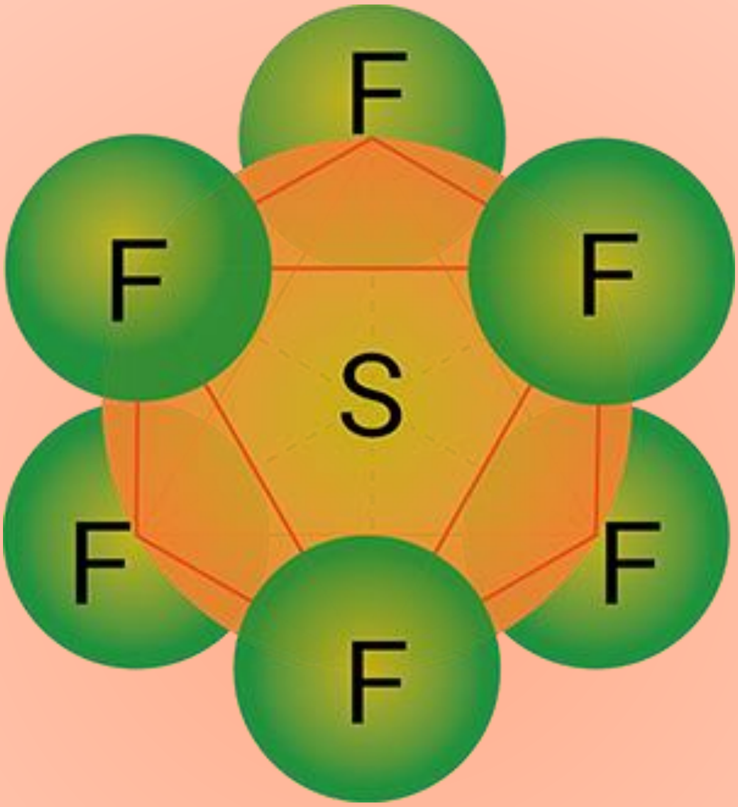
4. CHEMICAL BONDING AND MOLECULAR



Chemistry Smart Booklet
Theory + NCERT MCQs +Topicwise Practice
MCQs+ NEET PYQs

TYPES OF BONDS

IONIC/ELECTROVALENT BOND

- Strong electro static force of attraction between positive and negative ions.
- Crystalline in nature
- High M.P and B.P
- Soluble in Polar Solvents.

Eg: NaCl. $MgCl_2$ etc.

HYDROGEN BOND

- Bond formed when the -ve end of one molecule attracts the +ve end of other

1. Intermolecular: H-Bonding occur within one single molecule.
2. Intermolecular: H Bonding between two different molecules of same or diff. compounds.

CO-VALENT BOND

- Bond formed by mutual sharing of e-.
- Low M.P. and B.P.
- Bad conductor of electricityy
- Insoluble in Polar Solvents but soluble in non-polar solvent.

Ex: CH_4. H_2. Cl_2.

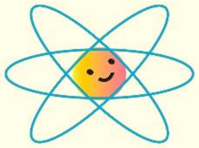
IONIC/ ELECTROVALENT BOND

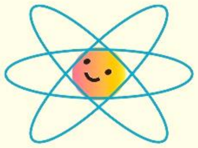
- Strong electro static force of attraction between positive and negative ions.
- Crystalline in nature
- High M.P and B.P
- Soluble in Polar Solvents.

Eg: NaCl. $MgCl_2$ etc.

TYPE OF CO-VALENT BOND

- Polar covalent bond
  Eg: NH_3. $CHCl_3$
- Non-polar covalent bond
  Eg: Cl_2. CO_2.

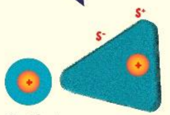




FAJAN'S RULE

No compounds is 100% ionic or 100% covalent

- Covalent nature ∝ Size of anion
- Covalent nature $\propto \frac{1}{\text{Size of cation}}$



Polarization of anion by cation

BOND PARAMETERS

FORMAL CHARGE

F.C. = r - L - $\frac{1}{2}$B

- Bond length: Equilibrium distance between the nuclei of two bonded atom

bod length $\propto \frac{1}{\text{bond order}}$

BOND ORDER — No. of Bond between the two atoms

&

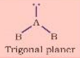
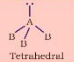
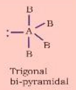
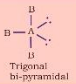
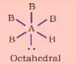
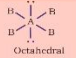
BOND ANGLE — Angle between the orbitals containing bonding e- pair around central atom.

BOND ENTHALPY — Amount of enrgy required to break one mole of bonds.

DIPOLE MOMENT — Product of the magnitude of the charge and distance between centres of positive and negative charge.

M = charge × Distance of seperation

CHEMICAL BONDING AND MOLECULAR STRUCTURE

Type of Molecule	No. of Bonding pair	No. of Lone Pair	Arrangement of e- pair	Shape	Example
AB_2E	2	1	 Trigonal planer	Bent	SO_2O_3
AB_3E	3	1	 Tetrahedral	Trigonal pyramidal	NH_3
AB_3E_2	2	2	 Tetrahedral	Bent	H_2O
AB_4E	4	1	 Trigonal bi-pyramidal	See saw	SF_4
AB_3E_2	3	2	 Trigonal bi-pyramidal	T-Shape	ClF_5
AB_5E	5	1	 Octahedral	Square pyramid	XeF_5
AB_4E_2	4	2	 Octahedral	Square Planner	XeF_4

THEORIES OF CO-VALENT BOND

KOSEL LEWIS APPROCH

KOSSEL LEWIS APPROACH

Atoms can combine either by transfer of e- or by sharing of valence e- in order to have an octet in their valence shell.

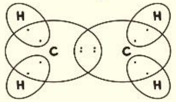
↓

Octet Rule

LEWIS SYMBOLS

Valence e- are represented by dots around the element.

H: Na: :C̈l : ·Ö· . :N:

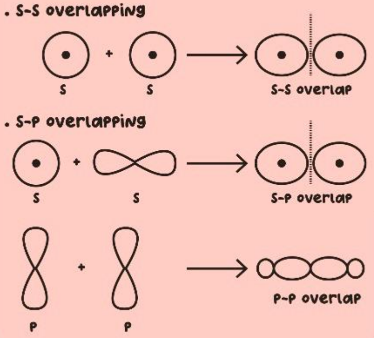


VALENCE BOND THEORY VBT

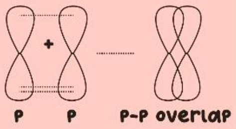
A covalent bond is formed by the overlapping of two half filled atomic orbitals.

Type of overlapping

Sigma(σ)
Sidewise overlapping



Pi(π)
Sidewise overlapping



Decreasing order of repulsive interaction:
lp - lp > lp - bp > bp . bp

VSEPR THEORY

The shape of a molecule depends upon the numbers of valence shell e^- (B.P or L.P) surrounding in the central atom

HYBRIDISATION

Concept of mixing atomic orbital to form new hybrid

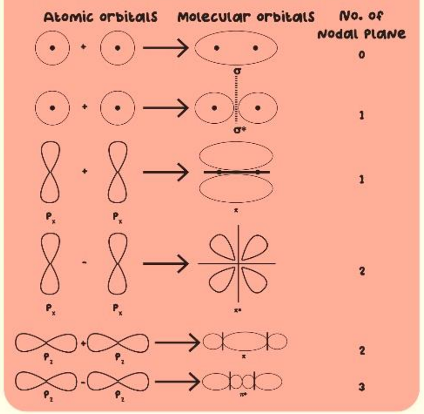
MOLECULAR ORBITAL THEORY

- MOT are formed the combinate of atomic orbitals.
- No. of molecular orbitals = No. of atomic orbital combined.

MOT

- Bonding molecular orbitals
- Anti bonding atomic orbitals

Formation of Molecular Orbitals



ELECTRONIC CONFIGURATION

<
$(\sigma 1S < \sigma^* 1S < \sigma 2S < \sigma^* 2S < \sigma 2P_z < (\pi 2P_x = \pi 2P_x)$
$< (\pi^* 2P_x = \pi^* 2P_y) < \sigma^* 2P_z$
(For O_2, F_2, Ne_2]

$(\sigma 1S < \sigma^* 1S < \sigma 2S < \sigma^* 2S < (\pi 2P_x = \pi 2P_y] < \sigma 2P_z)$
$< (\pi^* 2P_x = \pi^* 2P_y) < \sigma^* 2P_z$
(For B_2, C_2, N_2]

CHEMICAL BONDING AND MOLECULAR STRUCTURE

Introduction:

Structure and Bonding is the heart of chemistry. Chemical bond is very important to explain the properties and structure of compound. The important aspect of each type of force is its relative strength, how rapidly it decreases with increasing distance and whether it is directional in nature or not.

Chemical Bond:

It is the force of attraction between two atoms which hold them together in a compound or molecule. Nature loves stability and bond formation is associated with stability. Every element has a tendency to occupy inert electronic configuration which is considered as very stable. Noble gas electronic configuration can be achieved by

1. Transference of electrons
2. Mutual sharing of electrons
3. Donation of lone pair of electrons

Types of Bond

In order to explain the formation of a chemical bond in terms of electrons, Lewis postulated that atoms achieve stable octet when they are linked by a chemical bond. On the basis of this chemical bonds are following type:

1. Ionic bond
2. Covalent bond
3. Co-ordinate bond
4. Metallic bond
5. Hydrogen bond
6. van der Waal’s bond

Lewis Dot Structures

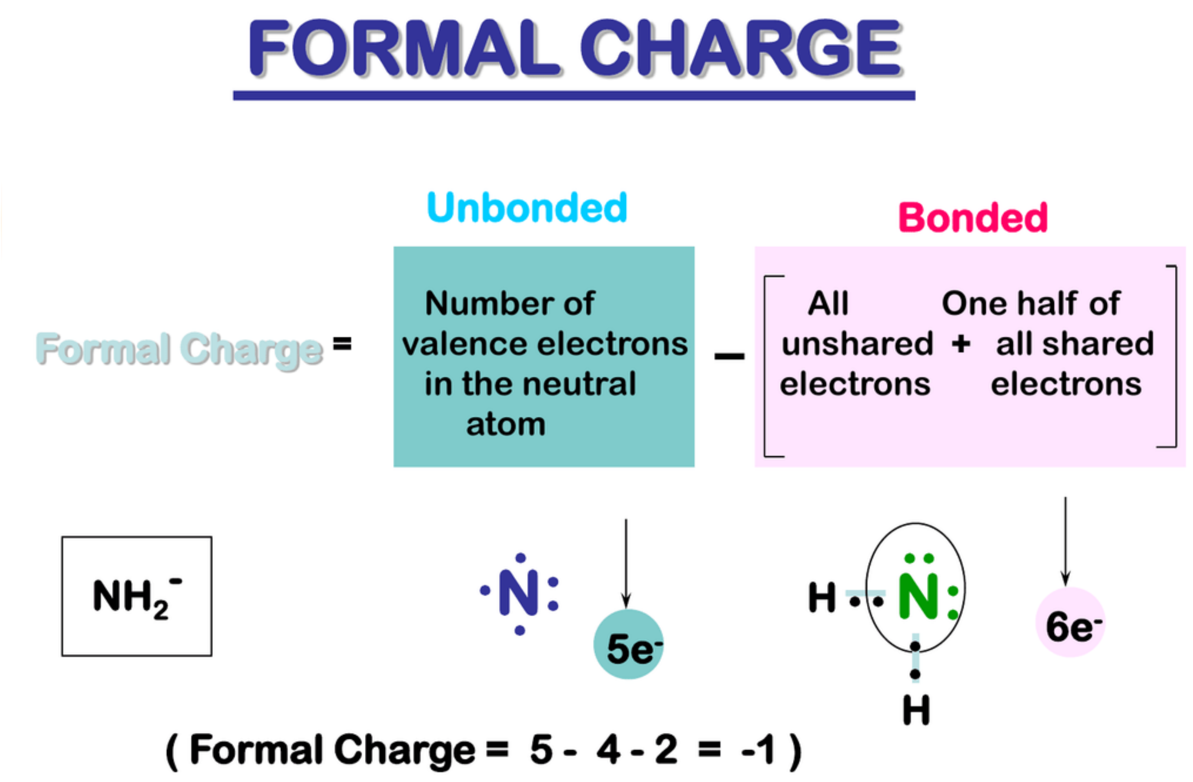
Valence Electrons: In the formation of a molecule only the outer shell electrons take part in chemical bond combination and they are known as valence electrons. In Lewis symbols, an element is shown with symbol and valence electrons.

Octet Rule

It is proposed by Kossel and Lewis and according to this, "Every atom has a tendency to attain Noble gas electronic configuration or to have 8 valence electrons". This is known as law of octet rule or if it has two valence electrons then this is known as law of duplet. According to Lewis, only those compounds will be stable which follow octet rule.

Formal Charge

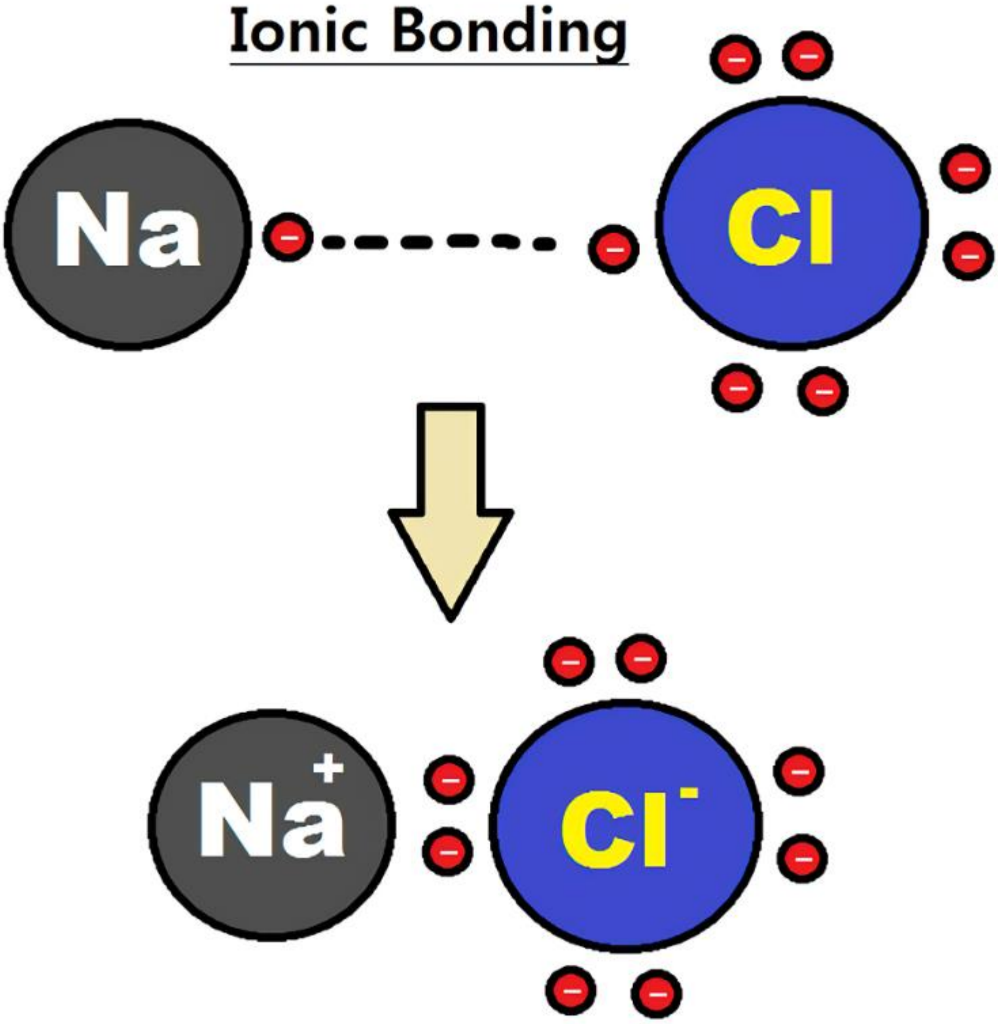
Formal charge on an atom is the difference between the number of valence electrons is an isolated atom and the number of electrons assigned to that atom in a Lewis structure. It is expressed as:



Ionic Bond

An ionic bond is formed by complete transference of one or more electrons from the valence shell of one atom to the valence shell of another atom. In this way both the atoms acquire stable electronic configurations of noble gases. The atom which loses electron becomes a positive ion and the atom which gains electron becomes negative ion.

