to CN^- , N_2 is chemically inert because of [JEE '92]
(A) Low bond energy
(B) Absence of bond polarity
(C) Unsymmetrical electron distribution
(D) Presence of more number of electron in bonding orbitals.

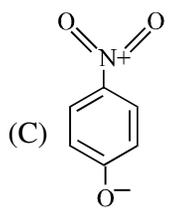
- Q.16 The maximum possible number of hydrogen bonds a water molecule can form is [JEE '92]
 (A) 2 (B) 4 (C) 3 (D) 1
- Q.17 Pick out the isoelectronic structures from the following [JEE '93]
 I. CH_3^+ II. H_3O^+ III. NH_3 IV. CH_3^-
 (A) I and II (B) III and IV (C) I and III (D) II, III and IV
- Q.18 The number of electrons that are paired in oxygen molecule is [JEE '95]
 (A) 7 (B) 8 (C) 16 (D) 14
- Q.19 Allyl isocyanide has [JEE '95]
 (A) 9s, 4p bonds (B) 9s, 3p bonds and 2 non-bonding electrons
 (C) 8s, 5p bonds (D) 8s, 3p bonds and 4 non-bonding electrons
- Q.20 The order of increasing thermal stabilities of K_2CO_3 (I), MgCO_3 (II), CaCO_3 (III), BaCO_3 (IV) is [JEE '96]
 (A) $\text{II} < \text{III} < \text{IV} < \text{I}$ (B) $\text{IV} < \text{II} < \text{III} < \text{I}$ (C) $\text{IV} < \text{II} < \text{I} < \text{III}$ (D) $\text{II} < \text{IV} < \text{III} < \text{I}$
- Q.21 Identify isostructural pairs from NF_3 (I), NO_3^- (II), BF_3 (III), H_3O^+ (IV), HN_3 (V) [JEE '96]
 (A) I & II, III & IV (B) I & V, II & III (C) I & IV, II & III (D) I & IV, III & V
- Q.22 (i) The number and type of bonds between two C-atom in CaC_2 are [JEE '96]
 (A) 1 sigma 1 pi (B) 1 sigma 2 pi (C) 1 sigma, $\frac{1}{2}$ pi (D) 1 sigma
- Q.23 Which is correct for CsBr_3 ? [JEE '96]
 (A) it is a covalent compound (B) it contains Cs^{3+} & Br^- ions
 (C) it contains Cs^+ & Br_3^- ions (D) it contains Cs^+ , Br^- & lattice Br_2 molecule
- Q.24 Among KO_2 , AlO_2^- , BaO_2 & NO_2^+ unpaired electron is present in [JEE '97]
 (A) NO_2^+ & BaO_2 (B) KO_2 & AlO_2^- (C) KO_2 only (D) BaO_2 only
- Q.25 Which of the following has maximum number of unpaired electrons? [JEE '96]
 (A) Mg^{2+} (B) Ti^{3+} (C) V^{3+} (D) Fe^{2+}
- Q.26 KF combines with HF to form KHF_2 . The compound contains the species [JEE '97]
 (A) K^+ , F^- and H^+ (B) K^+ , F^- and HF (C) K^+ and $[\text{HF}_2]^-$ (D) $[\text{KHF}]^+$ and F^-
- Q.27 Among the following compounds the one that is polar and has the central atom with sp^2 hybridisation is [JEE '97]
 (A) H_2CO_3 (B) SiF_4 (C) BF_3 (D) HClO_2
- Q.28 Which contains both polar & non polar covalent bonds [JEE '97]
 (A) NH_4Cl (B) HCN (C) H_2O_2 (D) CH_4
- Q.29 The type of hybrid orbitals used by the chlorine atom in ClO_3^- is [JEE '97]
 (A) sp^3 (B) sp^3d (C) sp^3d^2 (D) sp^2
- Q.30 Hybridisation seen in cation of solid PCl_5 [JEE '97]
 (A) sp^3d (B) sp^3 (C) sp^3d^2 (D) sp

