CHEMICAL BONDING

BRIDGE COURSE - II

Chemistry

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- Atoms of most elements (except noble gases) are not able to exist independently.
- A group of two or more atoms known as **molecules** have independent existence.
- Atoms of same element or of different elements can join together to form a molecule.
- **Example**: A molecule of oxygen is formed by joining two atoms of oxygen (O_2)

- **Example :** A molecule of water is formed by joining two atoms of hydrogen with one atom of oxygen (H_2O).
- The attraction between atoms or ions to form a molecule is called **chemical bond.**
- These molecules or ions aggregate in large numbers to form the **matter**

- **What is a chemical bond?**

The attractive force which holds constituents (atoms, ions, molecules, etc.) together in different chemical species is called as chemical bond.

- **What is a molecule**?

The smallest particle of an element or a compound made up of group of two or more atoms that is capable of independent existence and shows all the properties of that substance is called as molecule.

REASONS FOR BOND FORMATION

a) Tendency to acquire electronic configuration of nearest noble gas.

Noble gases or inert gases like Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe) and Radon (Rn) are the **most stable** elements because atoms of these elements possess an **octet structure** i.e. eight electrons in the outer most orbit (**valence shell**).

Noble Gas	At. no.	Electronic config.	Valence shell	No of electrons in val. shell
He	2	$1s^2$	$1s^2$	2
Ne	10	$1s^2 2s^2 2p^6$	$2s^2 2p^6$	8
Ar	18	$1s^2 2s^2 2p^6 3s^2 3p^6$	$3s^2 3p^6$	8
Kr	36	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$	$4s^2 4p^6$	8
Xe	54	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6$	$5s^2 5p^6$	8
Rn	86	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 4f^{14} 5d^{10} 6s^2 6p^6$	$6s^2 6p^6$	8

b) The atoms of noble gases exist **independently** (mono atomic) and **do not combine** with the atoms of other elements.

c) The atoms of other elements have **no octet structure** and hence try to attain **eight electrons in their valence shell** by combining with other atoms.

d) When two or more atoms combine to form a molecule the electrons in their outermost orbits are rearranged in such a way as to achieve **octet or duplet** structure of the **nearest noble gas.**

Example: Sodium (Na) has 11 electrons, 2 in the first orbit, 8 in the second and 1 in the third orbit. If Na loses one electron, it would attain the same electronic configuration of its nearest gas Neon (Ne).

To attain min. energy and max. stability

a) When two or more atoms combine to form a molecule, the **energy** of bonded system decreases.

b) Bonded system has less energy (more stable) than the un-bonded system (unstable).

c) Therefore atoms combine to form molecules to attain minimum energy and maximum stability.

Points to remember

The atoms of most elements combine to form molecules due to two reasons.

1. **To attain the octet structure of the nearest noble gas.**

2. **To form more stable molecules by losing energy.**

Concept of valence electrons

- The electrons present in the outermost shell of an atom are called **valence electrons** because the combining capacity of the element (i.e. valency) depends upon the number of these electrons.

- All the electrons present in the inner orbitals (core of the atom) excluding valence electrons are called **core electrons** which do not participate in chemical reaction.

Element	Atomic No	E.C	Group Noin the periodic table	Valance Electrons	Lewis symbol	valency
Li	3	$1s^2 2s^1$	1	1	Li.	1
Be	4	$1s^2 2s^2$	2	2	Be:	2
B	5	$1s^2 2s^2 2p^1$	13	3	.B:	3
C	6	$1s^2 2s^2 2p^2$	14	4	. .C. .	4
N	7	$1s^2 2s^2 2p^3$	15	5	. :N. .	8-5=3
O	8	$1s^2 2s^2 2p^4$	16	6	.. :O. .	8-6=2
F	9	$1s^2 2s^2 2p^5$	17	7	.. :F. ..	8-7=1
Ne	10	$1s^2 2s^2 2p^6$	18	8	.. :Ne: ..	8-8=0

Significance of Lewis symbols

- The number of valence electrons (number of dots) helps to calculate the valence of the element.

- The valence is generally either equal to the number of dots in Lewis symbols or 8 minus the number of dots or valence electrons.