Ionic Bonding



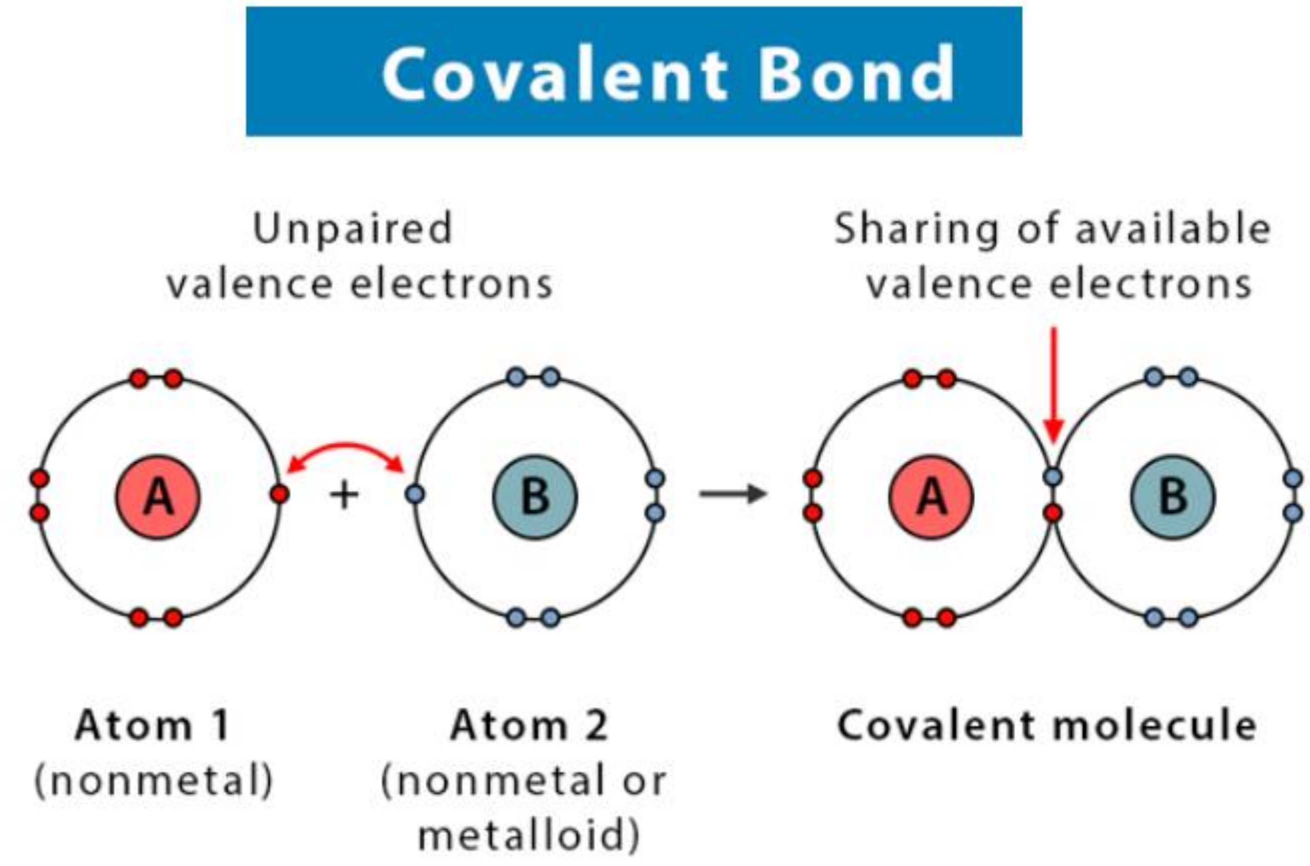
Note: Electrovalency is the number of electrons lost or gained during the formation of an ionic bond or electrovalent bond.

Characteristics of Ionic Compounds:

1. They are hard, brittle and crystalline.
2. They have high melting and boiling points.
3. They are polar in nature.
4. The linkage between oppositely charged ions is non rigid and non directional.
5. They are soluble in polar solvents such as water and insoluble in non polar solvents such as CCl_4, Benzene, ether etc.
6. They are good conductors of electricity in fused state and in solution due to mobility of the ions. They are bad conductors of electricity in solid state because ions are unable to move.

Covalent Bond

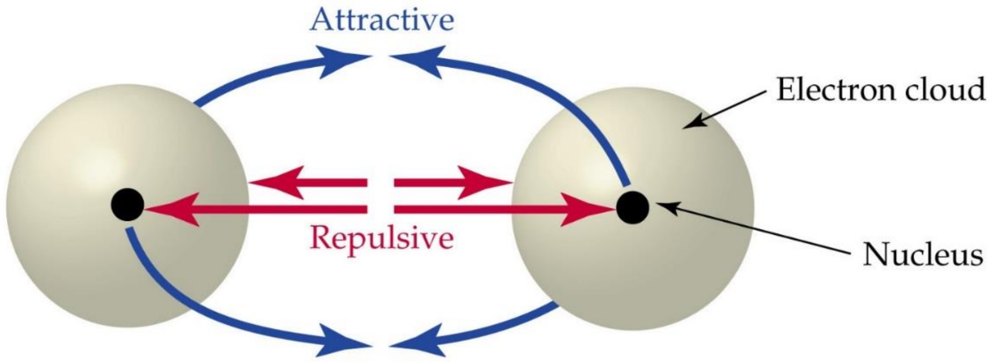
A force which binds atoms of same or different elements by mutual sharing of electrons is called a covalent bond. If the combining atoms are same the covalent molecule is known as homoatomic. If they are different, they are known as heteroatomic molecule.



Valence Bond Theory (VBT)

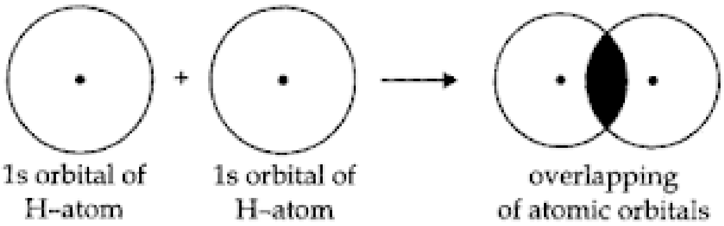
Valence bond theory was introduced by Heitler and London (1927) and developed by Pauling and others. It is based on the concept of atomic orbitals and the electronic configuration of the atoms. Let two hydrogen atoms A and B having their nuclei NA and NB and electrons present in them are eA and eB. As these two atoms come closer new attractive and repulsive forces begin to operate.

1. The nucleus of one atom is attracted towards its own electron and the electron of the other and vice versa.
2. Repulsive forces arise between the electrons of two atoms and nuclei of two atoms. Attractive forces tend to bring the two atoms closer whereas repulsive forces tend to push them apart.



Orbital overlap concept

If we refer to the minimum energy state in the formation of hydrogen molecule the two H-atoms are enough near so as to allow their atomic orbitals to undergo partial interpenetration. This partial interpenetration of atomic orbitals is called overlapping of atomic orbitals. The overlap between the atomic orbitals can be positive, negative or zero depending upon the characteristics of the orbitals participating to overlap.

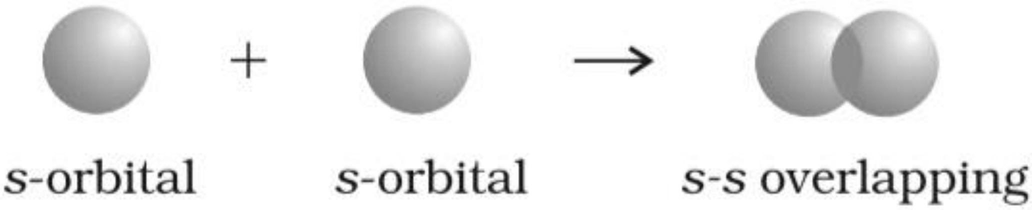


Types of overlapping

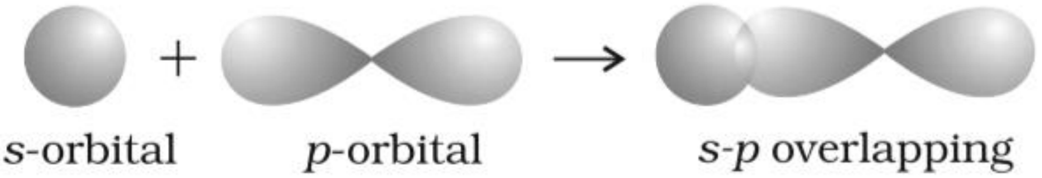
The covalent bonds can be classified into two different categories depending upon the type of overlapping. These are:

Sigma (σ) bond: This type of covalent bond is formed by the axial overlapping of half-filled atomic orbitals. The atomic orbitals overlap along the internuclear axis and involve end to end or head on overlap. There can be three type of axial overlap among s and p-orbitals as discussed below:

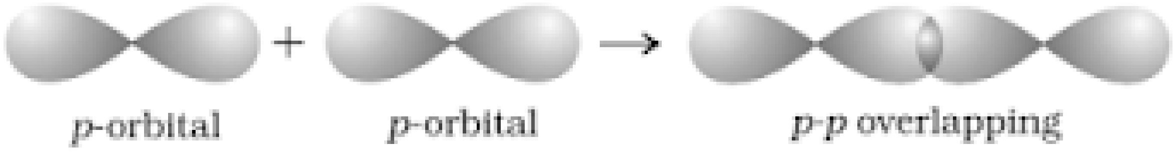
i. **s-s overlap:** In this case, there is overlap of two half-filled s-orbitals along the internuclear axis as shown below.



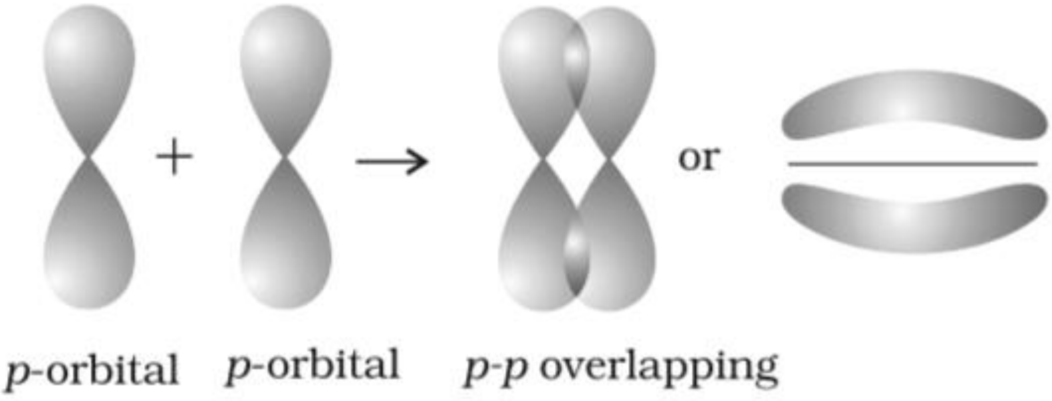
ii. **s-p overlapping:** It involves the overlapping of half filled s-orbitals of one atom with the half filled p-orbitals of the other atom. The bond thus formed is called s-p sigma bond.



iii. **p-p overlapping:** It involves the co-axial overlapping between half filled p-orbitals of one atom with half filled p-orbitals of the other atom. The bond as formed is called p-p sigma bond.



pi (π) bond: This type of covalent bond is formed when the atomic orbitals overlap in such a way that their axis remain parallel to each other and perpendicular to the internuclear axis. The orbitals formed due to sidewise overlapping consists of two saucer type charged clouds above and below the plane of the participating atoms. The electrons involved in the π bond formation are called pi-electrons.



Hybridisation: Hybridisation is the process of intermixing of the orbitals of slightly different energies so as to redistribute their energies, resulting in the formation of new set of orbitals of equivalent energies and shape. The atomic orbitals combine to form new set of equivalent orbitals known as hybrid orbitals.

Salient Features of Hybridisation:

i. The number of hybrid orbitals is equal to the number of the atomic orbitals that get hybridised.
ii. The hybridised orbitals are always equivalent in energy and shape.
iii. The hybrid orbitals are more effective in forming stable bonds than the pure atomic orbitals.
iv. The type of hybridisation indicates the geometry of the molecules.

Important conditions for hybridisation:

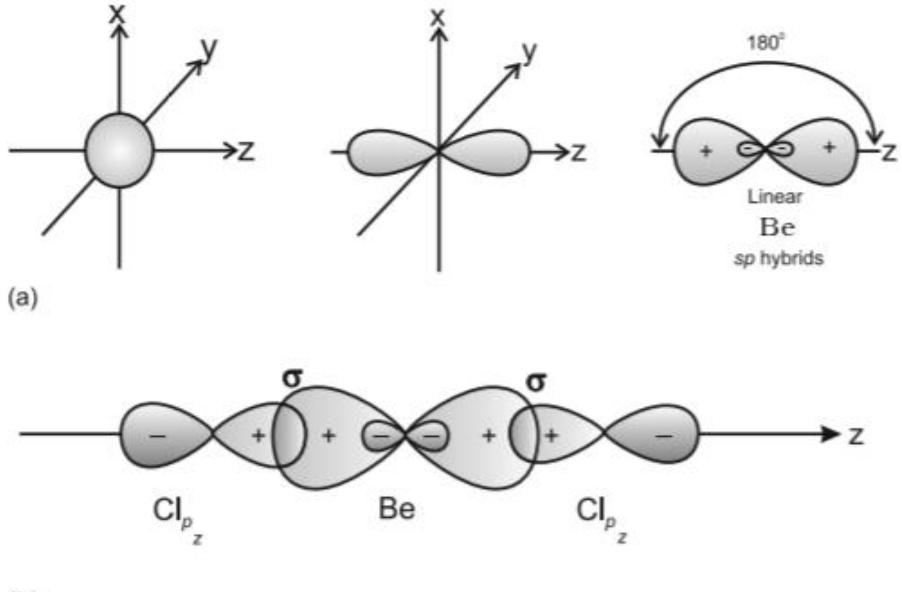
i. The orbitals present in the valence shell of the atom are hybridised.
ii. The orbitals taking part in hybridisation must have only a small difference of energies.
iii. Promotion of electron is not essential condition prior to hybridisation.
iv. It is not necessary that only half filled orbitals participate in hybridisation.

Types of hybridisation

There are many different types of hybridisation depending upon the type of orbitals involved in mixing such as sp^3, sp^2, sp, sp^3d, sp^3d^2 etc.

