Chemical Bonding

1. "The attractive force that holds two or more atoms or ions together in a molecule or ion is called a chemical bond."
2. Atoms of elements except Noble gases are less stable and more energetic.
3. Atoms combine to form molecules to attain stability by loosing some part of their Potential energy .Thus molecules are less energetic than atoms.

   E.g.: H + H------ H_2 + 434.72KJ

   Cl + Cl---- Cl_2 + 239.1KJ
4. Formation of a Chemical bond is an exothermic process.
5. Chemical bond is formed when both attractive and repulsive forces exist in equilibrium.
6. The combining capacity of an element is called valency. It is defined asthe number of hydrogen (or) halogen (or) double the number of oxygen atoms which combine with one atom of the element in a molecule.

Examples

In NH_3 , Nitrogen valency is 3

In CH_4, Carbon valency is 4

In N_2O_5, Nitrogen valency is 5

In SF_6, Sulphur valency is 6

Kossel - Lewis Theory ("Electronic Theory of Valency")

7. According to this,

i. The outer most energy level in an atom is known as valence shell and the electrons present in it are called Valence electrons.

ii. The electrons present in the inner energy levels are known as core electrons. Nucleus alone with inner electrons is called kernel.

iii. Elements of Zero groups are more stable due to eight electrons in their valence shell (OCTET Configuration). Eventhough 'He' has only two electrons in the valence shell, it is highly stable and chemically inert (duplet Configuration).

iv. Atom of elements other than Zero group contain less than eight electrons in their valence shell.Hence they try to acquire eight electrons in their outer most orbit either by transfer (Or) by sharing of electrons.It is called Octet Rule.

v. Acquiring octet is two types: by the transfer of electrons (ionic bond) or by mutual sharing of electrons (covalent bond). The valence due to transfer of electrons is called electrovalency. The valence due to sharing of electrons is called covalency.

E.g.: In the formation of NaCl, Electrovalency of Na is 1 & Cl is 1.

E.g-In $NH_{3,}$ Nitrogen co-valency is 3 as it shares 3 electrons with 'H' atoms.

Types of Bonds

If the difference in electronegativities of the bonded atoms is high, an ionic bond is formed and if it is less, a covalent bond is formed.

Variation of the nature of the bond with the difference in electrone gativity of the bonded atoms isgiven in the following Table

S.No.	Electro negativities		changes occurring in the valence electrons	nature of the bond formed
	ELEMENT A	ELEMENT B		
1	Low	High	Transfer of electrons	Ionic bond
2	High	High	Sharing of electron pair	Covalent bond
3	Low	Low	Sea of electrons	Metallic bond

Lewis Electron dot symbols

(a) The symbol of the element reprsents the nucleus along with all the inner electrons which do not take part in the bond formation

(b) The dots on the symbol represent the valency electrons. The number of dots represents the number of valency electrons i.e group number.

Example:-

Lewis symbol	•Li	•Be•	B	C	N	O	F	Ne
no.of valence Electrons	1	2	3	4	5	6	7	8

c) The Lewis dot structures can be used to calculate the group valence of the element. For example, has four electrons, therefore valence of C is 4 and has five electrons, Therefore valence of 'N' is (8-5). (I.e. 8-number of valence electrons).

Covalent Bond

1. This bond formed between two atoms by the mutual sharing of their valence electrons

i. Single bond is formed by the mutual sharing of one pair of electrons between two atoms.Single bond is represented as '-'

ii. Double bond is formed by the mutual sharing of two pairs of electrons between two atoms.Double bond is represented as '='

iii. Triple bond is formed by the mutual sharing of three pairs of electrons between two atoms. Triple bond is represented as '≡'

iv. Pure covalent bond or non-polar covalent bond is formed by the sharing of electron pairs between two like atoms.All homo molecules have this type of bond.

E.g.: $H_2, Cl_2, O_2, N_2, P_4, S_8$ etc.

v. Polar covalent bond is formed by the unequal sharing of electron pairs between two dissimilar atoms. It appears in hetero molecules.

E.g. $HF, HCl, ICl, H_2O, CO_2, SO_2, BeCl_2, SO_3$ etc.

vi. Compounds like H_2O_2, N_2O_4 having both polar and non-polar covalent bonds

Types of Covalent molecules

Depending upon number of electrons present in valence shell of central atom, molecules are classified into following two types.

Number of electrons present in valence shell of central atom=Group number+valency

Type 1: Octet molecules i.e central atom having 8electrons in valence shell.

Example: $CH_4, H_2O, NH_3, HCl, CO_2, CO$ etc

Type 2: Molecules with number of electrons present in valence shell of central atomare called Octet violet molecules .These are two types

a) Electron deficient molecules i.e., molecules with number of electrons present in valence shell of central atom < 8

Examples: $BeCl_2, BF_3, BBr_3, BCl_3$ etc.

* Generally compounds of IIIA group are Electron difficent.

b) Expand octet molecules i.e, molecules with number of electrons present in valence shell of central atom > 8

Examples: $PCl_5, SF_6, IF_7, SCl_4, SO_2$ etc.

