



The elements present in the third period and beyond it have 3d orbitals apart from 3s and 3p orbitals for bonding. So in number of compounds of these elements there are more than eight valence electrons around the central atom. This is known as expanded octet.

Question 4

**Define octet rule. What is its significance?**

**Ans.**

The octet rule states that atoms of various elements enter into chemical combination so as to attain the configuration of eight electrons in their outermost shell. It is quite useful in explaining the normal valency of large number of elements.

Question 5

**Name the noble gas which is an exception to the octet rule?**

**Ans.**

Helium is an exception to the octet rule as it has a duplet of electrons.

Question 6

**The formation of NaCl involves conversion of sodium atom into sodium ion and chlorine atom into chloride ion. Comment upon the energy changes involved in these reactions.**

**Ans.**

In the formation of NaCl conversion of sodium atom in to sodium ion is an endothermic process and the conversion of chlorine atom into chloride ion is an exothermic process.

Question 7

**What do you understand by the term valence electrons?**

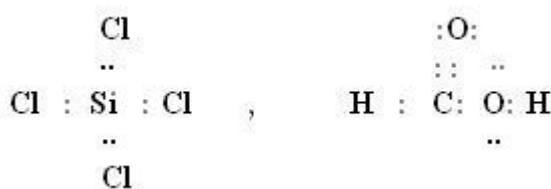
**Ans.**

The electrons present in the outer shell of an atom that take part in a chemical reaction are known as valence electrons.

Question 8

**Draw the Lewis structures of  $\text{SiCl}_4$  and  $\text{HCOOH}$ ?**

**Ans.**



Question 9

**"In the molecule H-Br the H would have a partial negative charge and the Br would have a partial positive charge." Is it true? Explain.**

**Ans.**

No, the statement is wrong. In HBr, the H has partial positive charge while Br has partial negative charge. Br being more electronegative attracts the shared pair of electrons towards itself. The compound HBr is a polar covalent compound.

Question 10

**What is the maximum number of covalent bonds an element with atomic number 16 can make with hydrogen? Give its formula and the type of bond formed.**

**Ans.**

Sulphur has atomic number = 16. Electronic configuration = 2, 8, 6. It needs 2 more electrons to complete its octet.

Thus, it shares its 2 electrons with two different hydrogen atoms and forms two single-covalent bonds.

The formula of the compound is  $H_2S$  and it has polar covalent bond.

Question 11

**Classify the given compounds as ionic or covalent?**

**$CH_4$ ,  $NaCl$ ,  $H_2O$ ,  $CO_2$ ,  $O_2$ ,  $KBr$ .**

**Ans.**

Ionic compounds are formed by complete transfer of electrons from one atom to another. The ionic compounds are:  $NaCl$ ,  $KBr$ .

Covalent compounds are formed by sharing of electrons between the atoms in the molecule. The covalent compounds are:  $CH_4$ ,  $H_2O$ ,  $CO_2$ ,  $O_2$ .

Question 12

**What type of bond is present in present in  $NH_3$ ? Explain in brief.**

**Ans.**

Ammonia ( $NH_3$ ) has polar covalent bond.

A non-polar covalent bond is formed when the shared pair of electron is not equally shared between the atoms of the molecule. The shared pair of electrons shifts towards the more electronegative atom. This results in formation of partial charges on the atoms in the molecule. Nitrogen has partial negative charge while hydrogen has partial positive charge. Thus, ammonia has polar covalent bond.

Question 13

**Which molecule is most likely to have a dipole moment:  $\text{CS}_2$ ,  $\text{SO}_3$ ,  $\text{H}_2\text{S}$  and  $\text{SnCl}_4$ ? Give reasons for your answer.**

**Ans.**

$\text{H}_2\text{S}$  molecule has irregular geometry. It has two lone pair of electrons on sulphur atom. Thus, it is expected to have a dipole moment.

Question 14

**Explain why reactions involving covalent compounds are generally slow?**

**Ans.**

Covalent bond compounds are formed by the mutual sharing of electrons between the atoms in the compound. These compounds do not produce ions in the aqueous solution.

Reactions of covalent bonded compounds involve breaking of bonds in reacting molecules and forming new covalent bonds in the products. Thus, these reactions are relatively slow.