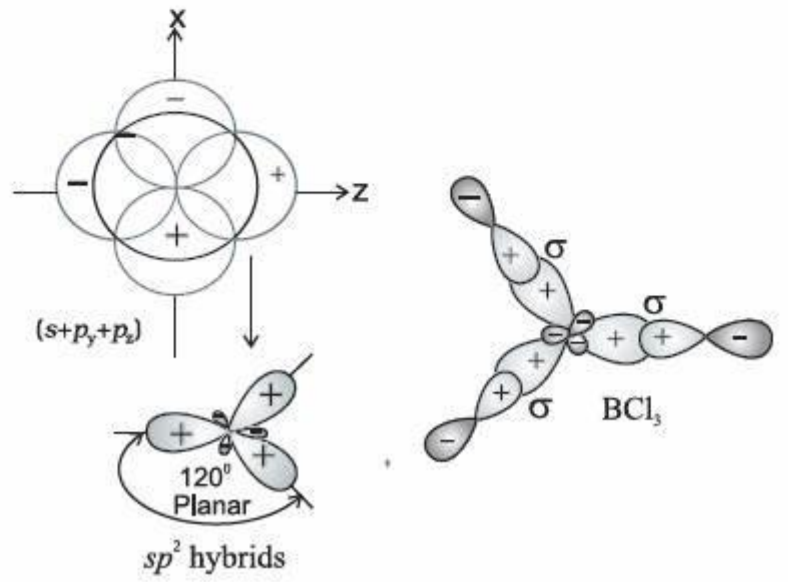
i. sp-hybridisation: In this hybridisation one s and one p orbitals hybridise to produce two equivalent hybrid orbitals, known as sp hybrid orbitals. The two sp-hybrid orbitals are oriented in a straight line making an angle of 180° and therefore the molecule possesses linear geometry. Each of hybrid orbitals has 50% s-character and 50% p-character.

Example of molecules having sp-hybridisation are BeF_2, $BeCl_2$, BeH_2 etc.



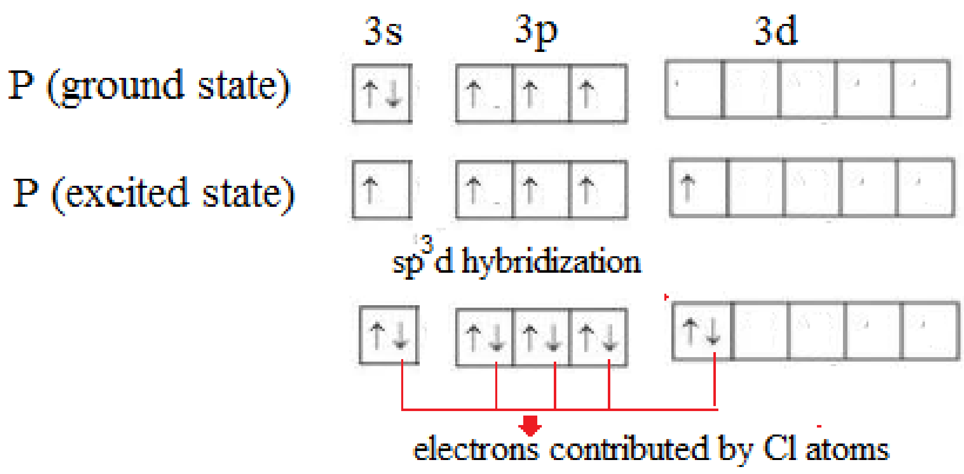
(b) $BeCl_2$ molecule

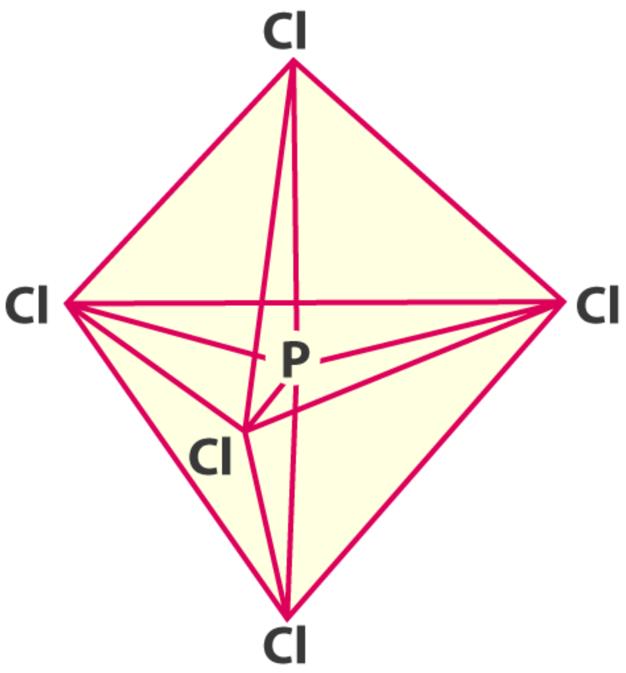
ii. **sp^2-hybridisation:** In this hybridisation one s and one 2p orbitals hybridise to produce three equivalent hybrid orbitals, known as sp^2 hybrid orbitals. sp^2 hybrid orbitals are larger in size than sp-hybrid orbitals but slightly smaller than that of sp^3 hybrid orbitals. Each sp^2 hybrid orbitals has 1/3 (or 33.33%) s-character and 2/3 (or 66.7%) p-character. Example, BF_3, BCl_3, BH_3 etc.



iii. **sp^3d-hybridisation:** This type of hybridisation involves mixing of one s, three p and one d-orbitals to form five sp^3d hybridised orbitals which adopt trigonal bipyramidal.

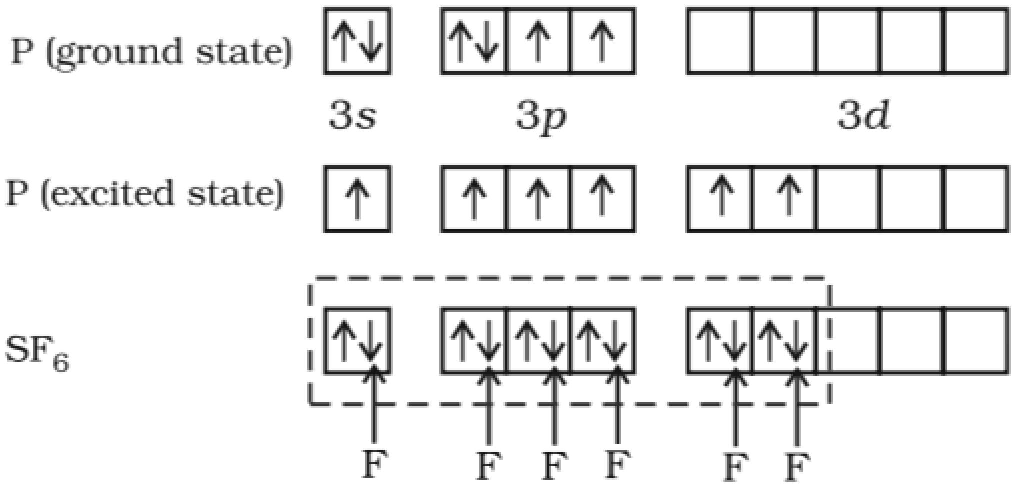
Formation of PCl_5: The ground state electronic configuration of phosphorus is $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^3$. Under the conditions of bond formation the 3s-electrons get unpaired and one of the electron is promoted to vacant $3dz^2$ orbital. The ground state and excited state configurations of phosphorus are shown below:



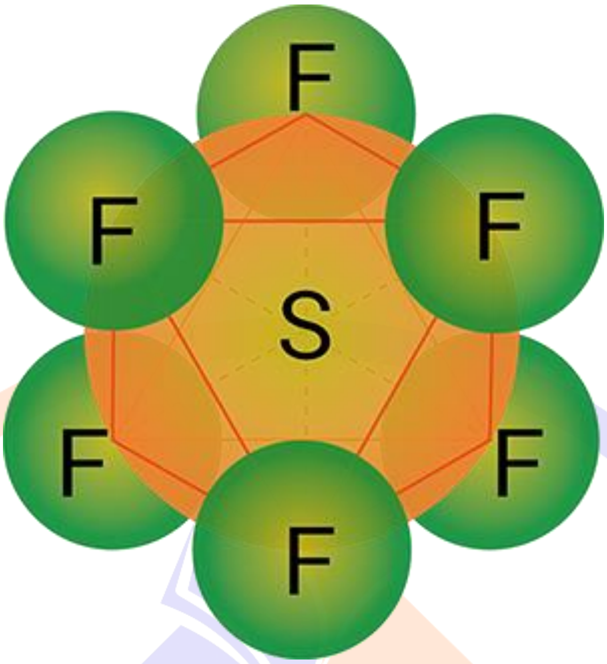


iv. **sp^3d^2-hybridisation:** In this type of hybridisation one s, three p and two d-orbitals undergo intermixing to form six identical sp^3d^2 hybrid orbitals. These six orbitals are directed towards the corners of an octahedron and lie in space at an angle of 90° to one another.

The ground state outer configuration of 16S is $3s^2$ $3p^4$. In the excited state the electron pairs in 3s and 3px orbitals get unpaired and one out of each pair is promoted to vacant $3dz^2$ and $3dx^2$-y^2 orbitals. The ground state and excited state configuration of 16S are given as follows:



sp^3d^2 hybridisation



Valence Shell Electron Pair Repulsion (VSEPR) Theory

Sidgwick and Powell in 1940, proposed a simple theory based on repulsive character of electron pairs in the valence shell of the atoms. It was further developed by Nyholm and Gillespie (1957). Main Postulates are the following:

i. The exact shape of molecule depends upon the number of electron pairs (bonded or non bonded) around the central atoms.

ii. The electron pairs have a tendency to repel each other since they exist around the central atom and the electron clouds are negatively charged.

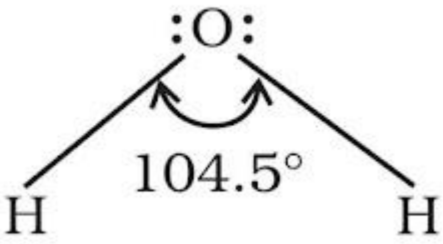
iii. Electron pairs try to take such position which can minimize the rupulsion between them.

iv. The valence shell is taken as a sphere with the electron pairs placed at maximum distance.

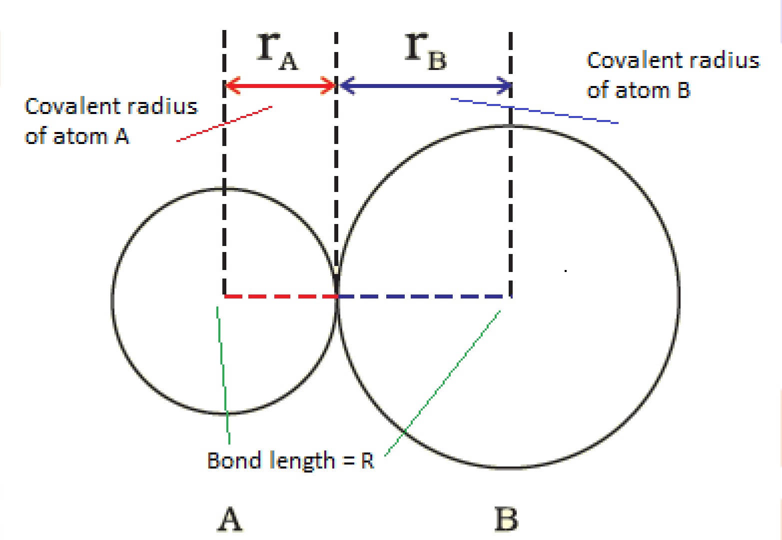
v. A multiple bond is treated as if it is a single electron pair and the electron pairs which constitute the bond as single pairs.

Bond Parameters:

i. **Bond Angle:** It is the distance between two consecutive crests or troughs and is denoted by λ. It is defined as the angle between the orbitals containing bonding electron pairs around the central atom in a molecule/complex ion. Bond angle is expressed in degree which can be experimentally determined by spectroscopic methods.



ii. **Bond Length:** Bond length is defined as the equilibrium distance between the nuclei of two bonded atoms in a molecule.



iii. **Lattice Enthalpy:** The Lattice Enthalpy of an ionic solid is defined as the energy required to completely separate one mole of a solid ionic compound into gaseous constituent ions. For example, the lattice enthalpy of NaCl is 788 kJ mol^{-1}.

iv. **Bond Order:** Bond order is defined as half of the difference between the number of electrons present in bonding and antibonding molecular orbitals. The bond order may be a whole number, a fraction or even zero. It may also be positive or negative.

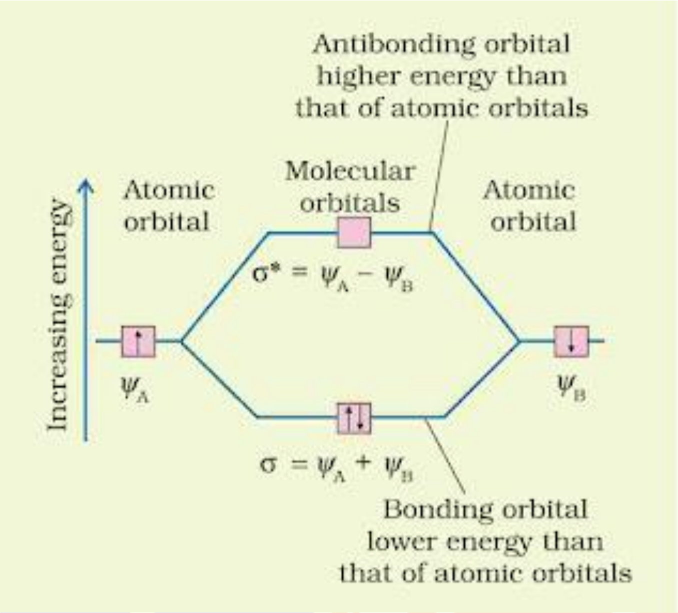
Bond order (B.O.) $= \frac{1}{2}\,[\mathbf{Nb} - \mathbf{Na}]$

v. **Bond Enthalpy:** It is defined as the amount of energy required to break one mole of bonds of a particular type between two atoms in a gaseous state. The unit of bond enthalpy is kJ mol–1. For example, the H – H bond enthalpy in hydrogen molecule is 435.8 kJ mol$^{-1.}$

Molecular Orbital Theory (MOT)

Molecular orbital (MO) theory was developed by F. Hund and R.S. Mulliken in 1932. According to MOT, a molecule is considered to be quite different from the constituent atoms. All the electrons belonging to the atoms constituting a molecule are considered to be moving along the entire molecule under the influence of all the nuclei. Thus, a molecule is supposed to have orbitals of varying energy levels, in same way as an atom. These orbitals are called molecular orbitals.

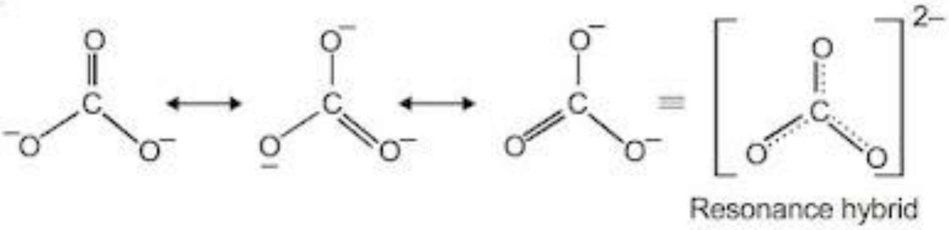
Energy Level Diagram for Molecular Orbitals:



Resonance

When light of a suitable frequency is allowed to incident on a metal, ejection of electrons take place. This phenomenon is known as photo electric effect.

