CHEMICAL BONDING AND MOLECULAR STRUCTURE

KOSSEL-LEWIS APPROACH TO CHEMICAL BONDING

INTRODUCTION

(a) It is well known fact that except for inert gases, no other element exists as independent atoms under ordinary condition.

(b) Most of the elements exist as molecules which are cluster of atoms. How do atoms combine to form molecules and why do atoms form bonds? Such doubts will be discussed in this chapter.

(c) A molecule will only be formed if it is more stable and has a lower energy, than the individual atoms.

Chemical Bond

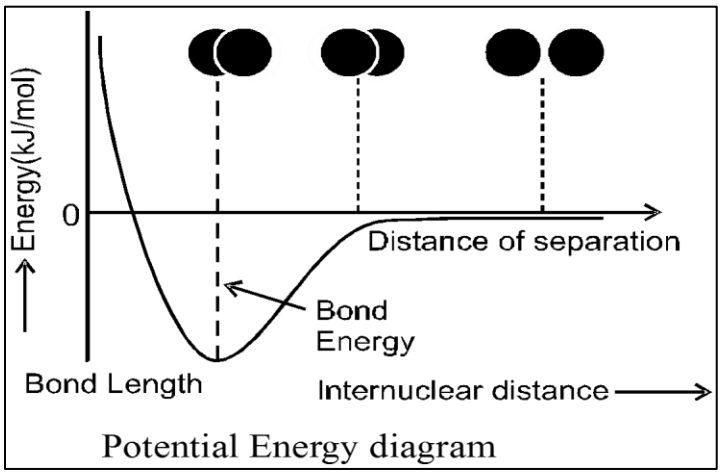
(a) A force that acts between two or more atoms to hold them together as a stable molecule.

(b) It is union of two or more atoms involving redistribution of e^- among them.

(c) This process accompanied by decrease in energy.

(d) Decrease in energy α Strength of the bond.

(e) Therefore, molecules are more stable than atoms.



Potential Energy diagram

CAUSE OF CHEMICAL COMBINATION

1. Tendency to Acquire Minimum Energy:

(a) When two atoms approach to each other- Nucleus of one atom attracts the electron of another atom.

(b) Two nuclei and electron of both the atoms respells each other.

(c) If net result is attraction, the total energy of the system (molecule) decreases and a chemical bond form.

(d) So, Attraction α 1/energy α Stability.

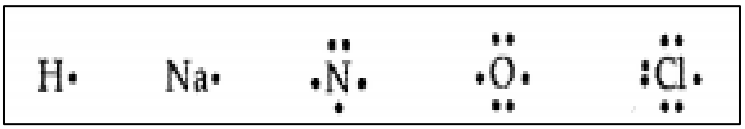
(e) Bond formation is an exothermic process

LEWIS SYMBOLS OF ELEMENTS

Chemical bonding mainly depends on the number of electrons present in the outermost energy level. These electrons are termed as valency electrons. The electronic configuration of sodium (Na) is 2, 8, 1 and that of sulphur has (S) 2, 8, 6. Thus, sodium has one valency electron while sulphur has six valency electrons. In the case of representative elements, the group number (Modem Mendeleev's periodic table) is equal to the number of valency electrons.

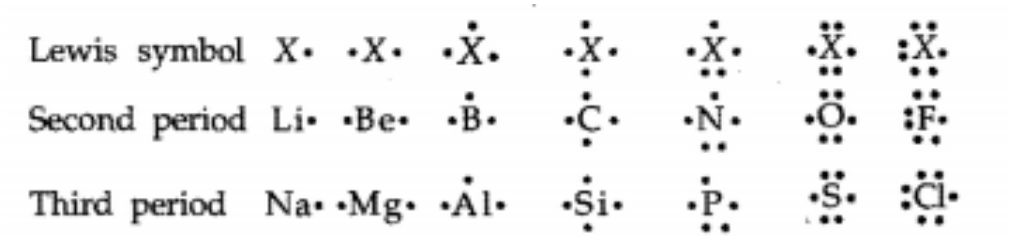
The valency electrons in atoms are shown in terms of Lewis symbols. To write Lewis's symbol for an element, we write down its symbol surrounded by a number of dots or crosses equal to the number of valency electrons. Paired and unpaired valency electrons are also indicated.

