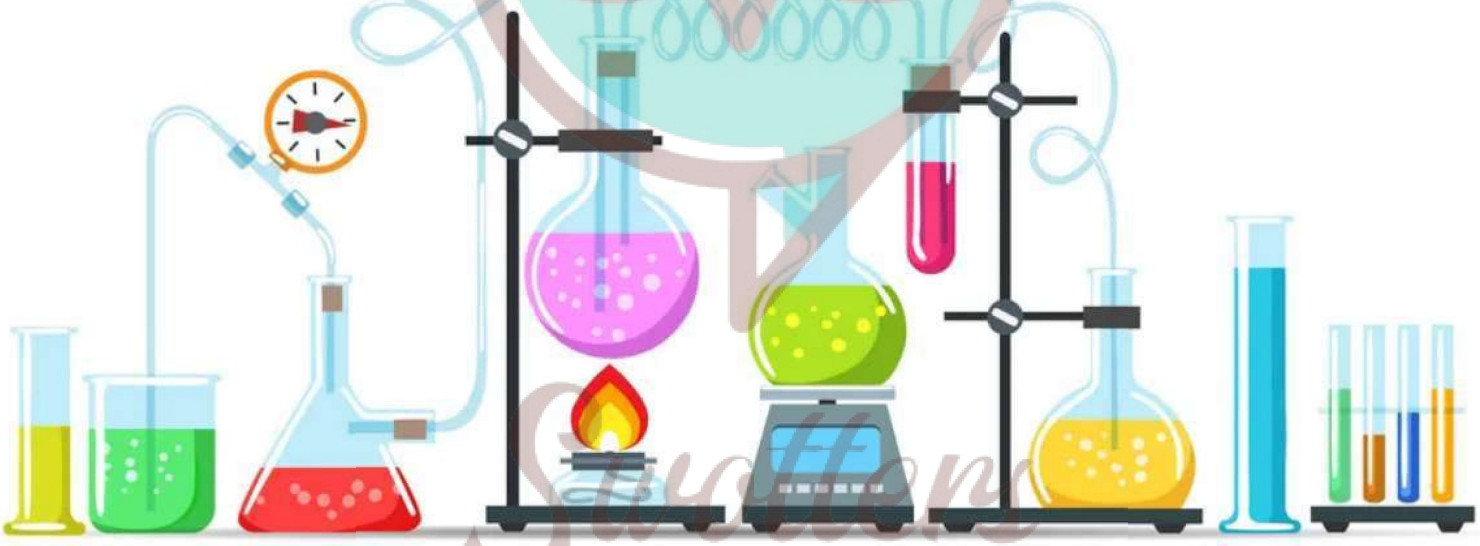
# CHEMISTRY



# Important Questions

## Multiple Choice questions-

Question 1. Three containers A, B, C of equal volume contain oxygen, neon and methane respectively at same temperature and pressure. The increasing order of their masses is

(a) A < B < C

(b) B < C < A

(c) C < A < B

(d) C < B < A

Question 2. A gas will approach ideal behaviour at

(a) Low temperature, low pressure

(b) Low temperature, high pressure

(c) High temperature, low pressure

(d) High temperature, high pressure

Question 3. Containers A and B have same gas. Pressure, volume and temperature of A are all twice those of B. The ratio of number of molecules of A and B is

(a) 1 : 2

(b) 2 : 1

(c) 1 : 4

(d) 4 : 1

Question 4. According to kinetic theory of gases,in an ideal gas,between two successive collisions a gas molecule travels

(a) In a circular path

(b) In a wavy path

(c) In a straight line path

(d) With an accelerated velocity

Question 5. When did substances exist in different crystalline forms the phenomenon is called:

(a) Allotropy

(b) Polymorphism

(c) Polymerization

(d) Isomorphism

Question 6. Sl unit of pressure is :

(a) Pascal

(b) torr

(c) mm of Hg

(d) none of the above

Question 7. If the pressure of a gas is increased then its mean free path becomes:

(a) 0

(b) Less

(c) More

(d) Infinity

Question 8. 1 atmosphere is equal to:

(a) 1 torr

(b) 760 cm

(c) 760 mm

(d) 76 torr

Question 9. Grahams law refers to :

(a) Boiling point of water

(b) Gaseous Diffusion

(c) Gas Compression

(d) Volume changes of gases

Question 10. The rise or fall of a liquid within a tube of small bore is called :

(a) Surface Tension

(b) Capillary Action

(c) Viscosity

(d) Formation of Curvature

Question 11. The rates of diffusion of gases are inversely proportional to square root of their densities . This statement refers to :

(a) Daltons Law

(b) Grahams Law

(c) Avogadros Law

(d) None of the Above

Question 12. Cooling is caused by :

(a) Evaporation

(b) Convection

(c) Conduction

(d) none of the above

Question 13. If helium and methane are allowed to diffuse out of the container under the similar conditions of temperature and pressure, then the ratio of rate of diffusion of helium to methane is:

(a) 2 : 1

(b) 1 : 2

(c) 3 : 5

(d) 4 : 1

Question 14. Equal masses of ethane and hydrogen are mixed in an empty container at 25°C . The fraction of total pressure exerted by hydrogen is

(a) 1 : 2

(b) 1 : 1

(c) 01 : 16

(d) 15 : 16

Question 15. The volume of 2.8 g of carbon monoxide at 27°C and 0.0821 atm is

(a) 30 L

(b) 3 L

(c) 0.3 L

(d) 1.5 L

## Very Short:

1. What change in energy takes place when a molecule is formed from its atoms?
2. Arrange the following in order of increasing bond strengths.
3. Name the shapes of the following molecules: $CH_4$, $C_2H_2$, $CO_2$.
4. Arrange the following in order of increasing strengths of hydrogen bonding O, F, S, Cl, N
5. Identify the compound/compounds in the following in which S does not obey the Octet rule: $SO_2$, $SF_2$, $SF_4$, $SF_6$.
6. Name one compound each involving $sp^3$, $sp^2$, sp hybridization.
7. s-s, s-p, p-p form a bond, and only p-p form π bond.

## Short Questions:

1. Which out of $CH_3F$ and $CH_3Cl$ has a higher dipole moment and why?
2. Define the term chemical bond. What are its different types?
3. Why covalent bonds are called directional bonds whereas ionic bonds are called non-directional?
4. $AlF_3$ is a high melting solid whereas SiF4 is a gas. Explain why?
5. Using the VSEPR theory identifies the type of hybridization and draw the structure of $OF_2$ What are oxidation states of O and F?
6. Account for the following: The experimentally determined N-F bond length in $NF_3$ is greater than the sum of the single covalent radii of N and F.

## Long Questions:

1. State with reasons, which is more polar $CO_2$ or $N_2O$?
2. Out of peroxide ion ($O_2$) and superoxide ion ($O_2$) which has larger bond length and why?
3. Explain the formation of the following molecules according to the orbital concept, F2, HF, $O_2$, $H_2O$, $N_2$, $NH_3$ molecules.
4. What is a hydrogen bond, what are its causes, and give the conditions for hydrogen bonding? What is the strength of hydrogen bonding? Describe the two types of hydrogen bonding.

## Assertion Reason Questions:

1. In the following questions, a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

   **Assertion (A):** Three states of matter are the result of balance between

   intermolecular forces and thermal energy of the molecules.

   **Reason (R):** Intermolecular forces tend to keep the molecules together but

   thermal energy of molecules tends to keep them apart.

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

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

   (iii) A is true but R is false.

   (iv) A is false but R is true.

2. In the following questions, a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

**Assertion (A):** At constant temperature, pV vs V plot for real gases is not a straight line.

**Reason (R) :** At high pressure all gases have Z > 1 but at intermediate pressure most gases have Z < 1.

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

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

(iii) A is true but R is false.

(iv) A is false but R is true.