When a compound has same molecular formula but different structural formulas and structures differ with respect to electrons only. These structures are known as resonating structures or canonical structures. None of these structures can explain all the properties of that compound. This phenomenon is known as resonance.



Hydrogen Bonding

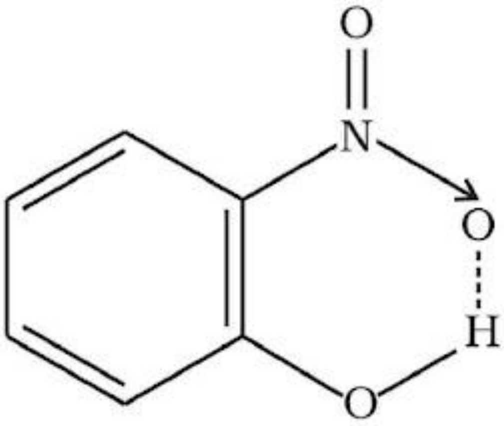
When highly electronegative elements like nitrogen, oxygen, flourine are attached to hydrogen to form covalent bond, the electrons of the covalent bond are shifted towards the more electronegative atom. Thus, partial positive charge develops on hydrogen atom which forms a bond with the other electronegative atom. This bond is known as hydrogen bond and it is weaker than the covalent bond.

Types of Hydrogen Bonding:

i. **There are two types of hydrogen bonding:** It is a type of hydrogen bonding between two similar or dissimilar molecules. Example : H – F, HF and water, NH_3, NH_3 and water, alcohol, alcohol and water etc.

$$H^{\delta+} - X^{\delta-} --- H^{\delta+} - X^{\delta-} --- H^{\delta+} - X^{\delta-}$$

ii. **Intramolecular hydrogen bonding:** It is a type of hydrogen bonding within the molecule. Example : Salicylaldehyde, O-nitrophenol etc.



Applications of Hydrogen Bonding

i. **State:** Hydrogen bonding may affect the state of a compound. For example, H_2O is liquid at room temperature whereas H_2S is gas. It is due to presence of intermolecular hydrogen bonding between H_2O molecules, which is not present in H_2S molecules.

ii. **Solubility:** Only those covalent molecules are soluble in water which have tendency to form intermolecular hydrogen bonding with water molecules.

iii. **Boiling point:** Intermolecular hydrogen bonding increases the boiling point of compound. For example, NH_3 has higher boiling point than PH_3. This is because, there is intermolecular hydrogen bonding in NH_3 but not in PH_3.

iv. **Density of ice is lower than water:** In ice, hydrogen bonding gives rise to a cage like structure of H–O–H molecules, in which each H–O–H molecule is linked tetrahedrally to four other H–O–H molecule. In this structure, some vacant spaces are formed, which decrease the density of ice.

Metallic Bonding

The force that binds a metal atom to a number of electrons within its sphere of influence is known as metallic bond.

This model could easily explain the following properties of metals:

i. High electrical conductivity
ii. High thermal conductivity
iii. Bright metallic lustre
iv. Malleability
v. Ductility
vi. Tensile strength
vii. Elasticity

Summary

1. **Chemical Bond:** The force of attraction which holds various chemical entities in different species.
2. Electrovalent Bond : The attractive force between the oppositely charged ions which comes into existence by the transference of electrons.
3. **Electrovalency:** The number of electrons which an atom loses or gains while forming ionic or electrovalent bond.
4. **Covalent Bond:** The bond comes into existence by the mutual sharing of electrons by the atoms participating in bonding.
5. **Valence Bond Approach of Covalent Bond:** The bond is formed by the overlapping of halffilled atomic orbitals having electrons with opposite spins.
6. **Covalency:** The number of half-filled atomic orbitals which an atom provides for participation in overlapping at the time of bonding.
7. **Dative Bond or Co-ordinate Bond:** The bond is formed by sharing of electrons in which the shared pair of electrons is contributed by one of the atom called donor while the other atom is called acceptor.
8. **Hybridisation:** The process of mixing or merging of orbitals (of slightly different energies) of an atom to form another set of orbitals with equivalent shape and energy.
9. **Geometry of the Molecule:** The definite relative arrangement of the bonded atoms in a molecule.
10. **Regular and Irregular Geometry:** The molecule is said to possess regular geometry if the repulsive interactions among the electron pair around the central atom are of equal magnitude. If the repulsive interactions among the electron pairs are unequal, the geometry is referred to as irregular.
11. **Electronegativity:** The power of an atom to attract bonding pair of electrons towards itself.

12. **Dipole Moment (μ):** A vector quantity defined by the product of charge developed on any of the atom and distance between the atoms; creating a dipole.
13. **Polar and Non-Polar Molecules:** The molecules with dipole moment (μ) > 0 are called polar molecules while those with μ = 0 are non-polar molecules.
14. **Dipole-Dipole Interactions:** The attractive interactions among the opposite ends of polar molecules in liquid and solid state.
15. **Hydrogen Bond:** The electrostatic force of attraction between covalently bonded H-atom of one molecule and the electronegative atom (F or N or O) of the other molecule.
16. **Resonance:** When a molecule is represented by more than one electronic arrangement none of which is able to explain the observed characteristics of the molecule, then the actual structure is intermediate of various electronic arrangements and is known as resonance hybrid. The various electronic arrangements are called resonating structures or canonical structure.
17. **Molecular Orbital Theory (MOT):** According to this theory, in molecules the electrons are present in new orbitals called molecular orbitals. Molecular orbitals are not associated with a particular atom but belong to nuclei of all the atoms constituting the molecule.
18. **LCAO Method:** This is an approximate method, according to which the molecular orbitals are obtained by linear combination of atomic orbitals.

NCERT LINE BY LINE QUESTIONS

04. CHEMICAL BONDING AND MOLECULAR STRUCTURE

(1.) Which of the following statements is correct regarding strength of sigma and pi bond **[Page: 117]**

(a.) Overlapping in sigma bond takes place in small extent.

(b.) Overlapping in pi bond takes place in large extent.

(c.) Overlapping in sigma bond takes place in large extent.

(d.) None of these

(2.) Some statements regarding dipole moment are given below. Identify the correct statements. **[Page: 108]**

(I) Dipole moment is usually expressed in Debye unit.
(II) It is a scalar quantity.
(III) It is the product of the magnitude of the charge and the distance between the centres of positive and negative charge.

(a.) I and II

(b.) II and III

(c.) I and III

(d.) I, II and III

(3.) If the electronic configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$, the four electrons involved in chemical bond formation will be **[NCERT Exemplar, Page: 105]**

(a.) $3p^6$

(b.) $3p^6, 4s^2$

(c.) $3p^6, 3d^2$

(d.) $3d^2, 4s^2$

(4.) Polarity in a molecule and hence the dipole moment depends primarily on electronegativity of the constituent atoms and shape of a molecule. Which of the following has the highest dipole moment) **[NCERT Exemplar, HOT, Page: 105]**

(a.) CO_2

(b.) HI

(c.) H_2O

(d.) SO_2

(5.) Match the xenon compound in column I with its structure in column II and assign the correct code. **[NEET-2019, HOT, Page: 120]**

Column I	Column II
(P) XeF_4	(i) Pyramidal
(Q) XeF_6	(ii) Square planar
(R) $XeOF_4$	(iii) Distorted octahedral
(S) XeO_3	(iv) Square pyramidal

(a.) P-(i), Q-(ii), R-(iii), S-(iv)

(b.) P-(ii), Q- (iii), R- (iv), S-(i)

(c.) P- (ii), O-- (iii), R-(i), S- (iv)

(d.) P- (iii), Q- (iv), R-(i), S- (ii)

(6.) The sum of lone pair of electrons present in the molecule of NH_3 and NF_3 is/are **[Page: 104]**

(a.) one

(b.) two

(c.) three

(d.) zero.

(7.) What is bond order of He_2 and O_2 respectively. **[Page: 126]**

(a.) 2 and 0

(b.) 2 and 2

(c.) 1 and 2

(d.) 0 and 2

(8.) Select the pair of molecules which has tetrahedral molecular geometry. **[Page: 111]**

(a.) PCl_5 and SF_6

(b.) CH_4 and NH_4^+

(c.) SP_4 and BrF_5

(d.) ClP_3 and H_2O

(9.) The bond angles of NH_3, CH_4 and H_2O molecules are **[Page: 110]**

(a.) $109.5^\circ, 107^\circ$ and 104.5° respectively.

(b.) $107^\circ, 109.5^\circ$ and 104.5° respectively.

(c.) $104.5^\circ, 107^\circ$ and 109.5° respectively.

(d.) $109.5^\circ, 104.5^\circ$ and 107° respectively.

(10.) Some statements regarding formal charge are given below. Identify the correct statement(s). **[Page: 100]**

(I) Formal charges do not indicate real charge separation within the molecule.

(II) Formal charges help in the selection of the lowest energy structure from a number of possible Lewis structures for a given species.

(III) In polyatomic ions, it is feasible to assign a formal charge on each atom.

(a.) I only

(b.) II and III

(c.) I and III

(d.) I, II and III

(11.) What is the factor responsible for the zero overlap? **[Page: 117]**

(a.) Out of phase due to different orientation direction of approach.

(b.) Out of phase due to same orientation direction of approach.

(c.) In phase due to different orientation direction of approach.

(d.) In phase due to same orientation direction of approach.

(12.) Select the pair of molecule which has the same type of hybridisation. **[Page: 118]**

(a.) BCl_3 and C_2H_6

(b.) C_2H_2 and $BeCl_2$

(c.) C_2H_4 and CH_4

(d.) NH_3 and C_2H_2

(13.) Which of the following statements is not correct from the viewpoint of molecular orbital theory. **[NCERT Exemplar, Page: 126]**

(a.) Be_2 is not a stable molecule.

(b.) He_2 is not stable but He_2^+ is expected to exist.

(c.) Bond strength of N_2 is maximum among the homonuclear diatomic molecules belonging to the second period.

(d.) The order of energies of molecular orbitals in N_2 molecules is

$$\sigma 2s < \sigma^* 2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < \left(\pi^* 2p_x = \pi^* 2p_y\right) < \sigma^* 2p_z$$

(14.) Identify the molecule which has one lone pair of electrons, tetrahedral geometry and trigonal pyramidal shape. **[Page: i i3]**

(a.) SP_4 (b.) BrP_5

(c.) PCl_5 (d.) NH_3

(15.) Select the correct statement. **[Page: 99]**

(a.) In NF_3 and CO_3^2 , nitrogen and fluorine are the central atoms whereas carbon and oxygen occupy the terminal positions.

(b.) In NF_3 and CO_3^2 , nitrogen and carbon are the central atoms whereas fluorine and oxygen occupy the terminal positions.

(c.) In NP_3 and CO_3^2 , fluorine and oxygen are the central atoms whereas nitrogen and carbon occupy the terminal positions.

(d.) In NF_3 and CO_3^2 , nitrogen and oxygen are the central atoms whereas fluorine and carbon occupy the terminal positions.

(16.) The direction of the C-H bond cannot be ascertained because **[Page: 116]**

(a.) the 2*s* orbital of carbon and the 1*s* orbital of H are spherically symmetrical and they can overlap in any direction.

(b.) the 1*s* orbital of carbon and the 2*s* orbital of H are spherically symmetrical and they can overlap in any direction.

(c.) the 1*s* orbital of carbon and the 1*s* orbital of H are spherically symmetrical and they can overlap in any direction.

(d.) the 2*s* orbital of carbon and the 2*s* orbital of H are spherically symmetrical and they can overlap in any direction.

(17.) Which of the following will be the strongest bond? **[Page: 103]**

(a.) $O-H$ (b.) $N-H$

(c.) $O-Cl$ (d.) $F-O$

(18.) Some statements regarding octet theory are given below. Identify the correct statement(s).**[Page: 99]**

(I) This theory does not account for the shape of molecules.
(II) It does not explain the relative stability of the molecules.
(III) This theory is totally silent about the energy of a molecule.

(a.) II only (b.) I and III

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

(19.) In *sp* hybridisation **[page: 118]**

(a.) 50% s – character and 50% %p – character

(b.) 25% s – character and 75% p – character

(c.) 75% s – character and 25% p – character

(d.) 40% s – character and 60% p – character

(20.) **Assertion:** O_2 molecule is paramagnetic while H_2 molecule is diamagnetic in nature.

Reason: Bond order of O_2 molecular is two while bond order of H_2 molecule is one. **[page: 126]**

(a.) Both A and R are true and R is the correct explanation of A.

(b.) Both A and R are true but R is not the correct explanation of A.

(c.) A is true but R is false.

(d.) Both A and R are false.

(21.) Some molecules are given below: **[Page: 111]** $SO_2, NH_3, H_2O, SP_4, ClP_3, BrP_5, XeF_4$

How many of them have two lone pair of electrons?

(a.) Two (b.) Three

(c.) Four (d.) Five

(22.) As per VSEPR theory, the pairs of electrons tend to occupy such position in space that **[page: 109]**

(a.) minimise repulsion and thus maximise distance between them.

(b.) maximise repulsion and thus maximise distance between them.

(c.) minimise repulsion and thus minimise distance between them.

(d.) maximise repulsion and thus minimise distance between them.

(23.) The molecular orbitals are filled in accordance with the **[Page: 122]**

(a.) aufbau principle. (b.) Pauli's exclusion principle.

(c.) Hund's rule. (d.) All of these.

(24.) N_a and N_b denoted for number of electrons present in antibonding and number of electrons present in bonding, then select correct option for stable molecule. **[page: 125]**

(a.) $N_b < N_a$ (b.) $N_a = N_b$

(c.) $N_a < N_b$ (d.) None of these

(25.) **Assertion:** In NH_3, N is sp^3 hybridised but bond angle is 107^o.

Reason: Shape of NH_3 molecule is trigonal pyramidal. **[Page: 110]**

(a.) Both A and R are true and R is the correct explanation of A.

(b.) Both A and R are true but R is nor the correct explanation of A.

(c.) A is true but R is false. (d.) Both A and R are false.

(26.) What is the bond angle in the molecule of $BeCl_2$ **[Page: 119]**

(a.) 60^o (b.) 90^o

(c.) 120^o (d.) 180^o

(27.) Overlapping of atomic orbitals depends upon **[Page: 114]**

(a.) the sign (phase) of orbital wave function in space.

(b.) direction of orientation of amplitude of orbital wave function in space.

(c.) both a and b. (d.) none of these.

(28.) How many lone pairs of electrons are present in SF_4 molecule **[Page: 112]**

(a.) One (b.) Two

(c.) Three (d.) Four

(29.) Which of the following pairs of molecules has expanded octet) **[Page: 101]**

(a.) SP_6, H_2O (b.) H_2SO_4, Li Cl

(c.) PF_5 and SF_6 (d.) CO_2 and PF_5

(30.) Select the correct order of increasing bond length of $C=C$, $C-C$, $C-O$ and $C-H$. **[Page: 103]**

(a.) $C-O < C-H < C-C < C=C$ (b.) $C-C < C=C < C-O < C-H$

(c.) $C-H < C=C, C-O < C-C$ (d.) $C-H < C-O < C-C < C=C$

(31.) Net dipole moment (l) of water molecule (H_2O) is 1.85 D. Its values in Cm is equal to **[Page: 108]**

(a.) 1.35×10^{-30}Cm (b.) 8.33×10^{-30}Cm

(c.) 6.17×10^{-30}Cm (d.) 5.21×10^{-30}Cm

(32.) Which of the following molecules/ions is diamagnetic in nature. **[Page: 126]**

(a.) O_2^2 (b.) O_2

(c.) O_2 (d.) O_2^+

(33.) Valence bond theory is based on the knowledge of the following: **[page: 113]**
(I) Atomic orbitals
(II) Electronic configurations of elements
(III) The overlapping criteria of atomic orbitals
(IV) Principles of variation and superposition
Select the correct option.

