CHAPTER-2
CHEMICAL BONDING

Topic-1

Electrovalent and Covalent Bonding

Concepts covered: • *Electron dot structures,* • *Electrovalent bonding and its properties,* • *Covalent bonding and its properties.*

Revision Notes

- Stability of an atom means possessing the electron arrangement of an inert gas, i.e., octet in its outermost shell.
- To attain stability, atoms tends to combine chemically by the redistribution of electrons in the outermost shell or valence electrons in the outermost shell so that they attain a **stable electronic configuration** (duplet or octet).
- Chemical combination occurs due to tendency of elements to acquire the nearest noble gas configuration in their outermost orbit.
- An atom is electrically neutral. The number of positively charged particles (i.e., proton) is equal to the number of negatively charged particles (i.e., electrons). Every atom tries to attain the stable configuration of nearest inert gas, i.e., eight electrons in the valence shell. Atoms attain the stable electronic configuration by either losing, gaining or sharing electrons.
- The force of attraction that holds two atoms together to maintain the stability of a molecule is called **chemical bond.** Atoms form chemical bonds in order to attain stable electronic configuration of the nearest noble gas with the release of energy.

A stable electronic configuration is achieved by:

(i) transfer of valence electrons from one atom to another (ionic bond or electrovalent bond).

(ii) sharing the pairs of electrons between two atoms (covalent bond).

(iii) donation of a pair of electrons from one atom to another (coordinate bond).

- **Electrovalent Bond**

  A chemical bond formed by the transfer of valence electrons from one atom (metal) to another atom (non-metal) is called an **electrovalent** or an **ionic bond.**

- **Electrovalency**

  The number of electrons lost or gained by an atom to form an electrovalent bond is called **electrovalency.**
  Conditions for the formation of an electrovalent bond are:

  (i) Low ionisation potential **(ii)** High electron affinity

  (iii) Large electronegativity difference

- **Electron Dot Structure**

  The symbolic representation of an element indicating their valence shell electrons is called **electron dot structure** or **Lewis structure.** *For example,* Electron dot structure for hydrogen is H· and for oxygen is $:\ddot{O}:$

- **Electron Dot Structure of Some Electrovalent Compounds:**

  (i) NaCl $Na^{x} + \cdot\ddot{Cl}: \rightarrow Na^{+} [{}^{x}\ddot{Cl}:]^{-}$ or NaCl

  Sodium atom (2,8,1) — Chlorine atom (2,8,7) — Sodium ion (2,8) — Chloride ion (2,8,8) — Sodium chloride

  (ii) $MgCl_2$ $Mg^{x}_{x} + 2\cdot\ddot{Cl}: \rightarrow [{}^{x}\ddot{Cl}:]^{-} [Mg^{2+}] [{}^{x}\ddot{Cl}:]^{-}$ or $[Mg^{2+}] [{}^{x}\ddot{Cl}:]^{2-}$ or $MgCl_2$

  Magnesium atom (2,8,2) — Chlorine atom (2,8,7) — Magnesium ion (2,8) — Chloride ion (2,8,8) — Magnesium chloride

  (iii) CaO $Ca^{x}_{x} + :\ddot{O}: \rightarrow [Ca^{2+}] [{}^{x}_{x}\ddot{O}:]^{2-}$ or CaO

  Calcium atom (2,8,8,2) — Oxygen atom (2,6) — Calcium ion (2,8,8) — Oxide ion (2,8) — Calcium oxide

- **Properties of Electrovalent Compounds:**

  (i) Electrovalent or Ionic compounds are hard solids. As their constituent particles are ions that are held by strong electrostatic forces of attraction, hence they cannot be separated easily.

  (ii) Ionic compounds have high melting point and boiling point. They are non-volatile solids. As in these compounds ions are held by strong electrostatic forces of attraction so there exists a large amount of attraction between the ions.