- Q.31 What type of hybridisation and how many lone pair of electrons are present in the species I_3^- on the central atom. [JEE '97]
 (A) sp^2 one lone pair (B) sp^3d three lone pair (C) sp three lone pair (D) sp no lone pair
- Q.32 In which of the following the central atom does not use sp^3 hybrid orbitals in its bonding? [JEE '97]
 (A) BeF_3^- (B) OH_3^+ (C) NH_2^- (D) NF_3
- Q.33 The structure of IBr_2^- involves hybridisation of the type. [JEE '97]
 (A) sp^3d (B) sp^3d^2 (C) dsp^3 (D) d^2sp^3
- Q.34 The maximum angle around the central atom H-M-H is present in [JEE '97]
 (A) AsH_3 (B) PH_3 (C) NH_3 (D) SbH_3
- Q.35 Which one of the following molecules is planar : [JEE '97]
 (A) NF_3 (B) NCl_3 (C) PH_3 (D) BF_3
- Q.36 Which one has sp^2 hybridisation [JEE '97]
 (A) CO_2 (B) SO_2 (C) N_2O (D) CO
- Q.37 The geometry & the type of hybrid orbitals present about the central atom in BF_3 is : [JEE '98]
 (A) linear, sp (B) trigonal planar, sp^2 (C) tetrahedral, sp^3 (D) pyramidal, sp^3
- Q.38 The correct order of increasing C - O bond length of, CO , CO_3^{2-} , CO_2 is [JEE '99]
 (A) $CO_3^{2-} < CO_2 < CO$ (B) $CO_2 < CO_3^{2-} < CO$
 (C) $CO < CO_3^{2-} < CO_2$ (D) $CO < CO_2 < CO_3^{2-}$
- Q.39 In the dichromate anion [JEE '99]
 (A) 4 Cr - O bonds are equivalent (B) 6 Cr - O bonds are equivalent
 (C) all Cr - O bonds are equivalent (D) all Cr - O bonds are non equivalent
- Q.40 The geometry of H_2S and its dipole moment are [JEE '99]
 (A) angular & non zero (B) angular & zero
 (C) linear & non zero (D) linear & zero
- Q.41 In compounds type ECl_3 , where E = B, P, As or Bi, the angles Cl - E - Cl for different E are in the order [JEE '99]
 (A) $B > P = As = Bi$ (B) $B > P > As > Bi$ (C) $B < P = As = Bi$ (D) $B < P < As < Bi$
- Q.42 The most unlikely representation of resonance structure of p-nitrophenoxide is:
- 

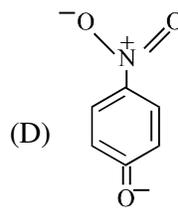
(A)



(B)



(C)



(D)
- Q.43 Amongst H_2O , H_2S , H_2Se and H_2Te , the one with the highest boiling point is [JEE 2000]
 (A) H_2O because of hydrogen bonding (B) H_2Te because of higher molecular weight
 (C) H_2S because of hydrogen bonding (D) H_2Se because of lower molecular weight

- Q.44 The hybridization of atomic orbitals of nitrogen in NO_2^+ , NO_3^- and NH_4^+ are [JEE 2000]
 (A) sp^2 , sp^3 and sp^2 respectively (B) sp , sp^2 and sp^3 respectively
 (C) sp^2 , sp and sp^3 respectively (D) sp^2 , sp^3 and sp respectively
- Q.45 Specify the coordination geometry around and hybridization of N and B atoms in a 1 : 1 complex of BF_3 and NH_3 [JEE 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.46 The nodal plane in the π -bond of ethene is located in [JEE 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 σ bond at right angle.
 (D) a plane perpendicular to the molecular plane which contains, the carbon-carbon bond.
- Q.47 Which of the following molecular species has unpaired electron(s)? [JEE 2002]
 (A) N_2 (B) F_2 (C) O_2^- (D) O_2^{2-}
- Q.48 Which of the following are isoelectronic and isostructural ? NO_3^- , CO_3^{2-} , ClO_3^- , SO_3 [JEE 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.49 Which species has the maximum number of lone pair of electrons on the central atom? [JEE 2005]
 (A) ClO_3^- (B) XeF_4 (C) SF_4 (D) I_3^-

Fill in the blanks.