The Lewis symbols for hydrogen, sodium, nitrogen, oxygen and chlorine may be written as:



Generalized, Lewis symbols for the representative elements are given in the following table:

	1	2	13	14	15	16	17
Group	IA	IIA	IILA	IVA	VA	VIA	VIIA
	ns^1	ns^2	ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5



2. Octet Rule

Octet rule was given by Lewis & Kossel Atoms Combines to complete an octet of electrons in their outer most orbit. Complete orbital represents to get most stable state. Hence all atoms have a tendency to acquire octet (s^2p^6) configuration in their outermost orbit.

The octet may be complete in following manner: Complete transfer of electrons from one atom to another.

Ex. NaCl, $CaCl_2$ & MgO etc. (Ionic Bond)

Sharing of electrons between atoms.

(a) Sharing of equal number of electrons between two atoms.

Ex. Cl_2, N_2, O_2 etc., (Covalent bond)

(b) Sharing of electron pair given by only one atom

Ex. $[NH_3 \rightarrow H^+]$ & $NH_3 \rightarrow BF_3$ (Co-ordinate Bond)

Exceptions of Octet Rule

1. Transition Metal Ions

Cr^{3+}	Mn^{2+}	Fe^{2+}
$[Ar]3d^3$	$[Ar]3d^5$	$[Ar]3d^6$
[2, 8, 11]	[2, 8, 13]	[2, 8, 14]

2. Pseudo Inert Gas Configuration [$s^2p^6d^{10}$]

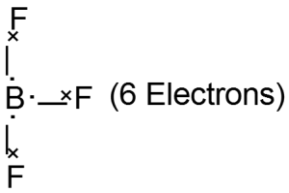
Zn^{2+} Cd^{2+}

$[Ar]3d^{10}$ $[Kr]4d^{10}$

3. Contraction of Octet (Incomplete Octet)

BeF_2 **B**F_3 **Al**Cl_3 **B**Cl_3

(4e) (6e) (6e) (6e)

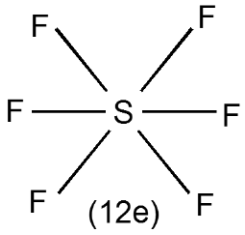


4. Expansion of Octet (Due to Empty d-Orbitals)

PCl_5 SF_6 ClF_3 ICl_5 IF_7

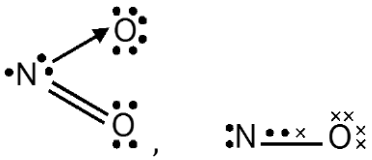
↓ ↓ ↓ ↓ ↓

(10e) (12e) (10e) (12e) (14e)



5. Odd Electron Species

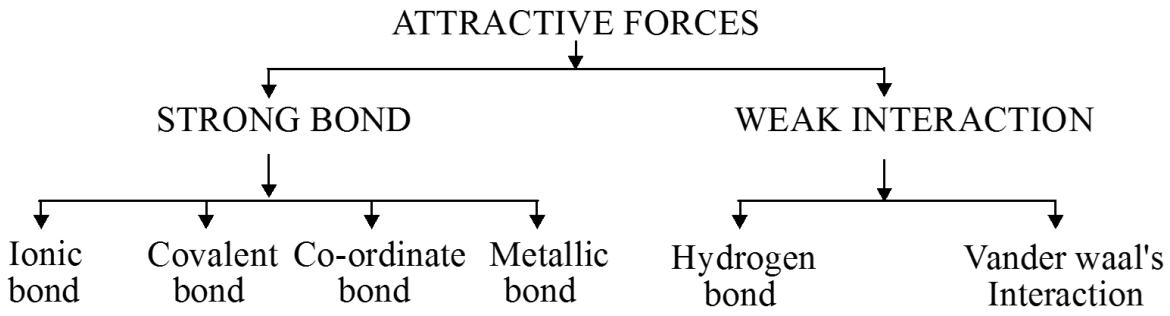
Ex. NO, NO_2, ClO_2 etc.