  (iii) Ionic compounds do not conduct electricity in their solid state as the ions are not free. They are held by strong electrostatic forces of attraction. However they can conduct electricity in their fused, molten and in their aqueous solution. However, in their molten state the strong forces of attraction gets weakened and thus, the ions become free to conduct electricity. In aqueous solution, the high dielectric constant overcomes strong electrostatic forces of attraction thus, the ions become free to carry the electric current so they also act as strong electrodes.

  (iv) Ionic compounds are soluble in water but they are insoluble in organic solvents. As water has maximum dielectric constant, the force of attraction decreases between the ions and thus it forms free ions and hence they dissolve.

  (v) On passing electric current through molten, fused and aqueous solution of ionic compounds, the ions dissociate and migrate towards electrodes.

  (vi) Ionic compounds undergo fast reactions in their aqueous solutions.

- **Covalent Bond**

  The bond formed as a result of neutral sharing of electrons is called **covalent bond.** The covalent bond formation takes place between two non-metallic elements.

- **Conditions for the Formation of a Covalent Bond**

  The combining atoms should have:

  (i) Four or more electrons in outermost shell **(ii)** High electronegativity

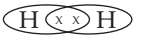
  (iii) High electron affinity **(iv)** High ionisation energy

  (v) Electronegativity difference should be zero or negligible.

➢ **Types of covalent bonds**

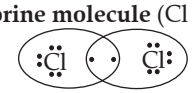
(i) A **single covalent bond** is formed by the sharing of one pair of electrons between the atoms, each atom is contributing only one electron. A single covalent bond is denoted by putting a single short line (—) between the two atoms.

(a) Formation of **hydrogen molecule** (H = 1)



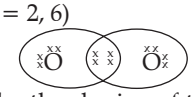
Or H — H ⟶ H_2

(b) Formation of **chlorine molecule** (Cl = 2, 8, 7)



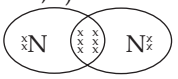
or Cl — Cl ⟶ Cl_2

(ii) A **double covalent bond** is formed by the sharing of two pairs of electrons between the two atoms to acquire stable electronic configuration. A double covalent bond is denoted by putting a double line (=) between the two atoms.
Formation of oxygen molecule (O = 2, 6)



or O = O ⟶ O_2

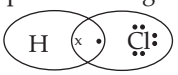
(iii) A **triple covalent bond** is formed by the sharing of three pairs of electrons between the two atoms. A triple covalent bond is denoted by putting three short lines (≡) between the two atoms.
Formation of nitrogen molecule (N = 2, 5)



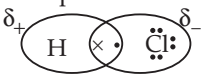
or N ≡ N ⟶ N_2

(iv) Polar covalent bonds: The covalent compounds in which the combining elements have large difference in their electronegativity are called polar covalent compounds.
Example: Hydrogen chloride gas (HCl), Water (H_2O) and Ammonia (NH_3).

(v) In case of hydrogen chloride gas, chlorine is more electronegative than hydrogen, therefore chlorine attracts the shared pair of electrons towards its side. Hence, chlorine acquires a partial negative charge and hydrogen acquires a partial positive charge. Thus, the bonds become polar.



Mutual sharing



Chlorine is more electronegative than hydrogen

(vi) The compounds formed by the mutual sharing of electrons are called as covalent compounds.

➢ **Properties of covalent compounds:**

(i) Covalent compounds are liquids or gases. Their constituent particles are held together by weak van der Waals forces.

(ii) Covalent compounds are volatile compounds with low melting point and boiling point. As in these compounds, the molecules are held by weak van der Waals forces, so less amount of energy is required to overcome these forces of attraction.

(iii) Covalent compounds do not conduct electricity as they do not contain ions. They only contain molecules.

(iv) On passing electric current through the covalent compounds, they do not ionise as they contain only molecules and not ions. However, polar covalent compounds on dissolving in water produce ions and thus act as electrolytes.