- [12 × 2 = 24]
- Q.1 Silver chloride is sparingly soluble in water because its lattice energy is greater than _____ energy. [JEE '87]
- Q.2 _____ phosphorous is reactive because of its highly strained tetrahedral structure. [JEE '87]
- Q.3 The shape of CH_3^+ is _____. [JEE '90]
- Q.4 The valence atomic orbitals on C in silver acetylide is _____ hybridised. [JEE '90]
- Q.5 Amongst the three isomers of nitrophenol, the one that is least soluble in water is _____. [JEE '94]
- Q.6 The kind of delocalization involving sigma bond orbitals are called _____. [JEE '94]
- Q.7 The two types of bonds present in B_2H_6 are covalent & _____. [JEE '94]
- Q.8 When N_2 goes to N_2^+ , the N - N distance _____ & when O_2 goes to O_2^+ , the O - O bond distance _____. [JEE '96]
- Q.9 Among N_2O , SO_2 , I_3^+ & I_3^- , the linear species are _____ & _____. [JEE '97]
- Q.10 Among PCl_3 , CH_3^+ , NH_2^- & NF_3 , _____ is least relative towards water. [JEE '97]
- Q.11 The P - P - P angle in P_4 molecule is _____. [JEE '97]
- Q.12 Compounds that formally contain Pb^{4+} are easily reduced to Pb^{2+} . The stability of lower oxidation state is due to _____. [JEE '97]

- State whether true or false.** [16 × 2 = 32]
- Q.1 In benzene carbon uses all the three p-orbitals for hybridisation. [JEE '87]
- Q.2 sp^2 hybrid orbitals have equal S & P character . [JEE '87]
- Q.3 In group I A of alkali metals , the ionisation potential decreases down the group. Therefore lithium is a poor reducing agent . [JEE '87]
- Q.4 All the Al - Cl bond in Al_2Cl_6 are equivalent . [JEE '88]
- Q.5 Both potassium ferrocyanide & potassium ferricyanide are diamagnetic. [JEE '88]
- Q.6 The presence of polar bonds in a polyatomic molecule suggests that the molecule has non - zero dipole moment . [JEE '90]
- Q.7 Nitric oxide , though an odd electron molecule , is diamagnetic in liquid state. [JEE '91]
- Q.8 The decreasing order of EA of F, Cl, Br is $F > Cl > Br$. [JEE '93]
- Q.9 Diamond is harder than graphite . [JEE '93]
- Q.10 The basic nature of hydroxides of group 13 (III B) decreases progressively down the group. [JEE '93]
- Q.11 The tendency for catenation is much higher for C than Si. [JEE '93]
- Q.12 The dipole moment of CH_3F is greater than CH_3Cl . [JEE '93]
- Q.13 HBr is stronger acid than HI because of H-bonding. [JEE '97]
- Q.14 F atom has less negative EA than Cl atom. [JEE '97]
- Q.15 LiCl is predominantly a covalent compound. [JEE '97]
- Q.16 $Al(OH)_3$ is amphoteric in nature. [JEE '97]

Explain the following. [10 × 3 = 30]

- Q.1 Explain the molecule of magnesium chloride is linear whereas that of stannous chloride is angular. [JEE '87]
- Q.2 Give reason carbon oxygen bond lengths in formic acid are 1.23 \AA & 1.36 \AA and both the carbon oxygen bonds in sodium formate have the same value i.e. 1.27 \AA . [JEE '88]
- Q.3 Give reason that valency of oxygen is generally two whereas sulphur shows of 2 , 4 , & 6. [JEE '88]
- Q.4 Explain the first I.E. of carbon atom is greater than that of boron atom whereas the reverse is true for the second I.E. [JEE '89]
- Q.5 Explain why the dipole moment of NH_3 is more than that of NF_3 . [JEE '95]
- Q.6 The experimentally determined N - F bond length in NF_3 is greater than the sum of single bond covalent radii of N & F . Explain. [JEE '95]
- Q.7 Explain the difference in the nature of bonding in LiF & LiI. [JEE '96]
- Q.8 Explain PCl_5 is formed but NCl_5 cannot. [JEE '97]
- Q.9 Give reasons for the following in one or two sentences only. [JEE '99]
- (a) $BeCl_2$ can be easily hydrolysed (b) CrO_3 is an acid anhydride .
- Q.10 Explain why o-hydroxybenzaldehyde is a liquid at room temperature, while p-hydroxybenzaldehyde is a high melting solid. [JEE '99]

Arrange as directed.