Question 15

**What is lattice energy? Which compound  $\text{NaCl}$  or  $\text{MgO}$  has higher lattice energy and why?**

**Ans.**

Lattice energy is the amount of energy released when one mole of ionic solid is formed by the close packing of gaseous ions. Lattice energy depends on:

- **Size of the ions:** Small is the size of ion, lesser is the inter-nuclear distance and greater will be the attraction, thus larger will be the magnitude of lattice energy.
- **Charge on the ions:** More the charge on the ion, higher is the lattice energy.  
Between  $\text{NaCl}$  and  $\text{MgO}$ , lattice energy of  $\text{MgO}$  is higher as the positive charge on  $\text{Mg}$  is higher than  $\text{Na}$  ion.

Question 16

**Ionic compounds do not conduct electricity when solid. Why? When do they conduct electricity?**

**Ans.**

Ionic compounds are formed by attraction between the positive and negative ions. These ions cannot move out of their fixed positions. Thus, solid ionic compounds do not conduct electricity.

When ionic compounds are in molten state or dissolved in water forming a solution, the ions can move. Then ionic compounds conduct electricity.

Question 17

**How is ionic bond formed? Give the main physical and chemical properties of compounds having ionic bonding.**

**Ans.**

Ionic bond is formed by the transfer of one or more electrons from one atom to another. The atom which gives electron is the metal while the receiving atom is generally the non-metal.

General characteristics of ionic bonding:

- Ionic bond is non-directional in character.
- Compounds having ionic bond are soluble in polar solvents.
- They have high melting and boiling point.
- Ionic bonded compounds conduct electricity in solution and molten form.
- In solution, ionic compounds show fast and instantaneous reactions.

Question 18

**Discuss the factors on which the magnitude of bond energy depends.**

**Ans.**

Bond energy depends on:

- *Size of the participating atom:* Large the size of participating atom, smaller is the value of bond energy. The large size of the atom allows lesser extent of orbital overlapping.
- *Multiplicity of bond:* The magnitude of bond energy increases with the multiplicity of bond, even though the atoms involved would be the same. This is because the number of shared electrons increases with the multiplicity of bonds.

Question 19

**What do you understand by the bond energy for the O=O bond is 498 kJ/mole?**

**Ans.**

If the bond energy for O=O bond is 498 kJ/mole, 498 kJ is needed to break one mole of O=O bonds.

Bond energy is the amount of energy required to break one mole of bond of same kind, so as to separate the bonded atoms in the gaseous state.

Question 20

Compare three types of bonding in terms of bond energy and directional characteristics.

Ans.

Type of Bond	Bond Energy	Other characteristics
Ionic	strong	Non-directional
Covalent	variable	Directional
Metallic	variable	Non-directional

Question 21

Define bond length. Mentions its unit of measurement. On what factors does bond length depend?

Ans.

The average distance between the centres of the nuclei of the two bonded atoms in a molecule is known as bond length. It is expressed in Angstrom units ( $\text{\AA}$ ) or picometres (pm).

Bond length depends on:

**Size of atoms:** Bond length increases with the increase in the size of the atoms.

**Multiplicity of bonds:** the bond length decreases with the multiplicity of bonds.

Question 22

Why is the bond angle of water molecule less than the normal?

Ans.

Water molecule is made of two hydrogen atoms and one oxygen atom. Oxygen atom has 2 lone pair of electrons. This causes a slight redistributing of the charges around the oxygen.

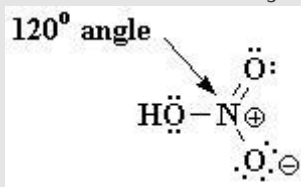
The lone pair of electrons pushes the bonded electrons together, decreasing the size of the angle.

Question 23

Draw an accurate Lewis structure for  $\text{HONO}_2$ , including all non-bonded electron pairs and formal charges. Additionally, provide bond angles around the nitrogen atom.

Ans.