(a.) II and III are correct. (b.) III and IV are correct.

(c.) I and III are correct. (d.) I, II, III and IV are correct.

(34.) Nyholm and Gillespie refined the VSEPR model by explaining that **[Page: 109]**

(a.) the lone pair electrons in a molecule occupy more space as compared to the bonding pairs of electrons.
(b.) the lone pair of electrons in a molecule occupy less space as compared to the bonding pairs of electrons.

(c.) the lone pair and bond pair in a molecule occupy the same space.
(d.) None of these.

(35.) Which of the following pairs of species has identical bond order? **[Page: 105]**

(a.) N_2 and O_2 (b.) P_2 and N_2

(c.) N_2 and HCl (d.) N_2 and CO

(36.) Dipole moment defined as the **[Page: 107]**

(a.) product of the magnitude of the charge and the distance between the centres of positive and positive charge.
(b.) product of the magnitude of the charge and the distance between the centres of negative and negative charge.

(c.) product of the magnitude of the charge and the distance between the centres of positive and negative charge.
(d.) product of the magnitude of the resistance and the distance between the neutral nuclei.

(37.) **Assertion:** Dipole moment of NH_3 is greater than that of NP_3.
Reason: Nitrogen is more electronegative than fluorine. **[Page: 108]**

(a.) Both A and R are true and R is the correct explanation of A.
(b.) Both A and R are true but R is not the correct explanation of A.

(c.) A is true but R is false. (d.) Both A and R are false.

(38.) Some statements regarding bond angle are given be10w. Identify the correct statement(s). **[Page: 104]**

(I) Bond angle is the angle between the orbitals containing bonding electron pairs around the central atom in a molecule/complex ion.

(II) Bond angle is expressed in degrees which can be experimentally determined by spectroscopic methods.

(III) Bond angle helps in determining the shape of the molecule/complex ion.

(IV) Bond angle gives some idea regarding the distribution of orbitals around the central atom in a molecule/complex ion.

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

(39.) The types of hybrid orbitals of nitrogen in NO_2^+, NO_3 and NH_4^+ respectively are expected to be **[NCERT Exemplar, Page: 120]**

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

(40.) Two statements for polarity of bonds are given below: **[Page: 105]**

(I) The existence of a 100% ionic or covalent bond represents an ideal situation.

(II) In reality no bond or a compound is either completely covalent or ionic.

The given statements I and II are true or false

(a.) FF
(b.) TT
(c.) TF
(d.) FT

(41.) According to VSEPR Theory, the shape of a molecule depends upon the number of valence shell electron pairs **[page: 109]**

(a.) bonded electron pair only.
(b.) non-bonded electron pair only.
(c.) bonded or non-bonded electron pair.
(d.) neither bonded nor non-bonded electron pair.

(42.) Two statements regarding SP_4 molecule are given below. Identify the correct statements with respect to more stable structure. **[Page: 113]**

(I) If lone pair of electrons present at axial position then molecule is more stable.

(II) If lone pair of electrons present at equatorial position then molecule is less stable.

(a.) Only I
(b.) Only II
(c.) Both I and II
(d.) Neither I nor II

(43.) What is the bond order of H_2 molecule **[Page: 125]**

(a.) One
(b.) Two
(c.) Three
(d.) Zero

(44.) Ionic bonds will be formed more easily **[Page: 102]**

(a.) between elements with comparatively low ionisation enthalpies and elements
(b.) between elements with comparatively high ionisation enthalpies and elements

with comparatively high negative value of electron gain enthalpy.

with comparatively low negative value of electron gain enthalpy.

(c.) between two elements which consist of low ionisation enthalpy and electron gain enthalpy.

(d.) between two elements which consist of high ionisation enthalpy and electron gain enthalpy.

(45.) **Assertion:** SF_4 molecule has see-saw shape.

Reason: Two lone pair of electrons are present in SF_4 molecules. **[Page: 113]**

(a.) Both A and R are true and R is the correct explanation of A.

(b.) Both A and R are true but R is nor the correct explanation of A.

(c.) A is true but R is false.

(d.) Both A and R are false.

(46.) Which molecule/ion out of the following does not contain unpaired electrons **[Page: 126]**

(a.) N_2^+

(b.) O_2

(c.) O_2^{2-}

(d.) B_2

(47.) What is the hybridisation of a molecule which has square planar shape **[Page: 120]**

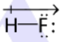
(a.) dsp^2

(b.) sp^3d

(c.) sp^3d^2

(d.) sp^3

(48.) The dipole moment of HP may be represented as: **[Page: 108]**



This arrow symbolises the direction of the shift of

(a.) proton density in the molecule.

(b.) electron density in the molecule.

(c.) neutron density in the molecule.

(d.) proton and neutron densities in the molecule.

(49.) Some conditions for the combination of atomic orbitals are given below: **[Page: 122]**

(I) The combining atomic orbitals must have the same or nearly the same energy.

(II) The combining atomic orbitals must have the same symmetry about the molecular axis.

(III) The combining atomic orbitals must overlap to the maximum extent.

Select the correct statement(s).

(a.) Only I

(b.) Only III

(c.) I and III

(d.) I, II and III

(50.) Bond length is defined as the equilibrium distance between the nuclei of two bonded atoms in a molecule and it is measured by **[Page: 103]**

(a.) spectroscopic technique.

(b.) X-ray diffraction technique.

(c.) electron-diffraction technique.

(d.) all of these.

TOPIC WISE PRACTICE QUESTIONS

TOPIC 1: Electrovalent, Covalent and Coordinate Bonding

1. Which of the following combination will form an electrovalent bond ?
1) P and Cl 2) NH_3 and BF_3 3) H and Ca 4) H and S

2. Which has a giant covalent structure?
1) PbO_2 2) SiO_2 3) NaCl 4) $AlCl_3$

3. Which one of the following contains a co-ordinate covalent bond ?
1) H_2O 2) HCl 3) $BaCl_2$ 4) $N_2H_5^+$

4. The number of dative bonds in sulphuric acid molecule is
1) 0 2) 1 3) 2 4) 4

5. Which of the following statements is not true about covalent compounds?
1) They may exhibit space isomerism 2) They have low melting and boiling points
3) They show ionic reactions 4) They show molecular reactions

6. Indicate the nature of bonding in CCl_4 and CaH_2
1) Covalent in CCl_4 and electrovalent in CaH_2 2) Electrovalent in both CCl_4 and CaH_2
3) Covalent in both CCl_4 and CaH_2 4) Electrovalent in CCl_4 and covalent in CaH_2

7. Lattice energy of an ionic compound depends upon
1) charge on the ion and size of the ion 2) packing of ions only
3) size of the ion only 4) charge on the ion only

8. Among the following which compound will show the highest lattice energy ?
1) KF 2) NaF 3) CsF 4) RbF

9. The compound that has the highest ionic character associated with the X—Cl bond is:
1) PCl_5 2) BCl_3 3) CCl_4 4) $SiCl_4$

10. Which combination of atoms can form a polar covalent bond?
1) H and H 2) H and F 3) N and N 4) Na and F

11. Which of the following pairs will form the most stable ionic bond ?
1) Na and Cl 2) Mg and F 3) Li and F 4) Na and F

12. In which of the following species central atom is NOT surrounded by exactly 8 valence electrons?
1) BF_4^- 2) NCl_3 3) PCl_4^+ 4) SF_4

13. Which of the following does not apply to metallic bond ?
1) Overlapping valence orbitals 2) Mobile valency electrons
3) Delocalized electrons 4) Highly directed bonds.

14. Which set contains only covalently bonded molecules?
1) BCl_3, $SiCl_4$, PCl_3 2) NH_4 Br, N_2H_4, HBr 3) I_2, H_2S, NaI 4) Al, O_3, As_4

15. Amongst LiCl, RbCl, $BeCl_2$ and $MgCl_2$ the compounds with the greatest and the least ionic character, respectively are:
1) LiCl and RbCl 2) RbCl and $BeCl_2$ 3) $MgCl_2$ and $BeCl_2$ 4) RbCl and $MgCl_2$

16. In ionic solids how crystal structure get stabilized
1) By the energy released in the formation of crystal lattice.
2) By achieving octet of electrons around the ionic species in gaseous state.
3) By electron gain enthalpy and the ionization enthalpy.
4) None of these

17. Which of the following statement is correct?
1) $FeCl_2$ is more covalent than $FeCl_3$. 2) $FeCl_3$ is more covalent than $FeCl_2$.
3) Both $FeCl_2$ and $FeCl_3$ are equally covalent. 4) $FeCl_2$ and $FeCl_3$ do not have any covalent character.

TOPIC 2: Octet Rule, Resonance, Dipole Moment and Bond Polarity

18. A pair of compounds which has odd electrons in the group NO, CO, ClO_2, N_2O_5, SO_2 and O_3 are
1) NO and ClO_2 2) CO and SO_2 3) ClO_2 and CO 4) SO_2 and O_3

19. Which of the following molecule(s) obey the octet rule?

(i) $[BF_4]^-$, (ii) $[AlCl_4]^-$, (iii) SO_2, (iv) CCl_4

1) (i), (ii), (iii), (iv) 2) (ii), (iii), (iv) 3) (i), (iii), (iv) 4) (i), (ii), (iv)

20. In the cyanide ion, the formal negative charge is on

1) C 2) N 3) Both C and N 4) resonate between C and N

21. Among the following, the species having the smallest bond order is

1) NO^- 2) NO^+ 3) O_2 4) NO

22. The bond length of C = O bond in CO is 1.20 Å and in CO_2 it is 1.34 Å. Then C = O bond length in CO_3^{2-} will be

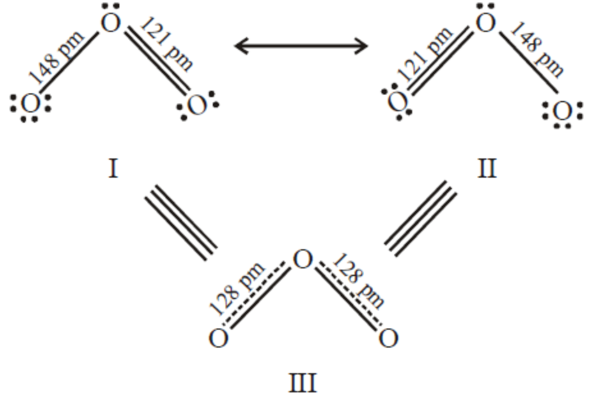
1) 1.50 Å 2) 1.34 Å 3) 1.29 Å 4) 0.95 Å

AND MOLECULAR STRUCTURE 53

23. Which one of the following pairs of molecules will have permanent dipole moments for both members ?

1) NO_2 and CO_2 2) NO_2 and $O_3$3) SiF_4 and CO_2 4) SiF_4 and NO_2

24. Which of the following structure represents structure of O_3 more accurately?



1) I and III only 2) II and III only 3) I and II only 4) All

25. Which of the following salt shows maximum covalent character?

1) $AlCl_3$ 2) $MgCl_2$ 3) CsCl 4) $LaCl_3$

26. Pauling's electronegativity values for elements are useful in predicting :

1) polarity of bonds in molecules 2) ionic and covalent nature of bonds

3) coordination number 4) both 1) and 2)

27. The molecule which has zero dipole moment is

1) CH_3Cl 2) NF_3 3) BF_3 4) ClO_2

28. Which bond angle q would result in the maximum dipole moment for the triatomic molecule YXY

1) q = 90° 2) q = 120° 3) q = 150° 4) q = 180°

29. Polarisibility of halide ions increases in the order

1) F^-, I^-, Br^-, Cl^- 2) Cl^-, Br^-, I^-, F^- 3) I^-, Br^-, Cl^-, F^- 4) F^-, Cl^-, Br^-, I^-

30. If one assumes linear structure instead of bent structure for water, then which one of the following properties cannot be explained?

1) The formation of intermolecular hydrogen bond in water.

2) The high boiling point of water.

3) Solubility of polar compounds in water.

4) Ability of water to form coordinate covalent bond.

TOPIC 3: VSEPR Theory, VBT Theory and Hybridization

31. The angle between the overlapping of one *s*-orbital and one *p*-orbital is

1) 180° 2) 120° 3) 109°28' 4) 120° 60'

32. Equilateral shape has

1) *sp* hybridisation 2) sp^2 hybridisation 3) sp^3 hybridisation 4) None of these

33. Which one of the following has the shortest carbon-carbon bond length ?

1) Benzene 2) Ethene 3) Ethyne 4) Ethane

34. Which of the following is the correct increasing order of lone pair of electrons on the central atom?

1) $IF_7 < IF_5 < CIF_3 < XeF_2$ 2) $IF_7 < XeF_2 < CIF_2 < IF_5$

3) $IF_7 < CIF_3 < XeF_2 < IF_5$ 4) $IF_7 < XeF_2 < IF_5 < CIF_3$

35. In which one of the following molecules the central atom is said to adopt sp^2 hybridization?
1) BeF_2 2) BF_3 3) C_2H_2 4) NH_3

36. Which of the following two are isostructural?
1) NH_3, BF_3 2) PCl_5, ICl_5 3) XeF_2, IF_2^- 4) CO_3^{-2}, SO_3^{2-}

37. The decreasing values of bond angles from NH3 (106°) to SbH3 (101°) down group-15 of the periodic table is due to
1) decreasing *bp-bp* repulsion 2) decreasing electronegativity
3) increasing *bp-bp* repulsion 4) increasing *lp-bp* repulsion

38. The shape of ClO_3^- ion according to Valence Shell Electron Pair Repulsion (VSEPR) theory will be
1) planar triangular 2) pyramidal 3) tetrahedral 4) square planar

39. Which of the following molecules has trigonal planar geometry?
1) BF_3 2) NH_3 3) PCl_3 4) IF_3

40. Linear combination of two hybridized orbitals belonging to two atoms and each having one electron leads to a
1) sigma bond 2) double bond 3) co-ordinate covalent bond 4) pi bond.