## Case Study Based Question:

1. Intermolecular forces are the forces of attraction and repulsion that exist between molecules of a compound. These cause the compound to exist in a certain state of matter – solid, liquid or gas and affect the melting and boiling points of compounds as well as the solubilities of one substance in another. Attractive intermolecular forces are also called van der Waals' forces. These are weak forces.

   (1) Dipole-dipole forces act between the molecules possessing permanent dipole. Ends of dipoles possess 'partial charges'. The partial charge is:

   (a) More than unit electronic charge

   (b) Equal to unit electronic charge

   (c) Less than unit electronic charge

   (d) Double the unit electronic charge

   (2) The nature of inter-particle forces in benzene is:

   (a) Dipole-dipole interaction

   (b) Dispersion force

   (c) Ion-dipole interaction

   (d) H-bonding.

   (3) The interaction energy between two temporary dipoles is proportional to (where r is the distance between the two particles)

   (a) $1/r^4$

   (b) $1/r^2$

   (c) $1/r^5$

   (d) $1/r^6$

   (4) Attractive intermolecular forces known as van der Waals forces do not include which of the following types of interactions?

   (a) London forces

(b) Dipole-dipole forces

(c) Ion-dipole forces

(d) Dipole-induced dipole forces

(5) In which of the following molecules, the van der Waals forces are likely to be the most important in determining the m.pt. and b.pt?

(a) CO

(b) $H_2S$

(c) $Br_2$

(d) HCl

2. If a hydrogen atom is bonded to a highly electronegative element such as fluorine, oxygen, nitrogen, then the shared pair of electrons lies more towards the electronegative element. This leads to a polarity in the bond in such a way that a slight positive charge gets developed on H-atom, viz

$$H^{\delta+} : O^{\delta-} \qquad H^{\delta+} : F^{\delta-} \qquad H^{\delta+} : N^{\delta-}$$

Such a bond between the hydrogen atom of one molecule and the more electronegative atom of the same or another molecule is called a hydrogen bond.

(1) Which of the following compounds can form hydrogen bond?

(a) $CH_4$

(b) $H_2O$

(c) NaCl

(d) $CHCl_3$

(2) The boiling point is not affected due to hydrogen bonding in:

(a) Water

(b) Ammonia

(c) Methyl alcohol

(d) Hydrogen chloride

(3) Unusual high b.p. of water is result of:

(a) Intermolecular hydrogen bonding

(b) Intramolecular hydrogen bonding

(c) Both intra and intermolecular hydrogen bonding

(d) High specific heat

(4) Which of the following statements is not true?

(a) Intermolecular hydrogen bonds are formed between two different molecules of compounds.

(b) Intramolecular hydrogen bonds are formed between two different molecules of the same compound.

(c) Intramolecular hydrogen bonds are formed within the same molecule.

(d) Hydrogen bonds have a strong influence on the physical properties of a compound.

## Answer Key:

### MCQ

1. (a) 0
2. (a) $Sp^2$
3. (b) Sp and $sp^2$
4. (c) $sp^3$, 0
5. (d) $K^+ < Ca^{2+} < Mg^{2+} < Be^{2+}$
6. (c) Acetonitrile
7. (c) $O_2^-$
8. (c) Triangular
9. (b) $A_2 B_3$
10. (b) $SF_4$
11. (c) NaCl
12. (d) Ice
13. (d) $NO^+$ and $CN^+$
14. (c) HCl and He atoms
15. (b) sp and $sp^2$

### Very Short Answer:

1. There is a fall in energy.

2. $F_2 < Cl_2 < O_2 < N_2$

3. $CH_4$: Tetrahedral; $C_2H_2$: Cylindrical; $CO_2$: linear

4. Cl < S < N < O <F.

5. $SF_4$, $SF_6$.

6. $sp^3$: $CH_4$: $sp^2$: $C_2H_4$: sp: $C_2H_2$

7. s-s, s-p, p-p form a bond, and only p-p form π bond.