MOLECULE	CENTRAL ATOM	TOTAL NO. OF VALENCE ELECTRONS IN THE CENTRAL ATOM
CH_4	C	8 (Octet)
NH_3	N	8 (Octet)
H_2O	O	8 (Octet)
CO_2	C	8 (Octet)
C_2H_6	C (each)	8 (Octet)
C_2H_4	C (each)	8 (Octet)
C_2H_2	C (each)	8 (Octet)
$BeCl_2$	Be	4 (Contracted Octet)
BCl_3	B	6 (Contracted Octet)
PCl_5	P	10 (Expanded Octet)
SF_6	S	12 (Expanded Octet)
IF_7	I	14 (Expanded Octet)

Covalency

1. It is the number of electron pairs shared by one atom of the element in combination with other atoms in a molecule .Generally it is equal to the total number of unpaired electrons in s- and p- orbitals of the valence shell in ground or excited state. For example

   $_8O = 1s^2, 2s^2, 2p^2{}_x, 2p^1{}_y, 2p^1{}_z$, Covalency of oxygen =2

   In excited state $_6C = 1s^2, 2s^1, 2p^1{}_x\ 2p^1{}_y, 2p^1{}_z,$ Covalency of carbon =4

2. The elements having vacant d- orbitals in their valence shell show variable covalency by. Unpairing the s- and p- electrons and promoting them to

   d- Orbitals. For example

   Ground state E.C of S = $1s^2$, $2s^2$, sp6, 3s2, 3p2x, 3p1y, 3p1z, covalency of sulphur = 2

   First excited state E.C is 3s2, 3p1x, 3p1y, 3p1z, 3d1xy, covalency of sulphur = 4

   Second excited state E.C is $3s^1$, 3p1x, 3p1y, 3p1z, 3d1xy, 3d1yz, covalency of sulphur = 6

   Similarly, i. Phosphorous shows covalencies equal to 3and5.

   ii. Except fluorine, the halogens show covalencies equal to 1, 3, 5 and 7.

   iii. d-block and f-block Elements show variable valency

3. Maximum covalency of a Representative element is generally equal to their group number except for N, O, F etc. Maximum covalency of N is 4, O is 3 and F is 1.

Formal Charge

It is a factor based on a pure covalent bond formed by the sharing of electron pairs equally by neigh bouring atoms. Formal charge of an atom in a polyatomic molecule or ion is defined as the difference between number of valence electrons of the atom in Free State and number of electrons assigned to the atom in the Lewis structure.

Formal charge is denoted by Q and is given by

$$Q_f = [N_A - N_M] = [N_A - N_{LP} \ - 1/2 N_{BP}]$$

N_A = Number of electrons in the valence shell of the free atom

N_M = Number of electrons belonging to the atom in the molecule

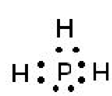
N_{LP} = Number of electrons in unshared pairs, i.e. number of electrons in lone pairs

N_{BP} = Number of electrons in bond pairs, respectively

Q_f is Formal charge

(Or)

F.C = No of valence electrons - (No of lonepairs of electrons -No of electrons involved in bonding /2)

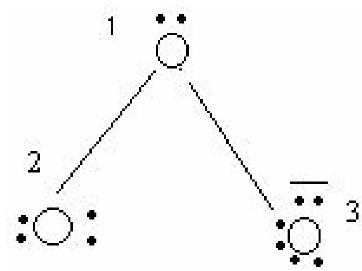


Example1. The Lewis dot formula of PH_3 is

i. Formal charge of P: ={5-2-1/2(6)} = (5-5) =0

ii. Formal charge of H: = (1-0-2/2) =0

Example 2: Formal charges on oxygen atoms of ozone

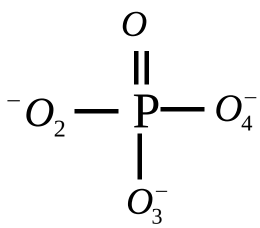


Formal charge of oxygen (1) = +1

Formal charge of end oxygen atom (2) =0

Formal charge of end oxygen atom (3) = -1

Example3: Formal charge of



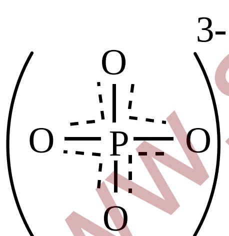
Formal charge of P is ‘O’

Formal charge of O_1 is ‘O’

Formal charge of O_2 is ‘-1’

Formal charge of O_4 is - 1

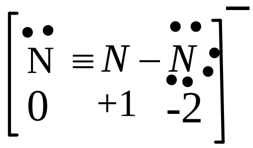
Formal charge on each oxygen in resonance hybrid is=



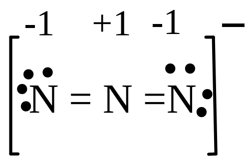
$$\frac{\text{Total charge on surrounding atoms}}{\text{no. of atoms surrounded around centeral atom}} = \frac{-3}{4} = -0.75$$

Bond order of P - O bond is $\frac{\text{no.of bonds surrounded}}{\text{no.of atoms surrounded}} = \frac{5}{4} = 1.25$

Example 4: Possible resonance structures & formal charges on atoms of N_3^- is



(Or)



Note: Formal charge of an atom in a molecule is not always constant. It varies from one resonating structure to another.