41. Which of the following statements is not correct for sigma and pi-bonds formed between two carbon atoms?
1) Sigma-bond determines the direction between carbon atoms but a pi-bond has no primary effect in this regard
2) Sigma-bond is stronger than a pi-bond
3) Bond energies of sigma- and pi-bonds are of the order of 264 kJ/mol and 347 kJ/mol, respectively
4) Free rotation of atoms about a sigma-bond is allowed but not in case of a pi-bond

42. How many s and p bonds are present in toluene?
1) $3\pi + 8\sigma$ 2) $3\pi + 10\sigma$ 3) $3\pi + 15\sigma$ 4) $6\pi + 3\sigma$

43. The number of lone pair and bond pair of electrons on the sulphur atom in sulphur dioxide molecule are respectively
1) 1 and 3 2) 4 and 1 3) 3 and 1 4) 1 and 2

44. How many sigma bonds are in a molecule of diethyl ether, $C_2H_5OC_2H_5$
1) 14 2) 12 3) 8 4) 16

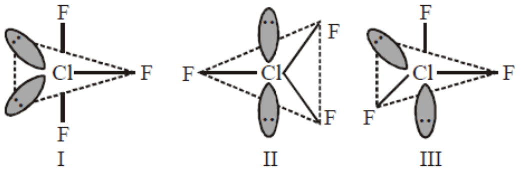
45. Which of the following statements is not correct?
1) Hybridisation is the mixing of atomic orbitals prior to their combining into molecular orbitals
2) sp^2 hybrid orbitals are formed from two *p*-atomic orbitals and one *s*-orbital
3) d^2sp^3 hybrid orbitals are directed towards the corners of a regular octahedron
4) dsp^3 hybrid orbitals are all at 90° to one another

46. Which of the following species has a linear shape ?
1) SO_2 2) NO_2^+ 3) CH_4 4) NO_2^-

47. Using VSEPR theory, predict the species which has square pyramidal shape
1) $SnCl_2$ 2) CCl_4 3) SO_3 4) BrF_5

48. Amongst the following, the molecule/ion that is linear is :
1) SO_2 2) CO_2 3) ClO_2^- 4) NO_2^-

49. Which of the following structure is most stable ?



Choose the correct option.
1) Only I 2) Only II 3) Only III 4) All three have same stability

50. The true statements from the following are
1. PH_5 and $BiCl_5$ do not exist 2. $p\pi - d\pi$ bond is present in SO_2
3. Electrons travel with the speed of light 4. SeF_4 and CH_4 have same shape

5. I_3^+ has bent geometry

1) 1, 3 2) 1, 2, 5 3) 1, 3, 5 4) 1, 2, 4

51. The hybrid state of S in SO_3 is similar to that of

1) C in C_2H_2 2) C in C_2H_4 3) C in CH_4 4) C in CO_2

52. Allyl cyanide molecule contains

1) 9 sigma bonds, 4 pi bonds and no lone pair 2) 9 sigma bonds, 3 pi bonds and one lone pair
3) 8 sigma bonds, 5 pi bonds and one lone pair 4) 8 sigma bonds, 3 pi bonds and two lone pairs

53. All bond angles are exactly equal to 109° 28' in :

1) methyl chloride 2) iodoform 3) chloroform 4) carbon tetrachloride

54. Which has the least bond angle

1) NH_3 2) BeF_2 3) H_2O 4) CH_4

55. The shape of IF_6^- is :

1) Trigonally distorted octahedron 2) Pyramidal
3) Octahedral 4) Square antiprism

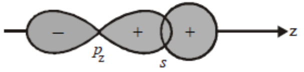
56. Which of the following statements is not correct?

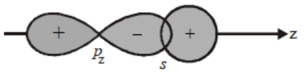
1) Double bond is shorter than a single bond 2) Sigma bond is weaker than a p (pi) bond
3) Double bond is stronger than a single bond 4) Covalent bond is stronger than hydrogen bond

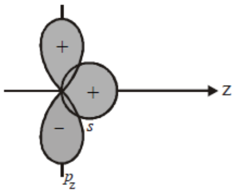
57. In which of the following pair both the species have sp^3 hybridization?

1) H_2S , BF_3 2) SiF_4, BeH_2 3) NF_3, H_2O 4) NF_3, BF_3

58. Which of the following represents zero overlap of atomic orbitals.

(a)


(b)


(c)


(d) All of these

59. The structure of the noble gas compound XeF_4 is :

1) square planar 2) distorted tetrahedral 3) tetrahedral 4) octahedral

60. Which of the following pairs of species have identical shapes?

1) NO_2^+ and NO_2^- 2) PCl_5 and BrF_5 3) XeF_4 and ICl_4^- 4) $TeCl_4$ and XeO_4

61. Amongst $NO_3^-, AsO_3^{3-}, CO_3^{2-}, ClO_3^-, SO_3^{2-}$ and BO_3^{3-}, the non-planar species are

1) $CO_3^{2-}, SO_3^{2-}, BO_3^{3-}$ 2) $AsO_3^{3-}, ClO_3^-, SO_3^{2-}$ 3) $NO_3^-, CO_3^{2-}, BO_3^{3-}$ 4) $SO_3^{2-}, NO_3^-, BO_3^{3-}$

62. What is the shape of the IBr_2^- ion?

1) Linear 2) Bent shape with bond angle of about 90°
3) Bent shape with bond angle of about 109° 4) Bent shape with bond angle of about 120°

63. According to VSEPR theory, in which species do all the atoms lie in the same plane?

1. CH_3^+ 2. CH_3^-

1) 1 only 2) 2 only 3) both 1 and 2 4) neither 1 nor 2

64. Which bonds are formed by a carbon atom with sp^2-hybridisation?

1) 4 π-bonds 2) 2 π-bonds and 2 σ-bonds 3) 1 π-bonds and 3 σ-bonds 4) 4 σ-bonds

65. SF_2, SF_4 and SF_6 have the hybridisation at sulphur atom respectively as :

1) sp^2, sp^3, sp^2d^2 2) sp^3, sp^3, sp^3d^2 3) sp^3, sp^3d, sp^3d^2 4) sp^3, spd^2, d^2sp^3

66. The strength of bonds formed by $s–s$, $p–p$ and $s–p$ overlap is in the order of

1) $s–p > s–s > p–p$ 2) $p–p > s–s > s–p$ 3) $s–s > p–p > s–p$ 4) $s–s > s–p > p–p$

TOPIC 4: MOT and Hydrogen Bonding

67. The bond order in N_2^+ is

1) 1.5 2) 3.0 3) 2.5 4) 2.0

68. The molecular electronic configuration of H_2^+ ion is?

1) $(\sigma 1s)^2$ 2) $(\sigma 1s)^2(\sigma^* 1s)^2$ 3) $(\sigma 1s)^2(\sigma^* 1s)^1$ 4) $(\sigma 1s)^3$

69. In the change of NO^+ to NO, the electron is added to

1) σ - orbital 2) π – orbital 3) $\sigma*$ - orbital 4) $\pi*$ - orbital

70. The correct statement with regard to $H2^+$ and $H2^-$ is

1) Both $H2^+$ and $H2^-$ do not exist 2) H_2^- is more stable than H_2^+

3) H_2^+ is more stable than H_2^- 4) Both H_2^+ and H_2^- are equally stable

71. If N_x is the number of bonding orbitals of an atom and N_y is the number of antibonding orbitals, then the molecule/atom will be stable if

1) $N_x > N_y$ 2) $N_x = N_y$ 3) $N_x < N_y$ 4) $N_x \leq N_y$

72. In an anti-bonding molecular orbital, electron density is minimum

1) around one atom of the molecule 2) between the two nuclei of the molecule

3) at the region away from the nuclei of the molecule 4) at no place

73. When two atomic orbitals combine, they form

1) one molecular orbital 2) two molecular orbital

3) three molecular orbital 4) four molecular orbital

74. Of the following hydrides which one has the lowest boiling point?

1) AsH_3 2) SbH_3 3) PH_3 4) NH_3

75. Which one of the following is the correct order of interactions?

1) covalent < hydrogen bonding < van der Waals < dipoledipole

2) van der Waals < hydrogen bonding < dipole-dipole < covalent

3) van der Waals < dipole-dipole < hydrogen bonding < covalent

4) dipole-dipole < van der Waals < hydrogen bonding < covalent

76. An ether is more volatile than an alcohol having the same molecular formula. This is due to

1) alcohols having resonance structures 2) intermolecular hydrogen bonding in ethers

3) intermolecular hydrogen bonding in alcohols 4) dipolar character of ethers

77. Paramagnetism is exhibited by molecules

1) not attracted into a magnetic field 2) containing only paired electrons

3) carrying a positive charge 4) containing unpaired electrons

78. Hydrogen bonding is maximum in :

1) C_2H_5OH 2) CH_3OCH_3 3) $(CH_3)_2C=O$ 4) CH_3CHO

79. What is the dominant intermolecular force or bond that must be overcome in converting liquid CH_3OH to a gas?

1) Dipole-dipole interaction 2) Covalent bonds

3) London dispersion force 4) Hydrogen bonding

80. In O_2^-, O_2 and O_2^{-2} molecular species, the total number of antibonding electrons respectively are

1) 7, 6, 8 2) 1, 0, 2 3) 6, 6, 6 4) 8, 6, 8

NEET PREVIOUS YEARS QUESTIONS

1. In the structure of ClF_3, the number of lone pair of electrons on central atom 'Cl' is **[2018]**

1) One 2) Two 3) Three 4) Four

2. Which of the following molecules represents the order of hybridisation *sp*2, *sp*2, *sp*, *sp* from left to right atoms? **[2018]**

1) $HC \equiv C-C \equiv CH$ 2) $CH_2=CH-C \equiv CH$ 3) $CH_3-CH=CH-CH_3$ 4) $CH_2=CH-CH=CH_2$

3. Consider the following species : **[2018]**

CN^+, CN^-, NO and CN Which one of these will have the highest bond order?

1) NO 2) CN^- 3) CN 4) CN^+

4. The species, having bond angles of 120° is : **[2017]**

1) ClF_3 2) NCl_3 3) BCl_3 4) PH_3

5. Which of the following pairs of species have the same bond order ? **[2017]**
1) O_2, NO^+ 2) CN^-, CO 3) N_2, O_2^- 4) CO, NO

6. Consider the molecules CH_4, NH_3 and H_2O. Which of the given statements is false? **[2016]**
1) The H–C–H bond angle in CH_4, the H–N–H bond angle in NH_3, and the H–O–H bond angle in H_2O are all greater than 90°
2) The H–O–H bond angle in H_2O is larger than the H– C–H bond angle in CH_4.
3) The H–O–H bond angle in H_2O is smaller than the H–N–H bond angle in NH_3.
4) The H–C–H bond angle in CH_4 is larger than the H–N–H bond angle in NH_3.

7. Predict the correct order among the following :- **[2016]**
1) lone pair- lone pair > lone pair - bond pair > bond pair - bond pair
2) lone pair - lone pair > bond pair - bond pair > lone pair - bond pair
3) bond pair - bond pair > lone pair - bond pair > lone pair - lone pair
4) lone pair - bond pair > bond pair - bond pair > lone pair - lone pair

8. Decreasing order of stability of O_2, O_2^-, O_2^+ and O_2^{2-} is : **[2015]**
1) $O_2^+ > O_2 > O_2^- > O_2^{2-}$ 2) $O_2^{2-} > O_2^- > O_2 > O_2^+$
3) $O_2 > O_2^+ > O_2^{2-} > O_2^-$ 4) $O_2^- > O_2^{2-} > O_2^+ > O_2$

9. The correct bond order in the following species is: **[2015]**
1) $O_2^{2+} < O_2^- < O_2^+$ 2) $O_2^+ < O_2^- < O_2^{2+}$ 3) $O_2^- < O_2^+ < O_2^{2+}$ 4) $O_2^{2+} < O_2^+ < O_2^-$

10. Which of the following pairs of ions are isoelectronic and isostructural? **[2015]**
1) ClO_3^-, CO_3^{2-} 2) SO_3^{2-}, NO_3^- 3) ClO_3^-, SO_3^{2-} 4) CO_3^{2-}, SO_3^{2-}

11. Maximum bond angle at nitrogen is present in which of the following? **[2015]**
1) NO_2^- 2) NO_2^+ 3) NO_3^- 4) NO_2

12. Which of the following species contains equal number of σ and $\pi -$bonds **[2015]**
1) XeO_4 2) $(CN)_2$ 3) $CH_2(CN)_2$ 4) HCO_3^-

13. Which of the following molecules has the maximum dipole moment? **[2014]**
1) CO_2 2) CH_4 3) NH_3 4) NF_3

14. Which one of the following species has planar triangular shape? **[2014]**
1) N_3^- 2) NO_3^- 3) NO_2^- 4) CO_2

15. The number of sigma (s) and pi (p) bonds in pent- 2-en-4-yne is :- (2019)
(1) 10 σ bonds and 3 π bonds (2) 8 σ bonds and 5 π bonds
(3) 11 σ bonds and 2 π bonds (4) 13 σ bonds and no π bond

16. Which of the following diatomic molecular species has only π bonds according to Molecular Orbital Theory? (2019)
(1) O_2 (2) N_2 (3) C_2 (4) Be_2

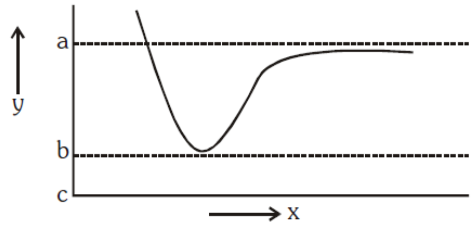
17. Which of the following is paramagnetic? (2019-ODISSA)
(1) N_2 (2) H_2 (3) Li_2 (4) O_2

18. Which of the following is the correct order of dipole moment ? (2019-ODISSA)
(1) $NH_3 < BF_3 < NF_3 < H_2O$ (2) $BF_3 < NF_3 < NH_3 < H_2O$
(3) $BF_3 < NH_3 < NF_3 < H_2O$ (4) $H_2O < NF_3 < NH_3 < BF_3$

19. The number of hydrogen bonded water molecule(s) associated with $CuSO_4 . 5H_2O$ is (2019-ODISSA)
(1) 3 (2) 1 (3) 2 (4) 5

20. Among the compounds shown below which one revealed a linear structure? (2020-COVID)
(1) NO_2 (2) HOCl (3) O_3 (4) N_2O

21. The potential energy (y) curve for H_2formation as a function of internuclear distance (x) of the H atoms is shown below. (2020-COVID)



The bond energy of H_2 is :

(1) $(b-a)$ (2) $\frac{(c-a)}{2}$ (3) $\frac{(b-a)}{2}$ (4) $(c-a)$

22. Identify a molecule which does not exist? **(NEET-2020)**

1) O_2 2) He_2 3) Li_2 4) C_2

23. Match List-I with List-II. **[NEET-2021]**

List I	**List II**
a) PCl_5	i) Square pyramidal
b) SF_6	ii) Trigonal planar
c) BrF_5	iii) Octahedral
d) BF_3	iv) Trigonal bipyramidal

Choose the correct answer from the options given below.