## Short Answer:

**Ans: 1.** The dipole moment of $CH_3Cl$ is greater than that of $CH_3F$. The C-F bond length in $CH_3F$ is smaller than the C-Cl bond length in $CH_3Cl$. The charge separation in the C-F bond is more than in t Cl-C bond- fluoride being more electronegative than chlorine. The bond length has a greater effect than the charge separation. Hence the dipole moment of $CH_3C1$ is greater than that of $CH_3F$.

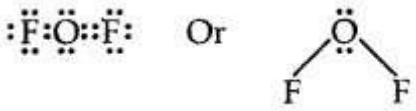
**Ans: 2.** The attractive forces which hold the constituent atoms in molecules or species in lattices et are called a chemical bond.
They are of the following types:

1. Electrovalent or ionic bond
2. Covalent bond
3. Coordinate or dative bond
4. metallic bond
5. hydrogen bond
6. van der Waals forces.

**Ans: 3.** A covalent bond is formed by the overlap of half-filled atomic orbitals which have definite directions. Hence covalent bond is directional. In ionic compounds, each ion is surrounded by a number of oppositely charged ions and hence there is no definite direction.

**Ans: 4.** $AlF_3$ is an ionic solid due to the large difference in electronegativities of Al and F whereas $SiF_4$ is a covalent compound and hence there are only weak van der Waal's forces among its molecules.

**Ans: 5.** The electron dot structure of $OF_2$ is

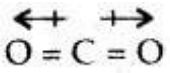


Thus, the central atom (O-atom) has 4 pairs of electrons (2 bond pairs and 2 lone pairs). Hence oxygen in $OF_2$ is $sp^3$ hybridized and the molecule is V-shaped oxidation state of F = – 1, oxidation state of O = + 2.

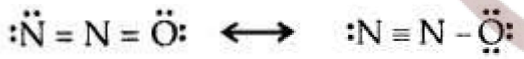
**Ans: 6**. This is because both N and F are small and hence have high-electron density. So they repel the bond pairs thereby making the N-F bond length larger.

## Long Answer:

**Ans: 1.** $N_2O$ is more polar than $CO_2$ which is a linear molecule and thus symmetrical. Its net dipole moment is zero.



$N_2O$ is linear but unsymmetrical. It is a resonance hybrid of the following canonical structures:

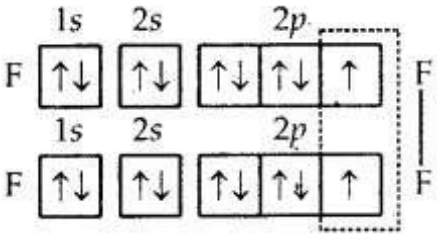


It has a net dipole moment of 0.116 D.

**Ans: 2.** The bond order of $O_2^-$ is 1.5 while that of $O_2^{2-}$ is 1.0.

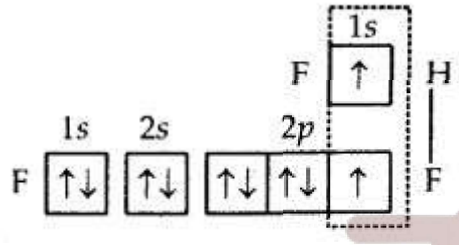
The lesser the bond order, the greater is the bond length as the bond order is inversely proportional to bond length. (Hence $O_2^{2-}$ has a larger bond length than $O_2^{2-}$.

**Ans: 3**. 1. Formation of F2 molecule. Atomic number (Z) of fluorine is 9 and its orbital electronic configuration is $1s^2\ 2s^2\ 2p^2x, 2p^2y, 2p^1z$. Thus, a fluorine atom has one half-filled atomic orbital. Therefore, two atoms of fluorine combine to form the fluorine molecule as a result of the combination for their half-filled atomic orbitals shown in Fig. The two atoms get linked by a single covalent bond

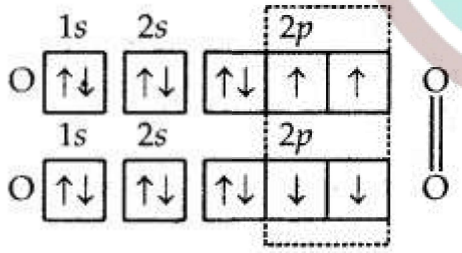


Formation of $F_2$ molecule

2. Formation of HF molecule. Fluorine atom, as stated above, has one half-filled atomic orbital. Hydrogen atom (Z = 1) has only one electron in Is orbital. Thus, the hydrogen fluoride (HF) molecule. is formed as a result of the combination (or overlap) of the half-filled orbitals belonging to the participating atoms.



