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## CHEMICAL BONDING

The attractive force which binds two or more atoms of same or different elements is called a chemical bond."

### REASON FOR BONDING:

Most atoms are not stable and are not capable of independent existence. It has been found that atoms which have outermost shells completely filled with two or eight electrons are stable. Only the atoms of noble gases (Group VIII-A) have completely outermost shell. This tendency is important base of chemical bonding.

Atoms of different elements tend to acquire their octet (eight electrons) or duplet (two electrons) in the outermost shell in different ways. They may tend to :

Lose electrons. OR Gain electrons OR share electrons.

### TYPES OF CHEMICAL BOND:

There are two main types of chemical bonds.

- i. Ionic bond.
- ii. Covalent bond.

### IONIC OR ELECTROVALENT BOND:

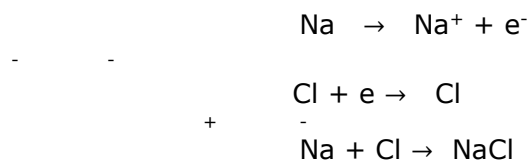
"The chemical bond formed by the complete transference of one or more electrons between two or more atoms is called electrovalent bond or ionic bond."

#### Explanation:

When an atom loses electrons equal to its valency from its outermost shell these electrons pass over to the outermost shell of another, by this transference, positive and negative atoms possessing stable electrons octets or duplets are formed. These charged atoms are called ions. Such oppositely charged ions then held together by an electrostatic force of attraction. This force of attraction is called electrovalent or ionic bond.

### EXAMPLE: FORMATION OF AN IONIC BOND (NaCl).

Sodium loses one electron which is picked up by the chlorine atom in the result of which Na<sup>+</sup> (sodium ion) and Cl<sup>-</sup> (chloride ion) are formed and in this way their outermost shells acquire eight electrons.



These oppositely charged ions are held together by electrostatic force of attraction. In this way sodium chloride salt is formed.

### EFFECT OF IONIZATION ENERGY ON IONIC BOND:

If an element has low ionization energy. It loses electron more easily to form cat-ion. The metal at the extreme left of the periodic table i.e. Group I-A have lowest ionization energies hence these metals have the strongest tendency to form ionic bonds with other elements. Most of the transition metals, some of

the members of Group III-A and Tin (Sn) and Lead (Pb) usually form ionic bonds due to their lower ionization energies.

### **EFFECT OF ELECTRONEGATIVITY ON IONIC BOND:**

"The tendency of an atom to attract electrons is called electronegativity."

It is obvious that atom having greater electronegativity gains electron more easily and form anion. Usually non-metals have greater electronegativity values. They have tendency to form anion consequently they form ionic bonds e.g. S, O, N, F etc.

### **PROPERTIES OF IONIC COMPOUNDS:**

- i. Ionic compounds are generally hard solids due to the strongest bonding forces.
- ii. Ionic compounds have high melting and boiling point.
- iii. They are soluble in water and their aqueous solutions contain ions.
- iv. They are non-conductors in the solid state as the ions are not free to move. However they are good conductors of electricity in the fused (molten) and in an aqueous solution due to free movement of the ions, so they are electrolytes.
- v. They are non-volatile.

### **THE COVALENT BOND:**

"The chemical bond formed by the mutual sharing of electrons is called COVALENT BOND."

#### **Explanation:**

The idea of electron pair bond as covalent bonds was first introduced in 1916 by G. N. Lewis. A covalent bond is generally represented by a short straight line (-) between two bonded atoms. Each electron pair is attracted by the nuclei of bonded atoms.

#### **Example:**

In a molecule of methane. Carbon forms four covalent bonds with four atoms of hydrogen. Carbon and hydrogen atoms complete the electron in their outer most shell.

### **TYPES OF COVALENT BOND:**

There are three types of covalent bonds.

- i. Single covalent bond.
- ii. Double covalent bond.
- iii. Triple covalent bond.

### **SINGLE COVALENT BOND:**

"A covalent bond formed by the mutual sharing of one electron pair is called a single covalent bond and it is denoted by single short straight line."

#### **Example:**



When two atoms of chlorine combine, a pair of electrons is shared between these atoms. In this way each atom of chlorine has obtained eight electrons in its outermost shell.

### DOUBLE COVALENT BOND:

"A covalent bond formed by sharing of two electron pairs is called double covalent and it is denoted by two short line (=)." E.g. O<sub>2</sub>, C<sub>2</sub>H<sub>4</sub> etc.

#### Example:

Ethane is an organic compound formed when two carbon atoms combine by sharing two pairs of electrons with each other.

### TRIPLE COVALENT BOND:

"A three electron pairs bond is called a triple covalent bond and is denoted by three short lines (≡)." E.g. N<sub>2</sub>, C<sub>2</sub>H<sub>2</sub> etc.

#### Example:

In nitrogen there is a triple covalent bond between the atoms N<sub>2</sub> molecule. Similarly, in Ethyne two carbons are triple covalent bounded while C-H is a single bond.



### DOT AND CROSS MODELS AND LEWIS FORMULA:

Models and formulae are used to express the covalent bonding. Some time with the help of dot and cross sharing of electrons is represented. Lewis also gave a method to represent the sharing, it is called Lewis formula.