The structure of  $\text{HNO}_3$  is:



Question 24

**What are bond pair and lone pair of electrons?**

**Ans.**

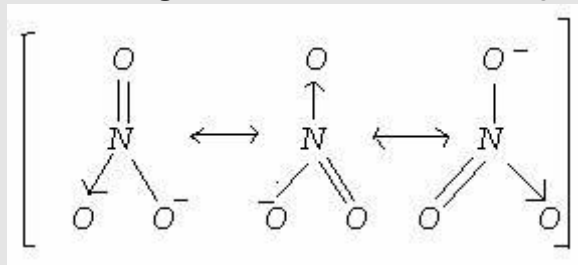
Bond pair of electrons is the electron pair that is directly involved in bond formation. The lone pair of electrons is electron pairs which are not involved directly in bonding.

Question 25

**Draw the resonating structures of nitrate ion? Calculate the bond order of N-O.**

**Ans.**

The resonating structures of nitrate ion  $\text{NO}_3^-$  are:



Bond order of NO bond is  $= \frac{4}{3} = 1.33$

Question 26

**Define bond enthalpy. Give its units.**

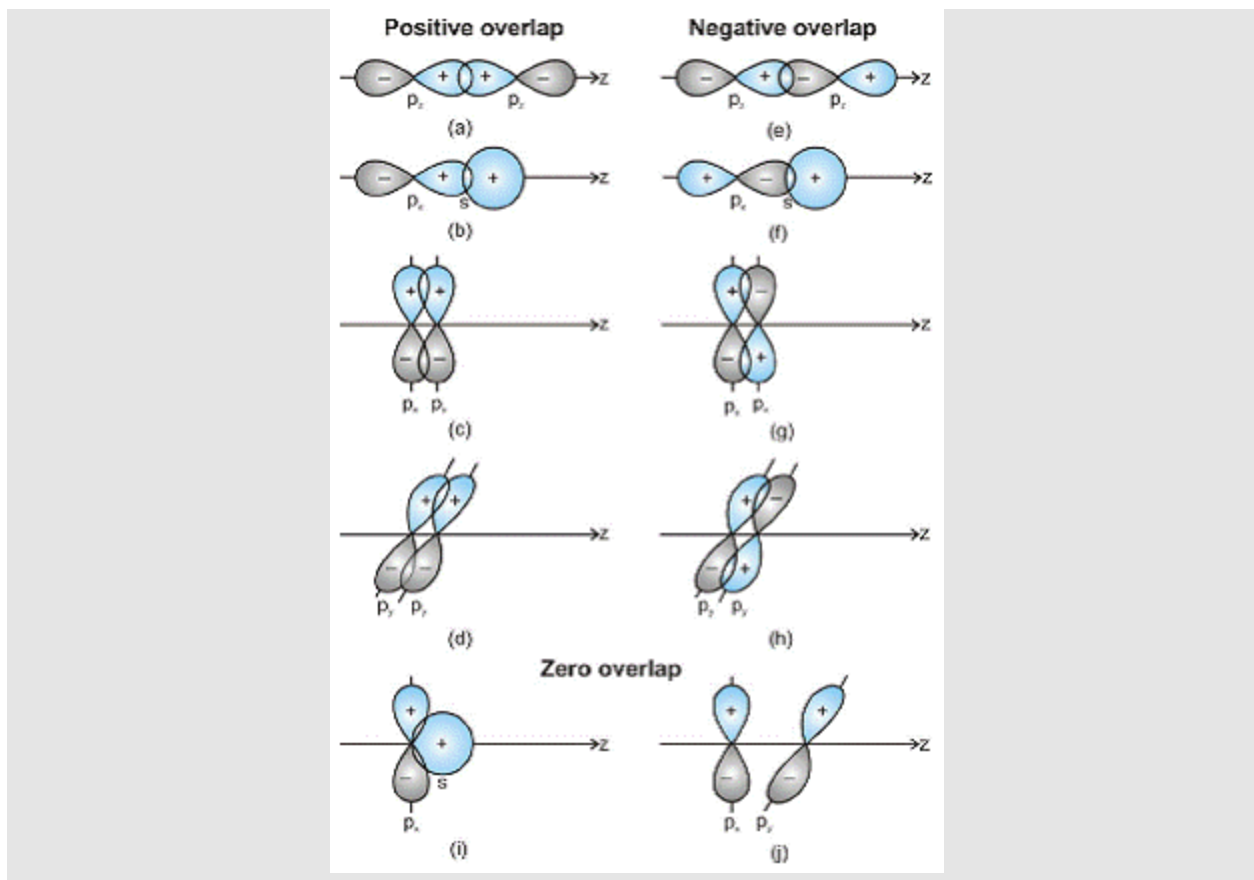
**Ans.**

The amount of energy required to break one mole of bonds of a particular type between two atoms in a gaseous state is known as bond enthalpy. Its unit is  $\text{kJ mol}^{-1}$ .