(v) Covalent compounds are insoluble in water but soluble in organic solvents.

(vi) Covalent compounds only contain molecules and their dissociation to ions does not take place.

(vii) Covalent compounds undergo slow speed of reactions.

Mnemonics

1. Concept: Bonding **Mnemonics:** **S**hare **C**oconuts **T**ogether **I**ndia **Interpretation:** **S**- Shared pair of electrons **C**- Covalent bond **T** – Transfer of electrons **I** – Ionic bonding	**Interpretation:** **D** – double bond **O** – Oxygen **N** – Nitrogen **T** – Triple bond **S** – Single bond **H** – Hydrogen **C** – Covalent **B** – Bond Oxygen has double Covalent bond Nitrogen has triple Covalent bond Hydrogen has single Covalent Bond
2. Concept: Covalent bond examples **Mnemonics:** **DO NOT SHUT CARE BOX**	

Key Words

- **Ion:** Charged species of particles which exist freely in the solution.
- **Cation:** When an atom loses electron, it gets converted to positively charged particle called cation.
- **Anion:** When an atom gains electron, it gets converted to negatively charged particle called anion.
- **Octet rule:** It is the tendency of the atoms of the element to have eight electrons in its valence shell.
- **Noble Gases:** Gases which are chemically unreactive and have eight electrons in their valence shells. (except helium which has only two electrons in the first orbit).
- **Electropositive elements:** The elements which easily loose electrons and acquire positive charge are called electropositive elements. Metals are electropositive elements.
  Example: Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, etc.
- **Electronegative elements:** The elements which easily gain electrons and acquire negative charge are called electronegative elements. Non-metals are electronegative elements.
  Example: Cl^-, Br^-, I^-, F^-, O^{2-}, S^{2-}, N^{3-}, etc.
- **Electrovalency:** It is the number of electrons lost or gained by an atom of the element during the formation of ionic bond.
- **Crystal Lattice:** It is the definite, three dimensional geometrical arrangement of constituent atoms or ions in space.
- **Covalency:** It is the number of electrons contributed by an atom of the element for mutual sharing during the formation of a covalent bond.

Key Terms

- Sharing of one, two or three pairs of electrons between two atoms to form a covalent or molecular bond.
- The cation and anion being oppositely charged attract each other and form a chemical bond. Since, this chemical bond formation is due to the electrostatic force of attraction between a cation and an anion, it is known as electrovalent or ionic bond.
- Caesium fluoride (CsF) is the most ionic compound.
- Bonds formed between metals and non-metals are ionic or electrovalent.
- The electropositive atom undergoes oxidation while the electronegative atom undergoes reduction. This is known as redox process.
- The process by which covalent compounds are converted into ions is known as **ionisation.**
- The molecule that possesses both partial positive charge (δ^+) and partial negative charge (δ^-) is called a **dipole molecule.**
- Hydrogen can combine with all non-metals of Group IV A to VII A with the help of covalent bonds.

Topic-2

Coordinate Bonding

Concepts covered: • *Introduction of coordinate bond,* • *Characteristic properties of coordinate bond,* • *Formation of ammonium ion, hydronium ion and hydroxyl ion*

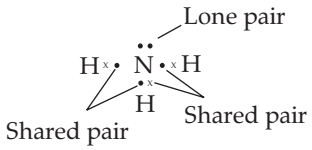
Revision Notes

Coordinate Bond:

- The bond formed between two atoms by sharing a pair of electrons both of which are contributed by only one of the bonding atoms but shared by both the atoms is called **coordinate bond.**
- The atom which provides the electron pair for the formation of a coordinate bond is known as **donor.** The atom or ion sharing the donated electron pair is known as **acceptor.**
- Coordinated bond has properties of both covalent and ionic bonds, thus, it is also known as **co-ionic bond.**
- A pair of electrons is not shared with any other atom for the formation of coordinate bond.
- The coordinate bond is shown by an arrow with its head pointing away from the donor to the acceptor atom ($\longrightarrow$).
- **Conditions for the Formation of Coordinate Bond**
  One of the two atoms must have at least one lone pair of electrons. While another atom should be deficient of at least one lone pair of electrons.