Octet rule (Kossel and Lewis)

- Atoms can combine either by **transfer of valence electrons** from one atom to another or by **sharing of valence electrons** in order to have an **octet electron structure** in their valence shells. This is known as **octet rule**. This theory of chemical combination is known as **electronic theory of chemical bonding**..

Remember

Elements with lower atomic number try to attain two electrons i.e. **duplet** (instead of octet). It is called **duplet rule.**

Types of Bonds

Type of bond formed between the atoms depends upon the way in which the combining atoms attain octet structure in their valence shell.

a) Ionic or electrovalent bond	b) Covalent bond
c) Coordinate covalent bond	d) Metallic bond
e) Hydrogen bond	f) Van der Waal's force of attraction

For your knowledge

- Electro negativity is the ability of an atom to attract bonded pair of electrons towards itself.
- Among all the elements F has highest electro negativity and Cs has lowest electro negativity
- The electro negativity of non metals is greater than metals

Chemistry

- **G.N.Lewis** suggested that when two atoms having similar or almost similar electro negativities can achieve a stable valence shell configuration (2 or 8 electrons in the outer shell) **by sharing one or more valence electrons** between them.

- A bond formed by mutual sharing of electrons is called a **covalent bond**.

- During the formation of covalent bond the two combining atoms contribute equal number of electrons for sharing.
- The shared electrons contribute equally two both the atoms and both the atoms attain **octet number of electrons** in the valence shell.
- The shared electrons is represented by a dash (—) and is responsible for holding the two atoms together.

- The shared pair constitutes what is known as covalent bond.
- The molecule formed is called **<u>covalent molecule</u>** **(** or covalent compound).

Points to remember

- The number of electrons contributed by an atom for sharing to form a covalent bond is called **co valence.**
- The valence electrons which are not involved in sharing are known as **non-bonding** or **lone pairs.**

Multiple covalent bonds

- When the atoms share one electron pair, the bond formed is called **single covalent bond.**
- If two electrons pairs are shared by the atoms, the bond formed is called **double covalent bond.**
- When the atoms share three electrons pairs, the bond is called **triple covalent bond.**
- The double and triple covalent bonds are called **multiple covalent bonds.**

Illustration of the formation of covalent bonds

Formation of hydrogen (H_2) molecule (H—H)

- Electronic configuration of H atom is $1s^1$.
- Each hydrogen atom share one electron pair between them to attain the helium gas configuration ($1s^2$)
- The two hydrogen atoms are thus joined by a single covalent bond.

Formation of oxygen (O_2) molecule (O=O)

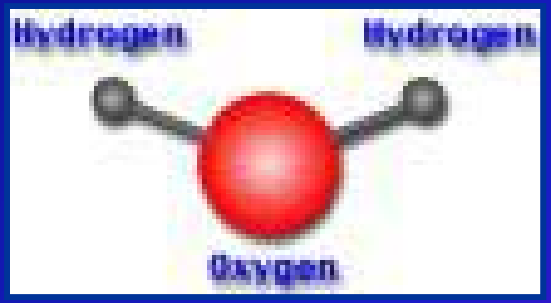
- Electronic configuration each oxygen atom is $1s^2$**$2s^2 2p^4$**.
- The number of valence electrons in each oxygen atom is 6. (Total valence electrons of both oxygen atoms : 6 + 6 = 12).
- Each atom **shares two electron pairs** between them to attain the octet number of electrons.
- The two oxygen atoms are thus joined by two covalent bonds (double bond).

Formation nitrogen (N_2) molecule ($N \equiv N$)

- Electronic configuration of each nitrogen atom is $1s^2 \mathbf{2s^2 2p^3}$.
- The number of valence electrons in each nitrogen atom is 5. (Total valence electrons of both nitrogen atoms : 5 + 5 = 10).
- Each atom **shares three electron pairs** between them to attain the octet number of electrons.
- The two nitrogen atoms are thus joined by three covalent bonds (triple bond).

Covalent Bonds can have multiple bonds, so you should be familiar with the following…

Single Covalent Bond: chemical bond resulting from sharing of an electron pair between two atoms.