Question 27

**Draw the diagrams showing positive, negative and zero overlap.**

**Ans.**



Question 28

**Explain why helium molecule does not exist?**

**Ans.**

Helium atom ( $1s^2$ ) has 2 electrons in its  $1s$  orbital. During the approach of two helium atoms, the repulsive forces are dominant over the attractive forces. As a result the energy of the system increases which leads to instability. Since energy of the separate helium atoms is smaller than that of the system when they are close to each other, they prefer to stay separate and do not form  $He_2$  molecule.

Question 29

**Define hybridization. Show the formation of ammonia ( $NH_3$ ) molecule.**

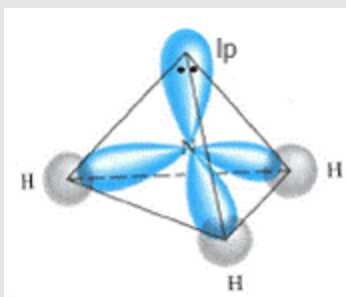
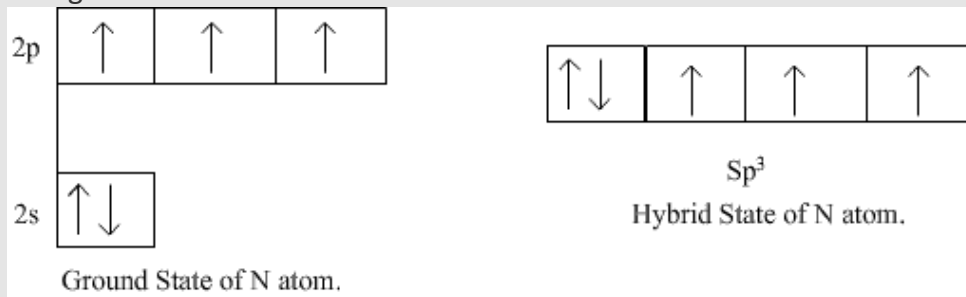
**Ans.**

i) The phenomena of intermixing of atomic orbitals of slightly different energies of the atom (by redistributing their energies) to form new set of orbitals of equivalent energies and identical shape is known as hybridization.

ii) **Formation of ammonia molecule**-In ammonia molecule the nitrogen atom is  $sp^3$  hybridized. Three  $sp^3$ -hybrid orbitals of N atom are used for forming  $sp^3-s$   $\sigma$  (sigma) bonds with H atoms.



The fourth  $sp^3$ -hybrid orbital carry lone pair of electrons. The relatively larger lp-bp interactions cause H-N-H angle to decrease from  $109^\circ 28'$  to  $107^\circ$ .



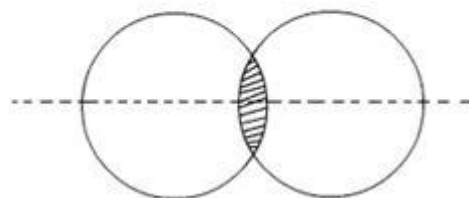
Question 30

**Explain the formation of sigma and pi bond.**

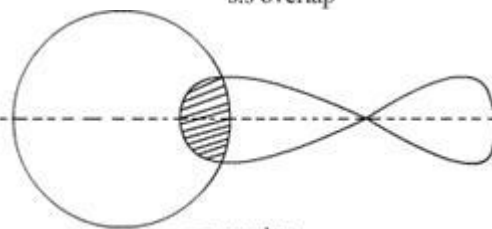
**Ans.**

Sigma bond is formed by the axial overlapping of half filled atomic orbitals where as pi bond is formed by the lateral or sidewise over lap of the atomic orbitals.