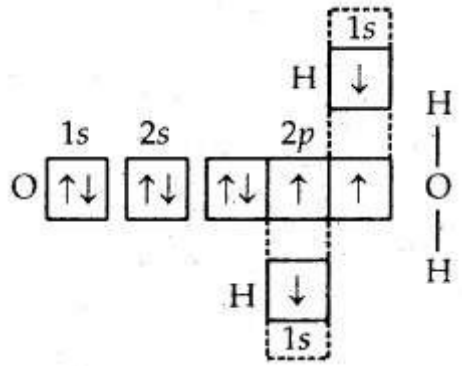

3. Formation of $O_2$ molecules. The atomic number (Z) of oxygen is 8 and its orbital electronic configuration is $1s^2\ 2s^2\ 2p^2x\ 2p^1x\ 2p^1z$. This means that an oxygen atom has two half-filled orbitals with one electron each. Two such atoms will combine to form a molecule of oxygen as a result of the overlap of the half-filled orbitals with opposite spins of electrons.




Formation of $O_2$ molecule

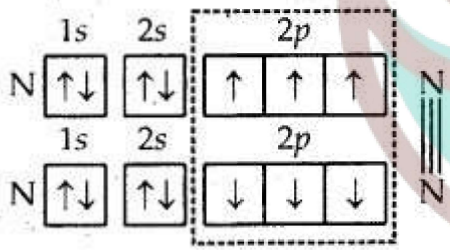
Thus, the two atoms of oxygen are bonded to each other by two covalent bonds or double bonds (O = O).

4. Formation of $H_2O$ molecule. In the formation of the $H_2O$ molecule, the two half-filled orbitals of the oxygen atom combine with the half-filled orbitals (1s) of the hydrogen atoms. Thus, the oxygen atom gets linked to the two hydrogen atoms by single covalent bonds as shown in



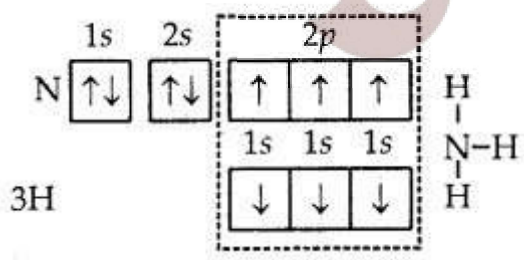

Formation of $H_2O$ molecule

5. Formation of $N_2$ molecule. The atomic number of nitrogen is 7 and its orbital electronic configuration is $1s^2\ 2s^2\ 2p^1x\ 2p^1y\ 2p^1\ z$. This shows that the nitrogen atom has three half-filled atomic orbitals. Two such atoms combine as a result of the overlap of the three half-filled orbitals and a triple bond gets formed (N = N)




Formation of $N_2$ molecule

6. Formation of $NH_3$ molecule. In the formation of ammonia ($NH_3$) molecule, three half-filled orbitals present in the valence shell of nitrogen atom combine with 1s orbital of three hydrogen atoms with one electron each. As a result, the nitrogen atom completes its octet and a molecule of $NH_3$ is formed in which the nitrogen atom is linked to three hydrogen atoms by covalent bonds.