- Q.1 N_2, O_2, F_2, Cl_2 in increasing order of bond dissociation energy. [9 × 2 = 18] [JEE '88]
- Q.2 $CO_2, N_2O_5, SiO_2, SO_3$ is the increasing order of acidic character. [JEE '88]
- Q.3 $HOCl, HOClO_2, HOClO_3, HOClO$ in increasing order of thermal stability. [JEE '88]
- Q.4 Increasing order of ionic size : $N^{3-}, Na^+, F^-, O^{2-}, Mg^{2+}$
- Q.5 Increasing strength of H-bonding . (X H - X) O, S, F, Cl, N .
- Q.6 Increasing order of extent of hydrolysis $CCl_4, MgCl_2, AlCl_3, PCl_5, SiCl_4$
- Q.7 Arrange in increasing order of dipole moment . [JEE '96]
Toluene, m-dichlorobenzene, o-dichlorobenzene, p-dichlorobenzene .
- Q.8 The decreasing order of acid strength of $ClOH, BrOH, IOH$. [JEE '97]
- Q.9 Arrange in order of increasing radii, $Li^+, Mg^{2+}, K^+, Al^{3+}$. [JEE '97]

Miscellaneous.

- Q.1 Write two resonance structures of ozone which satisfy the octet rule. [JEE '91]
- Q.2 Using VSEPR theory, identify the type of hybridisation & draw the structure of OF_2 . What are oxidation states of O & F. [JEE '94]
- Q.3 What are the types of bond present in B_2H_6 ? [IIT 1994]
- Q.4 Arrange toluene, m-dichlorobenzene, o-dichlorobenzene and p-dichlorobenzene in order of increasing dipole moment. [IIT 1996]
- Q.5 Draw the structures of [JEE '97]
(i) XeF_2 (ii) XeO_3 (iii) XeF_4 (iv) BrF_5 (v) SO_3^{2-}
- Q.6 Interpret the non-linear shape of H_2S molecule & non planar shape of PCl_3 using VSEPR theory. [JEE '98]
- Q.7 Discuss the hybridisation of C - atoms in allene (C_3H_4) and show the π - orbital overlaps. [JEE '99]
- Q.8 Using VSEPR theory, draw the shape of PCl_5 and BrF_5 . [JEE 2003]
- Q.9 Draw the structure of XeF_4 and OSF_4 according to VSEPR theory, clearly indicating the state of hybridisation of the central atom and lone pair of electrons (if any) on the central atom. [JEE 2004]

ANSWER KEY

EXERCISE - I

Q.1	C	Q.2	B	Q.3	A	Q.4	C	Q.5	D
Q.6	B	Q.7	D	Q.8	A,B,C,D	Q.9	A,B,C,D	Q.10	D
Q.11	A	Q.12	C	Q.13	B,C,D	Q.14	C	Q.15	A,C
Q.16	C	Q.17	D	Q.18	D	Q.19	B	Q.20	A
Q.21	D	Q.22	A,B	Q.23	A,C	Q.24	B,C	Q.25	A,B
Q.26	A,B,C	Q.27	B	Q.28	D	Q.29	C	Q.30	B,C,D
Q.31	D	Q.32	A	Q.33	D	Q.34	D	Q.35	C
Q.36	A,C	Q.37	A,B,C	Q.38	A,B	Q.39	B,C,D	Q.40	B,C,D
Q.41	A,B,C,D	Q.42	A,E	Q.43	A,C	Q.44	A	Q.45	D
Q.46	C	Q.47	B	Q.48	C	Q.49	B	Q.50	C
Q.51	A	Q.52	C	Q.53	C	Q.54	D	Q.55	B
Q.56	A	Q.57	A	Q.58	A	Q.59	B	Q.60	A
Q.61	C	Q.62	C	Q.63	B	Q.64	C	Q.65	C
Q.66	A	Q.67	B	Q.68	D	Q.69	A	Q.70	A,C,D
Q.71	A,B,D	Q.72	B,D	Q.73	A,B	Q.74	A	Q.75	A,B
Q.76	A,B,C,D	Q.77	B	Q.78	A,B,D	Q.79	A,B	Q.80	B,C
Q.81	A,D	Q.82	A,B,C	Q.83	C	Q.84	C	Q.85	D
Q.86	C	Q.87	D	Q.88	C	Q.89	C	Q.90	D
Q.91	B	Q.92	B	Q.93	C	Q.94	D	Q.95	C
Q.96	D	Q.97	B	Q.98	C	Q.99	A	Q.100	A
Q.101	B	Q.102	B,C,D	Q.103	B,D	Q.104	$O_2 > O_3 > H_2O_2$		
Q.105	A,D	Q.106	A,B,C	Q.107	A,B	Q.108	B	Q.113	A
Q.109	A,B,C,D	Q.110	A,B,C,D	Q.111	D	Q.112	A	Q.118	A
Q.114	C	Q.115	D	Q.116	D	Q.117	B	Q.123	A,C,D
Q.119	B	Q.120	C	Q.121	A	Q.122	D	Q.128	A
Q.124	B,C,D	Q.125	B,C,D	Q.126	A,B,C,D	Q.127	B	Q.133	B
Q.129	B	Q.130	C	Q.131	A	Q.132	B		
Q.134	A	Q.135	C	Q.136	D	Q.137	B,D		
Q.138	T, F, T, T, F, F, F, T, T, F			Q.139	F, F, F, F, T, T, F, F				
Q.140	(i) p-orbital, (ii) σ -bond, (iii) 1, (iv) LP-LP & LP-BP, (v) more, less, (vi) 36								
Q.143	(a) Linear, (b) square planar, (c) T.B.P. (d) bent, (e) linear, (f) bent								
Q.144	1.2 Å	Q.146	2.33 Å	Q.147	85%	Q.148	1.4 Å		
Q.149	84.5%	Q.150	25%						