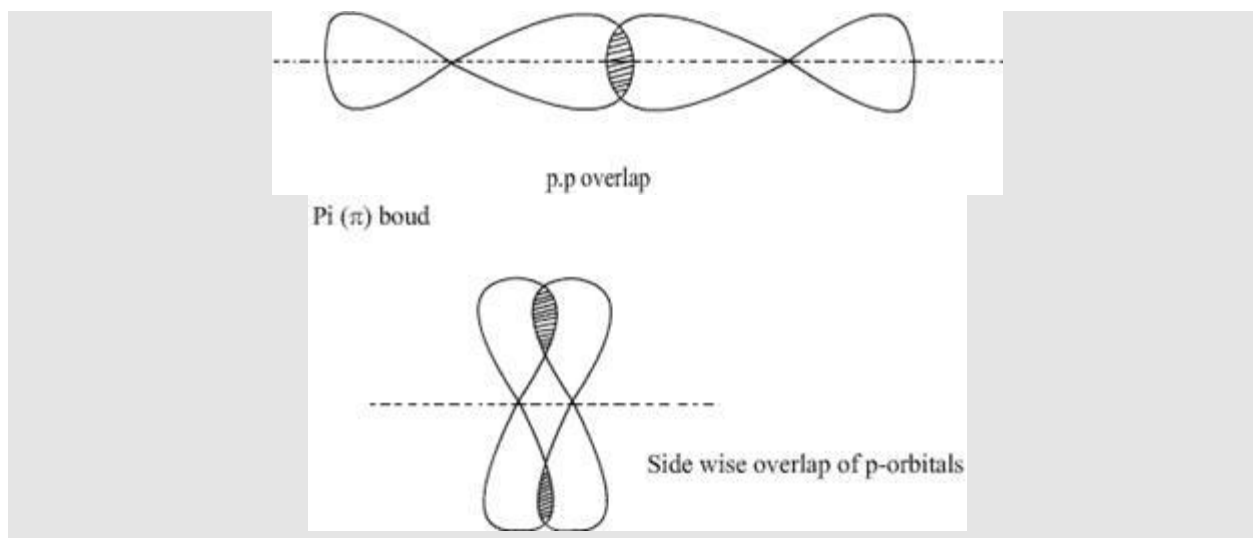
Sigma ( $\sigma$ ) bond



s.s overlap



s.p overlap



Question 31

**Differentiate between valence bond theory and Lewis concept in regard to the formation of covalent bond**

Ans.

Lewis concept	Valence bond theory
i) Lewis concept considers the formation of covalent bond by mutual sharing of electrons.	i) Valence bond theory considers the formation of covalent bond by overlap of half filled atomic orbitals.
ii) It does not provide explanation for different shape of molecules.	ii) Valence bond theory explains the shape of molecules.
iii) Lewis structure does not explain the bond strength	iii) Valence bond theory explains the bond strength.

Question 32

**What is the hybrid state of**

**B in  $\text{BF}_3$ , Al in  $\text{AlCl}_3$ , Be in  $\text{BeCl}_2$ , C in  $\text{CO}_2$  and  $\text{C}_2\text{H}_4$ ; S in  $\text{SO}_2$  and  $\text{SO}_3$ .**

Ans.

Element	Compound	Hybrid state
B	$\text{BF}_3$	$sp^2$
Al	$\text{AlCl}_3$	$sp^2$
Be	$\text{BeCl}_2$	$sp$
C	$\text{CO}_2$	$sp$
C	$\text{C}_2\text{H}_4$	$sp^2$
S	$\text{SO}_2$ and $\text{SO}$	$sp^2$ in both

Question 33

**Name the d- orbitals that are involved in  $sp^3d^2$  hybridization**

**Ans.**

In  $sp^3d^2$  hybridization  $dx^2-y^2$  and  $dz^2$  orbitals are involved.

Question 34

**Name one cation which is isostructural with  $NH_3$ .**

**Ans.**

$H_3O^+$  is  $sp^3$  hybridized and have pyramidal shape so it is isostructural with  $NH_3$ .

Question 35

**How many lone pairs, bond pairs are present around S in  $SF_4$  molecule? What is their arrangement?**

**Ans.**

In  $SF_4$  molecule, 4 bond pair and 1 lone pair is present. The arrangement is trigonal bipyramidal.