### DIFFERENCE BETWEEN IONIC AND COVALENT BOND:

| IONIC COMPOUND                                                                                                                                                       | COVALENT COMPOUND                                                                                                                                                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1)The ionic compounds are usually solid, hard and brittle                                                                                                            | 1)Covalent compounds exists all the three states i.e. solid, liquid and gas.                                                                                          |
| 2)The ionic compounds don't conduct electricity in solid state but are good conductors of electricity either in the melted state or in the form of aqueous solution. | 2)A pure covalent compound doesn't conducts electricity. Only polar covalent compounds can conduct electricity in their aqueous solution.                             |
| 3)Ionic compounds have high melting point and boiling point.                                                                                                         | 3)Covalent compounds melt and boil at relatively lower temperature.                                                                                                   |
| 4)Ionic compounds are non-volatile.                                                                                                                                  | 4)Covalent compounds are mostly volatile.                                                                                                                             |
| 5)Mostly ionic compounds are soluble in water but insoluble in petrol or kerosene etc.                                                                               | 5)Only polar covalent compounds are soluble in water but non-polar covalent compounds are insoluble and coordinate covalent compounds are sparingly soluble in water. |

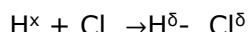
## POLAR COVALENT BOND:

"The covalent bond formed between atoms having different electro negativities is called Polar covalent bond."

### Explanation:

When a covalent bond is formed between two dissimilar electronegative atoms, the shared pair is always attracted more towards more electronegative atom. Hence that atom attains slightly negative charge and other atom attains slightly positive charge. Now both atoms are called negative pole and positive pole respectively such compounds are polar compound and bonds are called Polar bond e.g. HCl, NH<sub>3</sub>, H<sub>2</sub>O, HF etc.

### Example:



E.N value of H=2.1

E.N value of Cl=3.0

In case of hydrogen chloride, chlorine atom is much more electronegative than hydrogen atom, hence the shared pair of electrons is attracted more towards the chlorine atom and chlorine atom attain slightly negative charge and hydrogen become slightly positive charge that is why HCl is a polar compound.

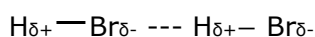
## CHARACTERISTICS OF COVALENT COMPOUNDS:

- i. Compounds with covalent bonds are usually made up of discrete units (molecule) with a weak inter molecular forces.
- ii. In the solid state, there are weak vander wall forces between the molecules. Hence covalent compounds are often gases, liquids or soft solids with low melting point. In few cases, three dimensional covalent structure formed rather than discrete units, hence diamond and silica are covalent but are very hard and have high melting points. Usually covalent compounds have low melting and boiling points.
- iii. They are insulator because they don't conduct electricity.
- iv. Covalent compounds are usually insoluble in polar solvents like water, but soluble in organic solvents like benzene, ether, carbon tetra chloride etc.

## DIPOLE-DIPOLE INTERACTION:

"The force of attraction present in between the two dipole molecules is called DIPOLE-DIPOLE INTERACTIONS."

In a polar covalent bond each atom carry partial positive and partial negative charge such bonds are described as DIPOLE. In such bond partial positive end attracts partial negative end of neighboring molecule. The strength of their attraction depends on the difference between the electro negativities of the atoms, which for the polarized bond. The greater the difference in E.N value the stronger the polarization of the bond and the greater the dipole-dipole interaction.



## THE HYDROGEN BOND:

"The inter molecular force in the polar molecules containing hydrogen atom is covalently bonded to atom of higher electronegative elements such as N, O, F etc is called HYDROGEN BOND." E.g. H<sub>2</sub>O.

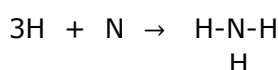
- The strongest hydrogen bonding present in HF where the molecules are held together in long chain like aggregates.
- The hydrogen bond is weak bond as compared to ionic and covalent bond that it is much stronger than other dipole-dipole interactions.
- The hydrogen bond has important effect on the physical properties of the compounds like HF, H<sub>2</sub>O and NH<sub>3</sub>.

## COORDINATE COVALENT BOND:

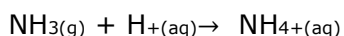
"The covalent bond in which a lone pair of electrons is provided by only one atom for sharing with other is called "Coordinate covalent bond."

### Example:

When a nitrogen atom combines with three hydrogen atoms to form molecule of Ammonia, the Nitrogen atom is surrounded by the bonding pairs and a lone pair of electron.



In certain cases, the lone pair can form another bond when Ammonia reacts with hydrogen ions in an aqueous solution of an acid, an Ammonium ion is formed.



In writing structures, the coordinate covalent bond is indicated by an arrow pointing towards the atom, which accepts the electron pair (NH<sub>3</sub> → H).

## EXERCISE

### 1. FILL IN THE BLANKS:

- i. **Non-polar** covalent molecule is electrically neutral as well as symmetrical.
- ii. The power of an atom to attract the shared pair of electrons towards itself is called **Electronegativity**.
- iii. **Covalent** compounds are usually made up of discrete units; with weak intra molecular forces.
- iv. NaCl is an **ionic** compound.
- v. If electronegativity difference of bonded atoms is more than 1.7, the bond is called **Electrovalent**.
- vi. The forces which hold atoms together in a molecule are called **intra molecular** force.
- vii. The attraction between the partially positive hydrogen and negative F, O or N is called **Hydrogen** bonding.

- viii. CO<sub>2</sub> is a **Non-polar** molecule. ix. The atom which accepts a lone pair of electron is called **Acceptor**.
- x. The electrostatic attraction between positive ions and the electrons of the atoms is called **Metallic** bond.