EXERCISE - II

Q.1	C	Q.2	A	Q.3	C	Q.4	A	Q.5	B	Q.6	A	Q.7	A
Q.8	C	Q.9	C	Q.10	D	Q.11	B	Q.12	B	Q.13	C	Q.14	A
Q.15	B	Q.16	B	Q.17	D	Q.18	D	Q.19	A	Q.21	C	Q.22	B
Q.23	C	Q.24	C	Q.25	D	Q.26	C	Q.27	A	Q.28	A	Q.29	A
Q.30	B	Q.31	B	Q.32	A	Q.33	B	Q.34	C	Q.35	D	Q.36	B
Q.37	B	Q.38	D	Q.39	B	Q.40	A	Q.41	B	Q.42	C	Q.43	A
Q.44	B	Q.45	A	Q.46	A	Q.47	C	Q.48	A	Q.49	D		

Fill in the blanks.

Q.1	hydration	Q.2	white	Q.3	trigonal planar	Q.4	sp
Q.5	ortho	Q.7	banana	Q.8	increases, decreases		
Q.9	N_2O, I_3^-	Q.10	NH_2^-	Q.11	60°	Q.12	inert pair effect

State whether true or false.

Q.1	F	Q.2	F	Q.3	F	Q.4	F	Q.5	F	Q.6	F	Q.7	T
Q.8	F	Q.9	T	Q.10	F	Q.11	T	Q.12	F	Q.13	F	Q.14	T
Q.15	T	Q.16	T										

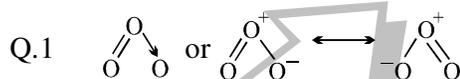
Explain the following.

Q.1	Lone pair	Q.2	Resonance	Q.3	expansion of octet
Q.5	Lone pair contribution	Q.7	LiF → Ionic charge, LiI → covalent charge		
Q.8	d-orbitals	Q.10	Intra-H-bonding in o-hydroxybenzaldehyde		

Arrange as directed.

Q.1	$F_2 < Cl_2 < O_2 < N_2$	Q.2	$SiO_2 < CO_2 < SO_3 < N_2O_5$
Q.3	$HClO < HClO_2 < HClO_3 < HClO_4$	Q.4	$Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$
Q.5	$S < Cl < N < O < F$		
Q.6	$CCl_4 < MgCl_2 < AlCl_3 < SiCl_4 < PCl_5$		
Q.7	p - dichlorobenzene < Toluene < m-dichlorobenzene < o-dichlorobenzene		
Q.8	$ClOH < BrOH < IOH$		
Q.9	$Li^+ < Al^{3+} < Mg^{2+} < K^+$		

Miscellaneous.



Q.5 (i) Linear, (ii) Pyramidal, (iii) Square planar, (iv) Square pyramidal, (v) pyramidal