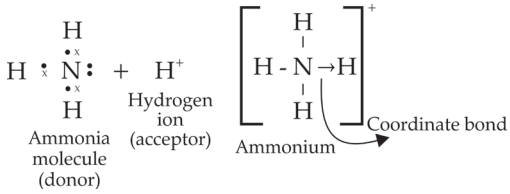
➢ **Formation of Ammonium Ion (NH_4^+)**

Ammonium ion (NH_4^+) is formed from ammonia molecule and hydrogen ion.



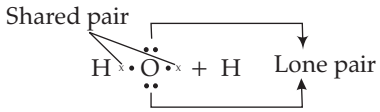
Formation of Ammonia

In ammonia (NH_3), N-atom have one lone pair of electrons, which is use for donation to H^+ ion for the formation of NH_4^+ ion.

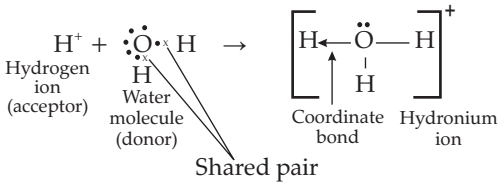


➢ **Formation of H_3O^+ Ion**

Hydronium ion is formed from water molecule and hydrogen ion. The oxygen atom of a water molecule possesses two lone pair of electrons.

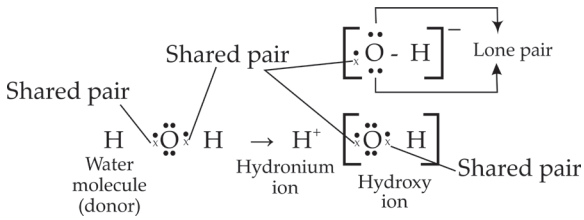


Out of these two lone pairs of electrons, one lone pair is used to donate to hydrogen ion.



➢ **Formation of Hydroxyl ion (OH^-)**

The hydroxyl ion or hydroxide ion is formed when one hydrogen ion (H^+) is removed from water molecule. After removing one hydrogen ion from water, the shared pair of electron remains with oxygen, as oxygen is more electronegative and thus hydroxyl ion has negative charge.



➢ **Self-ionization of water**

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

Hydronium ion — Hydroxide ion

Mnemonics

Concept: Examples of coordinate bond

Mnemonics: Aishwarya **M**ust **H**ave **N**ew **nterpretation:**

Heels **X**tra **L**arge

A M – ammonium

H N – Hydronium

HXL – hydroxyl ion

Key Words

- **Bond pair:** Bond pair of electrons is the pair of electrons shared between two atoms.
- **Lone pair:** Lone pair of electrons is present on one atom which does not take part in sharing.
- **Coordinate bond:** It is a special case of coordinate bond formed between two atoms in which both the electrons are contributed by one of the atoms whereas the other atom simply takes part in sharing.
- **Oxidation:** It is a chemical process in which an atom or an ion loses one or more electrons.
- **Reduction:** It is a chemical process in which an atom or ion loses one or more electrons.

Key Terms

- Addition of released H^+ ion to a lone pair of electrons of the oxygen atom of the polar water molecule leads to the formation of a hydronium ion.
- Hydronium ion is a hydrated proton.

$$\underset{\text{Proton}}{H^+} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+}$$

- When ammonium chloride (NH_4Cl) is formed, the cation NH_4^+ (possessing three covalent bonds and one coordinate bond) and anion Cl^- are attracted towards each other due to electrical charge between them, then ionic bond or electrovalent bond is formed. Hence, NH_4Cl is a good example of compound having all three types of bonds, i.e., covalent, coordinate and ionic bond.

❑❑