Question 36

**Among  $H_2^+$  and  $H_2^-$  molecular ions which ion is more stable and why?**

**Ans.**


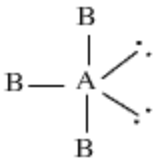
Among  $H_2^+$  and  $H_2^-$  molecular ions,  $H_2^+$  ion is more stable because the electron in  $H_2^+$  is present only in bonding orbital.

### Geometry & shapes of molecules

Question 37

**Draw the shapes of  $AB_2E_2$  and  $AB_3E_2$  type of molecules. Also mention the number of bond pairs, lone pair of electrons and example of the molecules.**

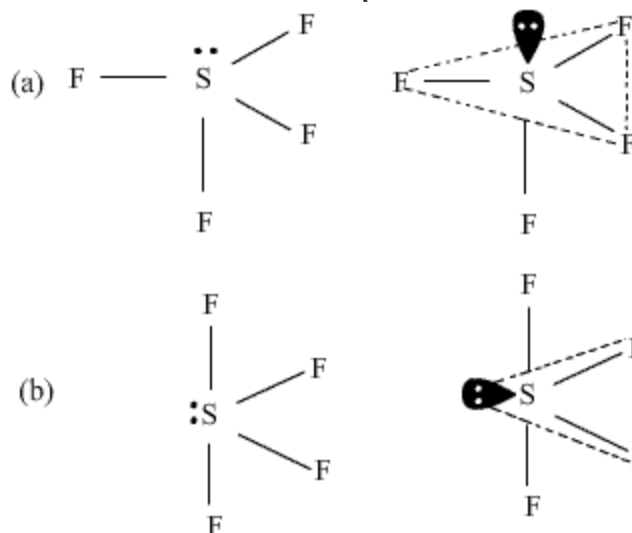
**Ans.**

Molecule type	No. of bonding pairs	No. of lone pairs	Arrangement of electron pairs	Shape	Examples
$AB_2E_2$	2	2	 Tetrahedral	Bent	$H_2O$
$AB_3E_2$	3	2	 Trigonal bi-pyramidal	T-shape	$ClF_3$

Question 38

Among the following structures of  $SF_4$  which one is more stable and why?

What is this shape called?



Ans.

In figure (a), the lone pair of electrons is present at the axial position so there are three lone pair-bond pair repulsions at  $90^\circ$ . In the second figure, the lone pair of electrons is present in the equatorial position and there are two lone-pair bond-pair repulsions. Hence figure b is more stable as compared to figure a. The shape shown in figure b is distorted tetrahedron, a folded square or a see saw.

Question 38

The bond angles of  $\text{PF}_3$ ,  $\text{PCl}_3$ ,  $\text{PBr}_3$  and  $\text{PI}_3$  are  $97^\circ$ ,  $100^\circ$ ,  $101.5^\circ$  and  $102^\circ$  respectively. This data shows a gradual increase in the bond angle. Explain why?

Ans.

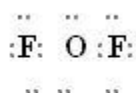
As the electro negativity of surrounding atom decreases, the electron pair lie closer to the central atom so the repulsion between the electrons increases and the bond angle also increases.

Question 39

Using VSEPR theories identify the type of hybridization and draw the structure of  $\text{OF}_2$  molecule.

Ans.

The Lewis dot structure  $\text{OF}_2$  is:



In  $\text{OF}_2$  molecule O is surrounded by 2 bond pair and 2 lone pair of electrons. Hence the arrangement of the bond pairs and the lone pairs should be tetrahedral. Therefore the hybrid state of oxygen should be  $\text{sp}^3$ .

Question 40

Explain why  $\text{MgCl}_2$  is a linear molecule while  $\text{SnCl}_2$  is angular?

Ans.