1) 1) –(i), 2)-(iii), 3)-(iv), 4)-(i) 2) 1) –(iii), 2)-(i), 3)-(iv), 4)-(ii)

3) 1) –(iv), 2)-(iii), 3)-(ii), 4)-(i) 4) 1) –(iv), 2)-(iii), 3)-(i), 4)-(ii)

24. BF_3 is planar and electron deficient compound. Hybridization and number of electrons around the central atom, respectively are: **[NEET-2021]**

1. sp^3 and 6 2. sp^2 and 6 3. sp^2 and 8 4. sp^3 and 4

25. From the following pairs of ions which one is not an iso- electronic pair? **[NEET-2021]**

1) Na^+, Mg^{2+} 2) Mn^{2+}, Fe^{3+} 3) Fe^{2+}, Mn^{2+} 4) O^{2-}, F^-

26. Which of the following molecules is non-polar in nature? **[NEET-2021]**

1) CH_2O 2) $SbCl_5$ 3) NO_2 4) $POCl_3$

27. Amongst the following which one will have maximum ‘lone pair-lone pair’ electron repulsions? **[NEET-2022]**

1) ClF_3 2) IF_5 3) SF_4 4) XeF_2

28. Match List – I with List – II **[NEET-2022]**

List – I **(Hydrides)**	**List – II** **(Nature)**
a)MgH_2	i)Electron precise
b)GeH_4	ii)Electron deficient
c) B_2H_6	iii) Electron rich
d) HF	iv) Ionic

Choose the correct answer from the options given below

1) (a)-(iv), (b)-(i),(c)-(ii),(d)-(iii)

2) (a)-(iii),(b)-(i),(c)-(ii),(d)-(iv)

3) (a)-(i),(b)-(ii),(c)-(iv),(d)-(iii)

4) (a)-(ii),(b)-(iii),(c)-(iv),(d)-(i)

NCERT LINE BY LINE QUESTIONS – ANSWERS

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

TOPIC WISE PRACTICE QUESTIONS – ANSWERS

1) **3**	2) **3**	3) **4**	4) **3**	5) **3**	6) **1**	7) **1**	8) **2**	9) **4**	10) **2**
11) **2**	12) **4**	13) **4**	14) **1**	15) **2**	16) **1**	17) **2**	18) **1**	19) **4**	20) **2**
21) **2**	22) **3**	23) **2**	24) **3**	25) **1**	26) **4**	27) **3**	28) **1**	29) **4**	30) **3**
31) **1**	32) **2**	33) **3**	34) **1**	35) **2**	36) **3**	37) **1**	38) **2**	39) **1**	40) **1**
41) **3**	42) **3**	43) **4**	44) **1**	45) **4**	46) **2**	47) **4**	48) **2**	49) **1**	50) **2**
51) **2**	52) **2**	53) **4**	54) **3**	55) **1**	56) **2**	57) **3**	58) **3**	59) **1**	60) **3**
61) **2**	62) **1**	63) **1**	64) **3**	65) **3**	66) **4**	67) **3**	68) **3**	69) **4**	70) **3**
71) **1**	72) **2**	73) **2**	74) **3**	75) **3**	76) **3**	77) **4**	78) **1**	79) **4**	80) **1**

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1) 2	2) 2	3) 2	4) 3	5) 2	6) 2	7) 1	8) 1	9) 3	10) 3
11) 2	12) 1	13) 3	14) 2	15) 1	16) 3	17) 4	18) 2	19) 2	20) 4
21) 1	22) 2	23) 4	24) 2	25) 3	26) 2	27) 4	28) 1		

NCERT LINE BY LINE QUESTIONS – SOLUTIONS

(1.) (c) Basically the strength of a bond depends upon the extent of overlapping. In case of sigma bond, the overlapping of orbitals takes place to a larger extent. Hence, it is stronger as compared to the pi bond where the extent of overlapping occurs to a smaller extent.

(2.) (c) Dipole moment is a vector quantity and by convention it is depicted by the small arrow with tail on the negative centre and head pointing towards the positive centre.

(3.) (d) Electrons from outermost shells *ns* and (*n*-1)*d* take part in bond formation for transition elements.
Assertion-Reason Type Questions

(4.) (c) H_2O has highest dipole moment.

(5.) (b) $XeP_4 - sp^3d^2 - \text{l.p.} = 2$, square planar

$XeF_6 - sp^3d^3 - \text{l.p.} = 1$, distorted octahedral

$XeOF_4 - sp^3d^2 - \text{l.p.} = 1$, square pyramidal

$XeO_3 - sp^3 - \text{l.p.} = 1$, pyramidal

(6.) (b) Both the molecules, NH_3 and NF_3, have pyramidal shape with a lone pair of electrons.

Therefore, the sum of lone pair of electrons present in the molecule of NH_3 and NF_3 is two.

(7.) (d) Electronic configuration of $He_2 : (\sigma 1s)^2 (\sigma^* 1s)^2$

Bond order of He_2 is $\frac{1}{2}(2-2)=0$

While bond order of O_2 is two.

(8.) (b) CH_4 and NH_4^+ both have tetrahedral molecular geometry.

(9.) (b) The bond angles of NH_3, CH_4 and H_2O molecules are $107^o, 109.5^o$ and 104.5^o respectively.

(10.) (d) All the given statements regarding formal charge are correct.

(11.) (a) Zero overlap due to the out of phase for different orientation direction of approach.

(12.) (b) Molecule C_2H_2 and $BeCl_2$ both have *sp* hybridisarion.

(13.) (d) The correct order of energies of molecular orbitals in N_2 molecule is

$$\sigma 2s < \sigma^* 2s < \left(\pi 2p_x = \pi 2p_y\right) < \sigma 2p_z < \left(\pi^* 2p_x = \pi^* 2p_y\right) < \sigma^* 2p_z$$

(14.) (d) Ammonia (NH3) has one lone pair of electrons, tetrahedral molecular geometry and trigonal pyramidal shape.

(15.) (b) In general, the least electronegative atom occupies the central position in the molecule/ion. For example, in the NF_3 and CO_3^{2-}, nitrogen and carbon are the central atoms whereas fluorine and oxygen occupy the terminal positions.

(16.) (a) The direction of the C - H bond cannot be ascertained because the 2*s* orbital of carbon and the 1*s* orbital of H are spherically symmetrical and they can overlap in any direction.

(17.) (a) O-H will be the strongest bond.

(18.) (d) All the given statements regarding octet theory are correct.

(19.) (a) In sp hybridisation, 50 %s – character and 50 % p-character.

(20.) (b) Both assertion and reason are true statements.

(21.) (b) Among the given molecules, H_2O, ClP_3, and XeF_4 have two lone pair of electrons. SO_2, NH_3, SF_4 and BrF_5 have one lone pair of electron.

(22.) (a) As per postulates of VSEPR theory, the pairs of electrons tend to occupy such positions in space that minimise repulsion and thus maximise distance between them.

(23.) (d) The molecular orbitals like atomic orbitals are filled in accordance with the aufbau principle obeying the Pauli's exclusion principle and the Hund's rule.

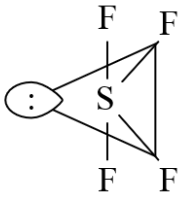
(24.) (c) A positive bond order, *i.e.* $N_b > N_a$, means a stable molecule while a negative, i.e. $N_b < N_a$, or zero (i.e., $N_b = N_a$) bond order means an unstable molecule.

(25.) (b) Both assertion and reason are true statement.

(26.) (d) $BeCl_2$ has sp-hybridisarion, the two sp-hybrid orbitals are oriented in opposite direction forming an angle of 180^o.

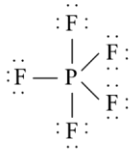
(27.) (c) Overlapping of atomic orbitals depends upon the sign (phase) and direction of orientation of amplitude of orbital wave function in space.

(28.) (a) One lone pair of electron is present in SF_4 molecule.

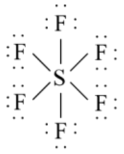


SF_4 molecule

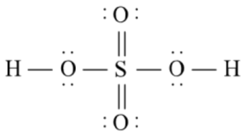
(29.) (c) PF_5 and SF_6 have expanded octet



PF_5
10 electrons around
the P atom



SF_6
12 electrons around
the S atom



H_2SO_4
12 electrons around
the S atom

(30.) (c) Correct order of increasing bond length is
$C-H<C=C<C-O<C-C.$

(31.) (c) Given, net dipole moment, $\mu = 1.85D$

Net dipole moment, ;$\mu = 1.85 \times 3.33564 \times 10^{30} Cm = 6.17 \times 10^{30} Cm.$

(32.) (a) O_2^{2-} ion , all the electrons are present in pair form, therefore they are diamagnetic in nature.

(33.) (d) A discussion of the valence bond theory is based on the knowledge of atomic orbitals, electronic configurations of elements, the overlap criteria of atomic orbitals, the hybridisation of atomic orbitals and the principles of variation and superposition.

(34.) (a) Nyholm and Gillespie refined the VSEPR model by explaining that the lone pairs are localised on the central atom, each bonded pair is shared between two atoms. As a result, the lone pair electrons in a molecule occupy more space as compared to the bonding pairs of electrons.

(35.) (d) Isoelectronic molecules and ions have identical bond orders, for example, F_2 and O_2^{2-} have bond order 1. N_2, CO and NO^+ have bond order 3.

(36.) (c) As a result of polarisation, the molecule possesses the dipole moment which can be defined as the product of the magnitude of the charge and the distance between the centres of positive and negative charge. It is usually designated by a Greek letter $\grave{\mu}$’. Mathematically, it is expressed as follows:
Dipole moment (μ) = Charge (Q) × Distance of separation (r).

(37.) (c) Fluorine is more electronegative than nitrogen.

(38.) (c) All the given statements regarding bond angle of molecule/complexion are correct.

(39.) (b) NO_2^+ : sp hybridisation
NO_3^- : sp^2 hybridisation
NH_4^+ : sp^3 hybridisation

(40.) (b) Both the given statements regarding polarity of bonds are true.

(41.) (c) The shape of a molecule depends upon the number of valence shell electron pairs (bonded or non-bonded) around the central atom.

(42.) (d) In SF_4 molecule, of lone pair of electrons present at axial position then molecule is less stable and if lone pair of electrons present at equatorial position then molecule is more stable.

(43.) (a) Electronic Configuration of $H_2 : (\sigma 1s)^2$

The bond order of H_2 molecule can be calculated as

Bond order $= \dfrac{N_b - N_a}{2} = \dfrac{2-0}{2} = 1$

(44.) (a) Ionic bonds will be formed more easily between elements with comparatively low ionisation enthalpies and elements with comparatively high negative value of electron gain enthalpy.

(45.) (c) One lone pair of electron present in SF_4 molecule.

(46.) (c) Among the given molecules/ions O_2^2 does not contain unpaired electrons.

(47.) (a) The hybridisation of a molecule which has square planar shape is dsp^2.

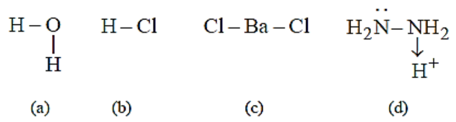
(48.) (b) $\overrightarrow{H-\underset{\bullet\bullet}{\overset{\bullet\bullet}{F}}}$: This arrow symbolises the direction of the shift of electron density in the molecule.

(49.) (d) All the given conditions are correct for the combination of atomic orbitals.

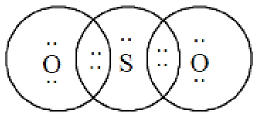
(50.) (d) Bond lengths are measured by spectroscopic, X-ray diffraction and electron-diffraction techniques.

TOPIC WISE PRACTICE QUESTIONS – SOLUTIONS

1. (3) Higher the difference in electronegativity between the two atoms, more will be electrovalent character of the bond. Among given choices, calcium and hydrogen have maximum difference in their electro negativities.
2. 3)
3. 4)



4. 3) 5. 3) 6. 1)
7. (1) The value of lattice energy depends on the charges present on the two ions and the distance between them.
8. (2) For compounds containing cations of same charge, lattice energy increases as the size of the cation decreases. Thus, NaF has highest lattice energy. The size of cations is in the order:$Na^+ < K^+ < Rb^+ < Cs^+$
9. (4) In SiCl4 difference between electronegativity of Si (1.8) and chlorine (3.0) is higher than in other given compounds.
10. (2) Hydrogen fluoride has a large value of dipole moment. This is due to very high electronegativity of the fluorine as a result it pulls electrons strongly.
11. (2) The stability of the ionic bond depends upon the lattice energy which is expected to be more between Mg and F due to +2 charge on Mg atom.
12. (4) In SF4 molecules central S-atom is surrounded by 10valence electrons and it is hypervalent compound.
13. (4) In metallic bonds, each ion is surrounded by equal number of oppositely charged electrons, hence have equal electrostatic attraction from all sides and hence do not have directional characteristics.
14. (1) The set of compounds BCl3, SiCl4, PCl3 are predominatly covalent compounds. NH4Br and NaI ionic compounds and Al contains metallic lattice.
15. (2) According to Fajan's rule smaller, highly charged cation has greatest covalent character while large cation with smaller charge has greatest ionic character.
16. (1) In ionic solids, the sum of the electron gain enthalpy and the ionization enthalpy may be positive but still the crystal structure gets stabilized due to the energy released in the formation of the crystal lattice.
17. (2) According to Fajan's rule, higher charge on the ions, more covalent is the compound.
18. (1)
19. 4)



20. 2) In CN^- ion, formal negative charge is on nitrogen atom due to lone pair of electrons.
21. 2)

$NO^-(16) - B.O. = 2$ $O_2(16) - B.O. = 2$
$NO^+(14) - B.O. = 3$ $NO(15) - B.O. = 2.5$

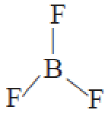
Higher the bond order lower is the bond length.
Hence NO+ will have smallest bond.

22. 3)In CO_3^{2-} , due to resonance, C = O bond length is in between triple and double bond, i.e. in between 1.2 and 1.34. Thus, answer is 1.29 Å.
23. (2) Both NO2 and O3 have angular shape and hence will have net dipole moment.
24. (3) I and II structure shown above constitute the cannonical structure. III structure represents the structure of O3 more accurately. This is also called resonance hybrid.

25. (1) According to Fajan's rule, as the charge on the cation increases, and size decreases, its tendency to polarise the anion increases. This brings more and more covalent nature to electrovalent compounds. Hence AlCl3 shows maximum covalent character.

26. (4)

27. (3) The dipole moment of symmetrical molecules is zero.



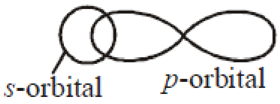
Triangular planar (symmetrical molecule)

28. (1) The dipole moment of two dipoles inclined at an angle θ is given by the equation $\mu=\sqrt{X^2+Y^2+2XY\cos\theta}, \cos 90^0=0$. Since the angle increases from 90° to 180°, the value of cos θ becomes more and more – ve and hence resultant dipole moment decreases. Thus, dipole moment is maximum when θ = 90°.

29. (4) In case of anions having same charge, as the size of anion increases, polarisibility of anion also increases.

30. (3) If the structure of water is linear, then μ = 0, hence it will be non-polar and thus the solubility of polar compound in water cannot be explained.

31. 1)



The overlap between *s*- and *p*-orbitals occurs along internuclear axis and hence the angle is 180°.

32. 2) Equilateral or triangular planar shape involves sp^2 hybridization.

33. (3) The bond length decreases in the order *sp*3 > *sp*2 > *sp*. Because of the triple bond, the carbon-carbon bond is shortest.

34. (1) The number of lone pairs of electrons on central atom in various given species are

Species	Number of lone pairs on central atom
IF_7	nil
IF_5	1
ClF_3	2
XeF_2	3

Thus the correct increasing order is $\underset{0}{IF_7}<\underset{1}{IF_5}<\underset{2}{ClF_3}<\underset{3}{XeF_2}$

35. 2) BF_3 involves sp^2 -hybridization.

36. (3) In XeF2 and -
IF2 both XeF2 and IF2
– are *sp*3*d* hybridized
and have trigonal bipyramidal (linear) shape due to presence of 3 *lp* of electrons.

37. (1) The bond angle decreases on moving down the group due to decrease in bond pair-bond pair repulsion.

NH3	PH3	AsH3	SbH3	BiH3
107°	94°	92°	91°	90°

This can also be explained by the fact that as the size of central atom increases and its electronegativity decreases. Thus distance between bond pairs of electron increases and *bp-bp* repulsion decreases. As a result bond angle decreases from NH3 to BiH3.