6. Compounds of Noble Gases

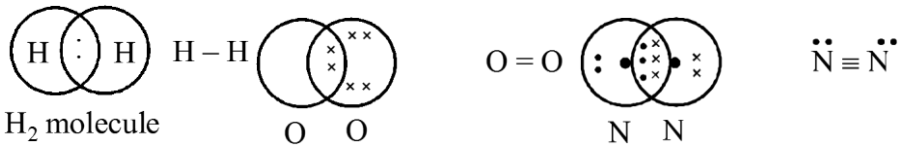
Noble gases which have already completed their octets (or doublet in case of He.) should not form compounds. However, their compounds like XeF_2, XeF_6 & KrF_2 etc., have been actually prepared.

CLASSIFICATION OF BONDS



Covalent Bond

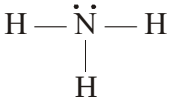
(a) A covalent bond is formed by the mutual sharing of electrons between two atoms of electronegativity elements to complete their octet. (Except H which completes its duplet)



(b) The shared pair of electrons should have opposite spins, and are localized between two atoms concerned.

(c) Sharing of electrons may occurs in three ways –

No. of electrons shared between two atoms	Bonded Electron pair	Bond.
2	1	Single bond (–)
4	2	Double bond (=)
6	3	Triple bond (≡)

Ex.  {Three single bonds (not triple bond}

$N \equiv N$ Triple bond. (Not three single bond) O = O (Double bond) H – O – H (Two single bonds.)

Co-ordinate Bond

(a) It is a covalent bond in which the shared electron pair come from one atom is called coordinate bond.

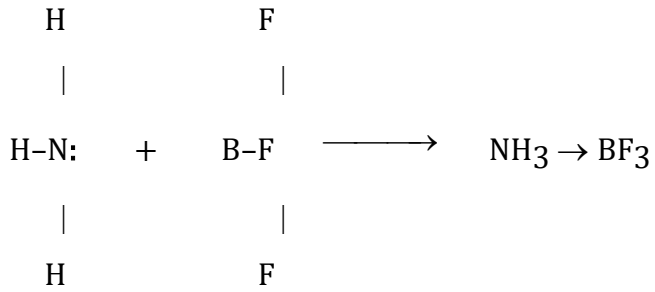
(b) Necessary conditions for the formation of co-ordinate bond are -

(i) Octet of donor atom should be complete and should have at least one lone pair of electrons.

(ii) Acceptor atom should have a deficiency of at least one pair of electrons.

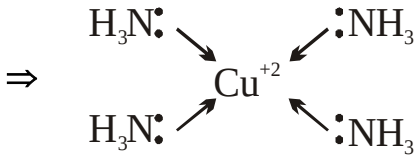
(c) Atom which provide electron pair for sharing is called donor.

(d) Other atom which accepts electron pair is called acceptor. That is why it is called donor-acceptor or dative bond.

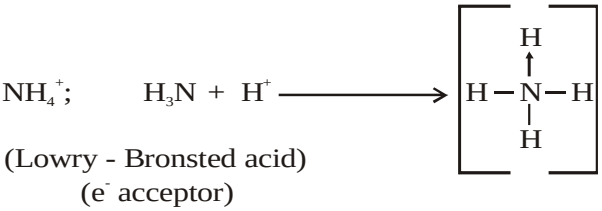


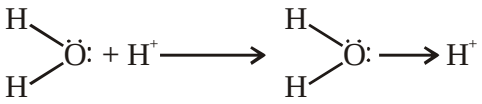
BF_3 is electron deficient compound.

Metal co-ordinate compounds - $[Cu(NH_3)_4]^{+2}$



Ex.



H_3O^+ ; 

N_2O ;