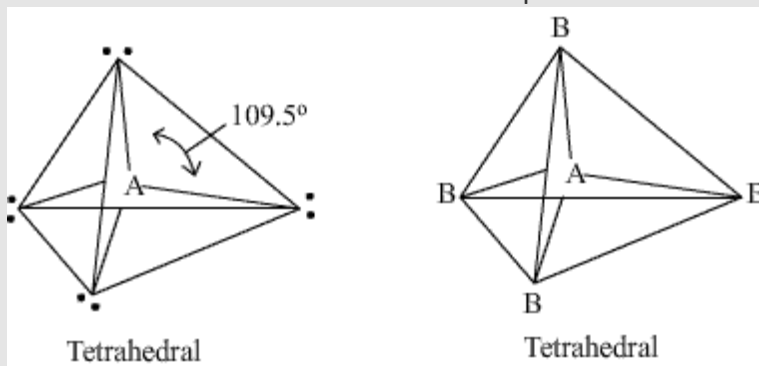
In  $\text{MgCl}_2$ , the central atom i.e. the magnesium ion is surrounded by only two bond pairs so there is no repulsion and the compound possesses a regular geometry whereas in the case of  $\text{SnCl}_2$  molecule the central atom is surrounded by two bond pairs and two lone pairs of electrons which leads to repulsion among them as a result the molecule possesses distorted geometry.

Question 41

A compound A has 4 pairs of electrons around the central atom and makes an angle of  $109^\circ 28'$ . Draw the shape of the compound.

Ans.

The compound has 4 pairs of electrons around the central atom and makes an angle of  $109^{\circ}28'$ , so it is tetrahedral in shape.



Question 42

**Give examples of the compounds which show  $AB_5$  and  $AB_6$  geometry.**

**Ans.**

$AB_6$ - $SF_6$ ,  
 $AB_5$ - $PCl_5$ ,  $SbCl_5$ .

$TeF_6$

Question 43

**What is the dipole moment and geometry of  $H_2$  and  $CO_2$  molecule?**

**Ans.**

The dipole moment of  $H_2$  and  $CO_2$  molecules is zero and their shapes are linear.

Question 44

**Why does the pair of electrons in the valence shell repel each other?**

**Ans.**

The pairs of electrons in the valence shell repel each other because their electron clouds are negatively charged.

Question 45

**Name two species which have tetrahedral shape.**

**Ans.**

$CH_4$  and  $NH_4^+$  have tetrahedral shape.

Question 46

**(i) Describe the conditions necessary for hydrogen bonding.**

**(ii) Differentiate between intermolecular and intramolecular hydrogen bonding.**

**(iii) How does energy of the conical structures contribute to the stability of resonance hybrid?**

Ans.

(i) The two conditions that are necessary for hydrogen bonding are:

- (a) Hydrogen atom should be bonded to a highly electronegative atom.
- (b) The size of the electronegative atom should be small.

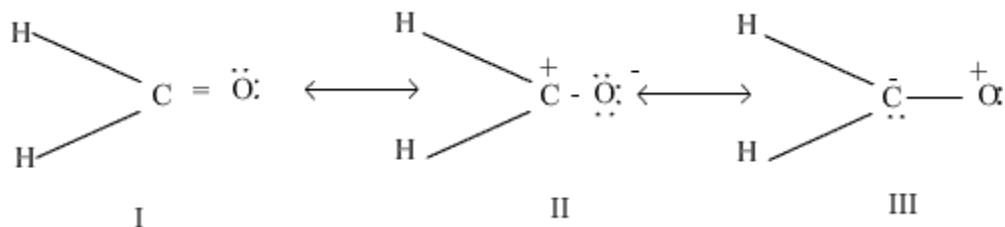
(ii)

Intermolecular hydrogen bonding	Intramolecular hydrogen bonding
(i) It is formed between two different molecules of the same or different substances.	(i) It is formed between the hydrogen atom and highly electronegative atom present within the same molecule.
(ii) Example: HF, alcohol, water molecule.	(ii) Example: O-nitro phenol, O-nitro benzoic acid.

(iii) The conical structures of similar energy contribute equally to the resonance hybrid where as the structure with higher energy is less stable and has lesser contribution to the resonance hybrid.

Question 47

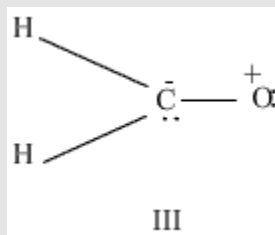
Out of the following resonating forms of formaldehyde which one is least significant and why?



ii) What are the factors on which the dipole moment of polyatomic molecules depends?

Ans.

i) Among the given structures the III structure is least significant because here positive charge is present on more electronegative atom.



ii) The dipole moment of polyatomic molecules depends upon the individual dipole moments of the bonds and the spatial arrangement of various bonds of the molecules.