38. (2) Hybridisation is *sp*3 and shape pyramidal.

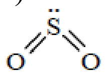
39. (1) BF3 is *sp*2 hybridised. So, it is trigonal planar. NH3, and PCl3 have *sp*3 hybridisation, hence have trigonal pyramidal shape. IF3, has *sp*3*d* hydridisation and has T-shape.

40. (1) Linear combination of two hybridized orbitals leads to the formation of sigma bond.

41. (3) As sigma bond is stronger than the π (pi) bond, so it must be having higher bond energy than π (pi) bond.

42. (3) 15 σ + 3 π

43. (4)



lp = 1

bp = 4

44. (1) Number of σ -bonds = 14

45. (4) 46. (2)

47. (4) BrF5 has square pyramidal geometry.

48. (2) Molecule or ion having *sp* hybridisation and no lone pair of electrons is linear. CO2 H = 1/2 (4 + 0 + 0 – 0) = 2 *sp* (linear shape)

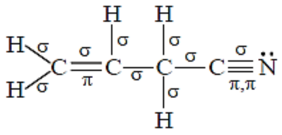
49. (1)

50. (2) SeF4 has distorted tetrahedral geometry while CH4 has tetrahedral geometry.

51. 2)

Molecule	**Hybridization**
SO_3	sp^2
C_2H_2	sp
C_2H_4	sp^2
CH_4	sp^3
CO_2	sp

52. 2) Allyl cyanide is :

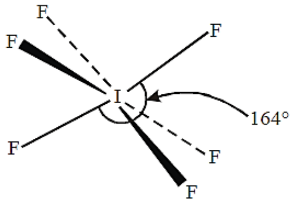


It contains 9 sigma bonds, 3 pi bonds and 1 lone pair of electrons.

53. (4) The bond angle will be exactly 109°.28’ when the central atom is *sp*3 hybridised and all bonds have same atom. CCl4 has all identical bonds (C – Cl) and central carbon is *sp*3 hybridised. So, it has bond angle exactly 109°.28’.

54. (3) H2O, NH3 and CH4 all are *sp*3 hybridized but due to two *lp* – *lp* repulsions, bond angle in H2O (104.5°) is lower than in NH3 (107°) which has one *lp* and CH4 (109° 28’) which has no *lp*. BeF2 on the other hand, has *sp* hybridization and hence has a bond angle of 180°.

55. (1) The structure of IF6 – is distorted octahedral This is due to presence of a “weak” lone pair.

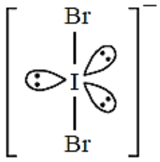


56. (2)

57. (3) Applying VSEPR theory, both NF3 and H2O are *sp*3 hybridized.

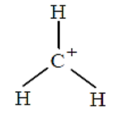
58. (3) 59. (1) 60. (3) 61. (2)

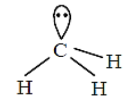
62. 1)



sp^3d-hybridisation Shape → Linear

63. 1)


(sp^3-hybrid)
(Trigonal planar)


(sp^3-hybridised)
(Trigonal pyramidal)

64. 3) By $sp2$-hybridisation. Hybridisation orbital $= 3[3\sigma - \text{bonds}]$ Unhybridised orbital $= 1[1\pi - \text{bond}]$

65. 3) Hybridisation :

1. $:\ddot{S}F_2 \Rightarrow \frac{1}{2}(6+2) = 4 = sp^3$
2. $:SF_4 \Rightarrow \frac{1}{2}(6+4) = 5 = sp^3d$
3. $SF_6 \Rightarrow \frac{1}{2}(6+6) = 6 = sp^3d^2$

66. 4)The strength of a bond depends upon the extent of overlapping. *s-s* and *s-p* overlapping results in the formation of σ bond but extent of overlapping along internuclear axis is more in case of s-s overlapping than in *s-p*. *p-p* overlapping may result in σ bond if overlapping takes place along internuclear axis or may result in π–bond if sideways overlapping takes place. In any case the extent of overlapping is lesser in $p-p$ than that of the other two, *s-s* and *s-p*. Hence the correct order is $s - s > s - p > p - p$

67. 3) $N_2^+ = 7+7-1 = 13$ electrons Configuration is $\sigma 1s^2, \sigma^*1s^2, \sigma 2s^2, \sigma^*2s^2, \pi 2p_x^2 = \pi 2p_y^2, \sigma 2p_z^1$

$$\text{Bond order} = \frac{nb - na}{2} = \frac{1}{2}(9-4) = \frac{1}{2}\times 5 = 2.5$$

68. 3) 69. 4)

M.O. configuration of NO^+ is :
$(\sigma 1s)^2(\sigma^* 1s)^2(\sigma 2s)^2(\sigma^* 2s)^2(\sigma 2p_z)^2(\pi 2p_x)^2(\pi 2p_y)^2$
and M.O. configuration of NO is :
$(\sigma 1s)^2(\sigma * 1s)^2(\sigma 2s)^2(\sigma * 2s)^2(\sigma 2p_z)^2(\pi 2p_x)^2$
$(\pi 2p_y)^2(\pi * 2p_x)^1$.

70. 3) $H_2^+ : (\sigma 1s^1); B.O = \frac{1}{2}(1-0) = \frac{1}{2}$

$H_2^- : (\sigma 1s^2)(\sigma^* 1s^1); B.O = \frac{1}{2}(2-1) = \frac{1}{2}$

Even though the bond order of H_2^+ and H_2^- are equal but H_2^+ is more stable than H_2^- as in the latter, an electron is present in the antibonding $(\sigma^* 1s)$ orbital of higher energy.

71. 1) 72. 2)

73. 2) One bonding M.O. and one anti-bonding M.O.

74. 3) NH3 undergoes H-bonding and hence has the highest b.p. Among the remaining hydrides i.e. PH3, AsH3 and SbH3 as we move from PH3 to BiH3, the molecular mass increases. As a result the van der waal's forces of attraction increases and the boiling point increases regularly from PH3 to BiH3.

75. 3)

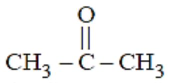
76. 3) In ether, there is no H-bonding while alcohols have intermolecular H-bonding.

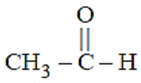
77. 4) Molecules having unpaired electrons show paramagnetism.

78. 1) Hydrogen bonding is possible only in compounds having hydrogen attached with F, O or N.

$C_2H_5 - OH$
(H-bonding possible)

$CH_3 - O - CH_3$
(H-bonding not possible)


$CH_3 - \overset{O}{\overset{\|}{C}} - CH_3$
(H-bonding not possible)


$CH_3 - \overset{O}{\overset{\|}{C}} - H$
(H-bonding not possible)

79. (4) Due to intermolecular hydrogen bonding in methanol, it exist as associated molecule.

80. (1) Molecular orbital electronic configuration of these species are :

$$O_2^-(17e^-)=\sigma 1s^2\sigma^*1s^2\sigma 2s^2\sigma^*2s^2\sigma 2p_z^2$$

$$\pi 2p_x^2=\pi 2p_y^2\pi^*2p_x^2=\pi^*2p_y^1$$

$$O_2(16e^-)=\sigma 1s^2\sigma^*1s^2\sigma 2s^2\sigma^*2s^2\sigma 2p_z^2$$

$$\pi 2p_x^2=\pi 2p_y^2\pi^*2p_x^1=\pi^*2p_y^1$$

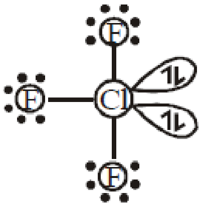
$$O_2^{2-}(18e^-)=\sigma 1s^2\sigma^*1s^2\sigma 2s^2\sigma^*2s^2\sigma 2p_z^2$$

$$\pi 2p_x^2=\pi 2p_y^2\,\pi^*2p_x^2=\pi^*2p_y^2$$

Hence number of antibonding electrons are 7, 6 and 8 respectively.

NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

1. 2) The structure of ClF_3 is



The number of lone pair of electrons on central Cl is 2.

2) $\overset{sp^2}{CH_2}=\overset{sp^2}{CH}-\overset{sp}{C}\equiv\overset{sp}{CH}$

3. 2)NO : $(\sigma 1s)^2(\sigma^*1s)^2(\sigma 2s)^2(\sigma^*2s)^2(\sigma 2p_z)^2\ (\pi 2p_x)^2=(\pi 2p_y)^2(\pi^*2p_x)^1=(\pi^*2p_y)^0$

$$B.O=\frac{10-5}{2}=2.5$$

$$CN^-:(\sigma 1s)^2(\sigma^*1s)^2(\sigma 2s)^2(\sigma^*2s)^2$$

$$(\pi 2p_x)^2=(\pi 2p_y)^2(\sigma 2p_z)^2$$

$$B.O.=\frac{10-4}{2}=3$$

$$CN:(\sigma 1s)^2(\sigma^*1s)^2(\sigma 2s)^2(\sigma^*2s)^2$$

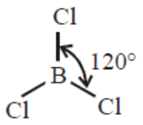
$$(\pi 2p_x)^2=(\pi 2p_y)^2(\sigma 2p_z)^1$$

$$B.O.=\frac{9-4}{2}=2.5$$

$$CN^+:(\sigma 1s)^2(\sigma^*1s)^2(\sigma 2s)^2(\sigma^*2s)^2(\pi 2p_x)^2=(\pi 2p_y)^2$$

$$B.O.=\frac{8-4}{2}=2$$

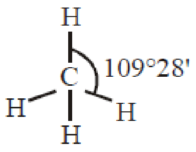
4. 3) BCl_3 is trigonal planar and hence the bond angle is 120°.



5. 2) CN^- and CO have same no. of electrons and have same bond order equal to 3.

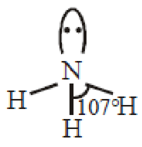
6. 2)

CH_4



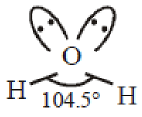
Tetrahedral;

NH_3



Trigonal pyramidal

H_2O



Bent

. **Note:** The geometry of H2O should have been tetrahedral if there are all bond pairs. But due to presence of two lone pairs the shape is distorted tetrahedral. Hence bond angle reduced to 104.5° from 109.5°.

7. **1)** According to VSEPR theory order of repulsion in between lp – lp, lp – bp and bp – bp is as under lp – lp > lp – bp > bp – bp

8. **1)** According to molecular orbital theory as bond order decreases stability of the molecule decreases

$$\text{Bond order} = \frac{1}{2}\left(N_b - N_a\right)$$

$$\text{Bond order for } O_2^+ = \frac{1}{2}\left(10-5\right) = 2.5$$

$$\text{Bond order for } O_2 = \frac{1}{2}\left(10-6\right) = 2$$

$$\text{Bond order for } O_2^- = \frac{1}{2}\left(10-7\right) = 1.5$$

$$\text{Bond order for } O_2^2 = \frac{1}{2}\left(10-8\right) = 1.0$$

hence the correct order is

$O_2^+ > O_2 > O_2^- > O_2^{2-}$

9. 3) O_2^+ ion - Total number of electrons (16 – 1) = 15. Electronic configuration

$$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_x^2$$

$$< \pi 2p_y^2 = \pi 2p_z^2 < \pi^* 2p_y^1$$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10-5}{2} = \frac{5}{2} = 2\frac{1}{2}$$

O_2^- (Super oxide ion): Total number of electrons

$(16+1) = 17$. Electronic configuration

$$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \sigma 2p_x^2$$

$$< \pi 2p_y^2 = \pi 2p_z^2 < \pi^* 2p_y^2 = \pi^* 2p_z^1$$

Bond order

$$= \frac{(N_b - N_a)}{2} = \frac{10-7}{2} = \frac{3}{2} = 1\frac{1}{2}$$

O_2^{+2} ion: Total number of electrons $= (16-2) = 14$

Electronic configuration

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

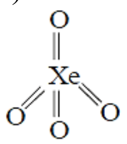
$$\text{Bond order} = \frac{(N_b - N_a)}{2} = \frac{10-4}{2} = \frac{6}{2} = 3$$

So bond order: $O_2^- < O_2^+ < O_2^{2+}$

10. 3) ClO_3^- and SO_3^{-2} both have same number of electrons (42) and central atom in each being *sp*3 hybridised.
Both are having one lone pair on central atom hence they are pyramidal.

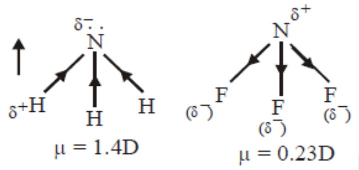
11. 2) NO_2^+ has *sp* hybridisation so it is linear with bond angle = 180°.

12. 1)



Number of σ bonds = 4
Number of π bonds = 4

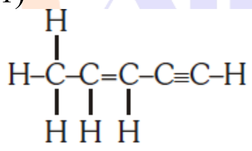
13. 3)
Dipole moment of $NH_3 > NF_3$



(F is more electronegative than N)

14. 2) $NO_3^- = \frac{1}{2}(5+0+1-0) = \frac{6}{2} = 3 = sp^2$ NO_2^- (nitrite ion) also has sp^2 hybridization and gives a trigonal planner geometry but because there are only two outer atoms, the molecular geometry is bent with $\angle 120^0$ bond angles.

15. 1)



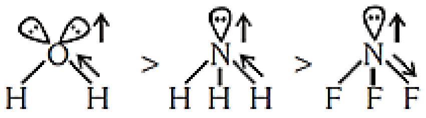
$$H-\overset{H}{\underset{H}{C}}-\underset{H}{C}=\underset{H}{C}-C\equiv C-H$$

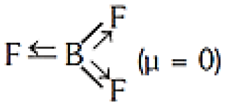
Number of sigma bonds = 10
Number of π -bonds = 3

16. 3) According to M.O.T. electronic configuration of C_2 molecule is –
$\sigma 1s^2 < \sigma^* 1s^2 < \sigma 2s^2 < \sigma^* 2s^2 < \pi_2 p_x^2 = \pi_2 p_y^2$
so, C_2 molecule contain only ' π ' bond

17. 4) According to MOT

18.





19. 2)
In $CuSO_4 \cdot 5H_2O$, only one water molecule take part in hydrogen bonding.

20. 4) $:N\equiv N \rightarrow \ddot{O}:$ (Linear)

21. (1) As per the given curve bond energy is the amountof energy is released during the bond formation is i.e. = Final – Initial
$= b - a$

22. 2)He_2 molecule does not exist

M.O configuration = $\sigma 1^2 gs1s^2$

$$B.O = \frac{1}{2}\left(N_6 - N_a\right) = \frac{1}{2}(2-2)$$

Bond order = O

23. 4) $PCl_5 \rightarrow (AB_5) \rightarrow$ Trigonal bipyramidal

$SF_6 \rightarrow (AB_6) \rightarrow$ Octahedral

$BrF_5 \rightarrow (AB_5E) \rightarrow$ Square pyramidal

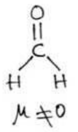
$BF_3 \rightarrow (AB_3) \rightarrow$ Trigonal planar

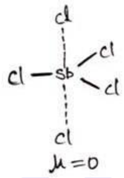
24. 2) BF_3 hybridization- SP^2

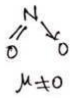
No of electrons -6

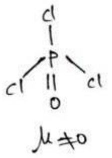
25. 3)

26. 2)









27. XeF_2 has 3 loneparis so, it has maximum lone-pair –lone pair repulsions

28. MgH_2 – Ionic
GeH_4 – Electron precise
B_2H_6 – Electron deficient
HF – Electron rich