Formation of $NH_3$ molecule

**Ans: 4.** When hydrogen is connected to small highly electronegative atoms such as F, O, and N in such cases hydrogen forms an electrostatic weak bond with an electronegative atom of the second molecule, this type of bond binds the hydrogen atom of one molecule and the

electronegative atom of the 2nd molecule is called as hydrogen bond. It is a weak bond and it is denoted by dotted lines e.g., in HF, hydrogen forms a weak bond with the electronegative F atom of the 2nd molecule neighboring HF.

$$\overset{\delta+}{H}-\overset{\delta-}{F}.....\overset{\delta+}{H}-\overset{\delta-}{F}.....\overset{\delta+}{H}-\overset{\delta-}{F}$$

So it means hydrogen is acting as a bridge between two molecules by one covalent bond and the other by a hydrogen bond. Due to this hydrogen bonding, HF will not exist as a single molecule but it will exist as an associated molecule (HF)n. So hydrogen bond may be defined as a weak electrostatic bond that binds the hydrogen atom of one molecule and electronegative bond atoms (F, O, N) of the second neighboring molecule.

Cause of hydrogen bonding: When a hydrogen atom is bonded to an electronegative atom (say F, O, N) through a covalent bond, due to electronegativity difference, the electronegative atom attracts the shared pair of electrons towards its side with a great force as a result of which the shared pair of electrons will be displaced toward electronegative atom and away from a hydrogen atom.

Due to which hydrogen atom will acquire a slightly negative charge and if another molecule is brought nearer to it in such a way that electronegative atom of the second molecule faces hydrogen atom of the 1st molecule, due to opposite charges present on the atoms, an electrostatic bond will be formed between the hydrogen atom of one molecule and electronegative atom of 2nd molecule and this is called as hydrogen bond.

$$\overset{\delta+}{H}-\overset{\delta-}{F}.....\overset{\delta+}{H}-\overset{\delta-}{F}.....\overset{\delta+}{H}-\overset{\delta-}{F}$$

Conditions for hydrogen bonding. The following two necessary conditions for hydrogen bonding are:

1. Hydrogen atom should be connected to highly electronegative atom say F, O, or N.
2. The electronegative atom of which the hydrogen atom is connected should be the same in size.

The smaller the size of the electronegative atom greater will be the attraction of that atom for shared pair of electrons and hence that pair will be displaced more nearer to that atom and hence that atom will develop greater negative charge and the hydrogen atom will develop a greater positive charge and hence hydrogen atom of this molecule will easily attract negative atom of the Ian molecule and hence a hydrogen bond will be easily formed.

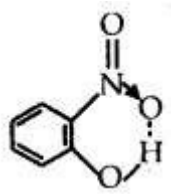
As both these conditions are satisfied only by F, O, N atoms so only three atoms show hydrogen bond.

Strength of Hydrogen Bond: A hydrogen bond is a very weak bond. It is weaker than an ionic or a covalent bond. Its strength ranges from 13 kJ mol-1 to 42 kJ $mol^{-1}$. The strength of the hydrogen bond for some of the molecules is the order H-F H (40 kJ mol-1) > O-H…… O (28 kJ $mol^{-1}$) > H-N…… H (13 kJ $mol^{-1}$) whereas the strength of a covalent bond is quite high. For example, the bond strength of the H-H bond in $H_2$ is 433 kJ $mol^{-1}$

Types of H-bonding

There are two types of hydrogen-bonds

1. Intermolecular hydrogen bond. It is formed between two different molecules of the same or different compounds. For example H-bond in case of HF, alcohol, or water.
2. Intramolecular Hydrogen bond. It is formed when a hydrogen atom is in between the two highly electronegative (F, O, N) atoms present within the same molecule. For example, in o-nitrophenol, hydrogen is in between the two oxygen atoms.



## Assertion Reason Answer:

1. (i) Both A and R are true and R is the correct explanation of A.
2. (ii) Both A and R are true but R is not the correct explanation of A.

## Case Study Answer:

**1. Answer:**

(1) (c) Less than unit electronic charge

(2) (b) Dispersion force

(3) (d) $1/r^6$

(4) (c) Ion-dipole forces

(5) (c) $Br_2$

**2. Answer:**

(1) (b) $H_2O$

(2) (d) Hydrogen chloride

(3) (a) Intermolecular hydrogen bonding

(4) (b) Intramolecular hydrogen bonds are formed between two different molecules of the same compound.