CHEMICAL COMBINATION

The rare or noble gases are very stable, owing to their electronic configuration. The tendency of the other elements is to try to attain this stable duplet or octet structure is achieved during chemical combination.

Chemical combination at most times result into compounds; at times it results into molecules of elements; and at other times it results into change of states.

There are two main types of chemical combination: *Electrovalent* (or ionic) *combination* and *Covalent* (ordinary and coordinate types) *combination*.

Electrovalent Combination

In electrovalent combination, there is a transfer of electrons from one atom (usually metallic) to another (usually non-metallic). Thus, we have atoms which acts as donors of electrons and those

which acts as acceptors of electrons. The electrons involved reside in the outermost shells of the atoms and are known as valence electrons. In electrovalent combination, after donating their valence electrons, metallic particles become positively charged, non-metallic particles becomes negatively charged after acquiring extra electrons. These charged particles are known as ions. Also, their number of protons (or atomic number) is unaffected by the transfer or acceptance of electrons.

This kind of combination results into electrovalent compounds which are very strong crystal structures. They exist mainly as solids in room temperature. They are hard and brittle. If a force is applied to such a crystal, it does not change the shape of the crystal, but it can shatter or fracture the crystal. Examples:

- The formation of sodium chloride (Na^+Cl^-)
  $Na \longrightarrow Na^+ + e^- + Cl \longrightarrow Na^+Cl^-$

- The formation of magnesium oxide ($Mg^{2+}O^{2-}$)
  $Mg \longrightarrow Mg^{2+} + 2e^{-} + O \longrightarrow Mg^{2+}O^{2-}$
- The formation of magnesium chloride ($Mg^{2+}2Cl^{-}$)
  $Mg \longrightarrow Mg^{2+} + 2e^{-} + 2Cl \longrightarrow Mg^{2+}2Cl^{-}$

Characteristics of Electrovalent Compounds

i. Electrovalent compounds have high melting and boiling points. For example, sodium chloride melt and boils at 801^{o}C and 1,467^{o}C repectively.

ii. Most ionic compounds readily dissolve in water, and other polar solvents like ethanol. They do not dissolve in non-polar solvents like benzene and tetrachloromethane.

iii. Ionic compounds can conduct electricity when molten and when dissolved in water. They do not conduct electricity in the solid state. As such we can say that they are

electrolytes. (Electrolytes are liquids which conduct electricity)

Ordinary Covalent Combination

In covalent combination, there is no transfer of electrons between the atoms. Instead, there is a sharing of a pair of electrons between the two reacting atoms so that both can attain the stable octet or duplet structure. This pair of electrons is known as the shared pair. Each reacting atom contributes one member of a shared pair. Sometimes, more than one pair of electrons may be shared between two reacting atoms. The shared electons may be regarded as revolving in orbits controlled by both nuclei, thereby forming the covalent bond. Thus, molecules (and not ions) are formed in covalent combination.

Diatomic molecules of elements are formed by covalent combination. Examples are the chlorine and hydrogen molecules. Organic

compounds are also formed by this method, e.g. the formation of methane.

Conventionally, the shared pair is represented by a stroke between the two atoms in the association, e.g. H–H, Cl–Cl, O=O, etc. Examples are:

- Formation of a hydrogen molecule, H_2



- Formation of a chlorine molecule, Cl_2



Other examples include the formation of water molecules, oxygen molecule, methane molecules, oxygen molecule, ammonia molecules, carbon(IV)oxide molecules, etc.

Characteristics of Covalent Compounds

i. Simple covalent compounds are often either gases or volatile liquids because their molecules being electrically neutral, are not bound by strong attractive forces.
ii. Covalent compounds usually dissolve in non-polar solvents and not in polar solvents like water.
iii. Most covalent compounds do not conduct electricity, i.e. they are not electrolytes. This is because covalent molecules do not contain charged particles.

Exceptional covalently bonded substances are diamond, graphite, hydrogen chloride gas, and water.

Coordinate Covalent Combination

Coordinate covalent combinationis also known as dative covalent combination. Like ordinary covalent combination, there is a sharing of electrons. But unlike the ordinary covalent boand, the shaped pair of electron is contributed by only one of the participants. Such pair of electrons is called the *lone pair*. Thus, one of the reactants in a coordinate covalent combination must have a *lone pair*. Examples:

- Formation of ammonium ion (NH_4^+)
- Formation of oxonium ion (H_3O^+)
- Hydration or ammonization of copper (II) ion, $[Cu(H_2O)_4]^{2+}$ or $[Cu(NH_3)_4]^{2+}$

Other compounds with the coordinate covalent bonds are the hexacyanoferrate (II), hexacyanoferrate (III), and silver diamine ion.

Other Binding Forces

Besides the ionic and covalent forces, other attractive forces also bind atoms and molecules together. The most important of these are the metallic bond, the Van der Waal's forces, and the hydrogen bond.

Metallic Bond. Some metals have one or two valence electrons which are loosely bound to the atom. These electrons move among the atoms in the metal, and are shared by the atoms in the metal. Thus, metals are said to be made up of positive ions embedded in a sea of delocalised or mobile electrons. These mobile electrons exert an attractive force on the positive ions which hold the atoms together in crystal lattice. The forces of attraction which hold metal atoms together in crystals lattice are called metallic bonds.

Van der Waals' Forces. Weak attractive forces exist even between discrete molecules. They were first described by J.D. Van der Waals. These

forces are very weak when compared with ionic and covalent bonds, but they are important in the liquefaction of gases and in the formation of molecular lattices as in iodine and naphthalene crystals.

Hydrogen Bond. The hydrogen bond is an intermolecular force which arises when hydrogen is covalently linked to elements like nitrogen, oxygen and fluorine. These elements are strongly electronegative. They require only a few electrons to attain their octet configuration. They tend to pull the shared pair of electrons in the covalent bonds towards themselves, resulting in the formation of a dipole where the hydrogen atom is partially positive, while the nitrogen, oxygen or fluorine atom is partially negative. An electrostatic attraction called hydrogen bond between two dipoles is set up when the positive pole of one mole attracts the negative pole of another.