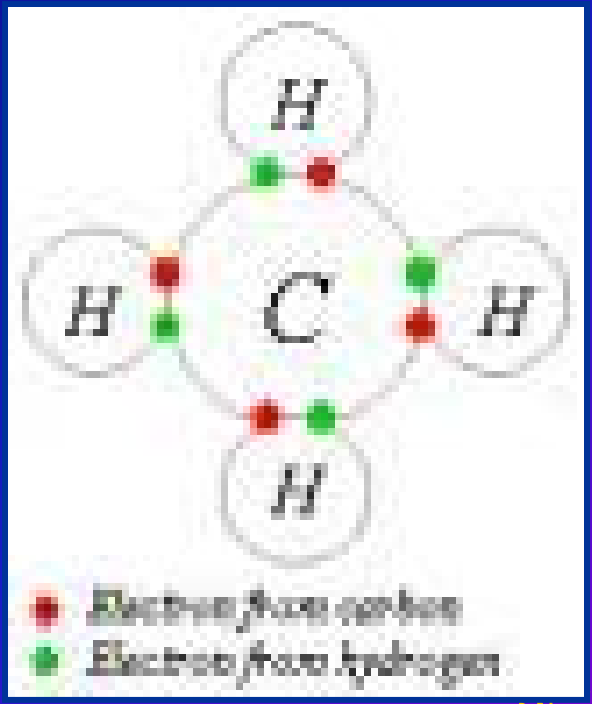


Double Covalent Bond: chemical bond resulting from sharing of two electron pairs between two atoms.

Triple Covalent Bond: chemical bond resulting from sharing of three electron pairs between two atoms.

Characteristics of a covalent bond :

- Covalent bonds have definite and predicable shapes.
- Very strong
- Low melting and boiling points

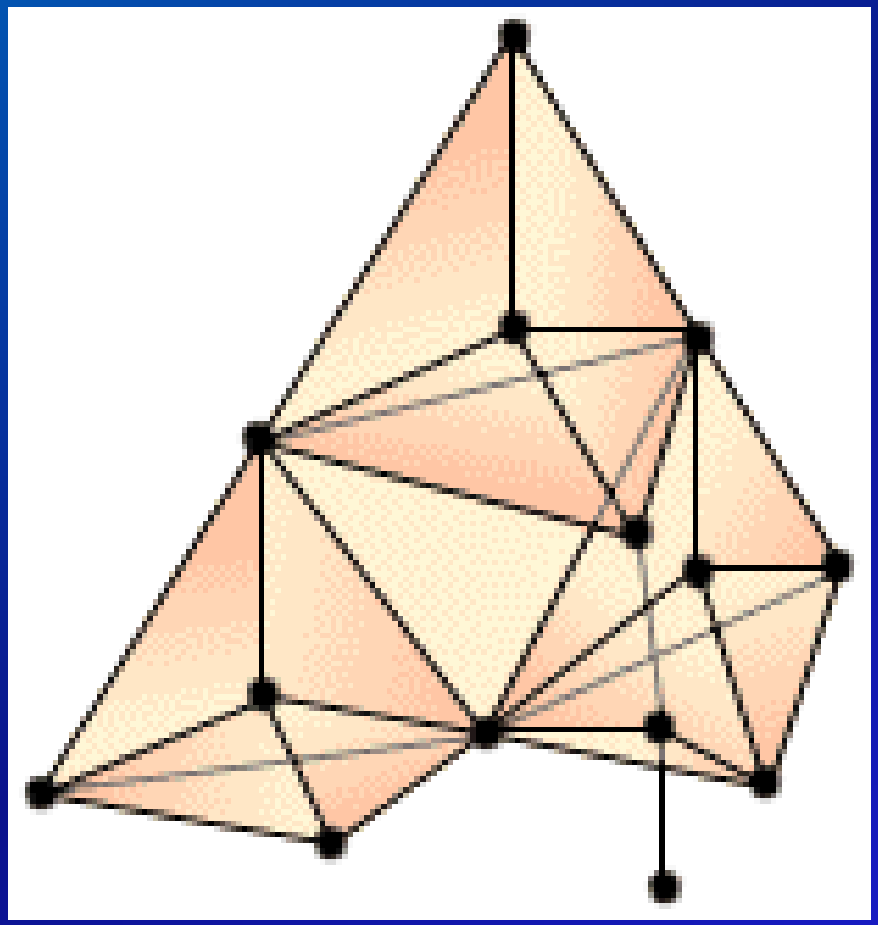


Covalent Network Structures

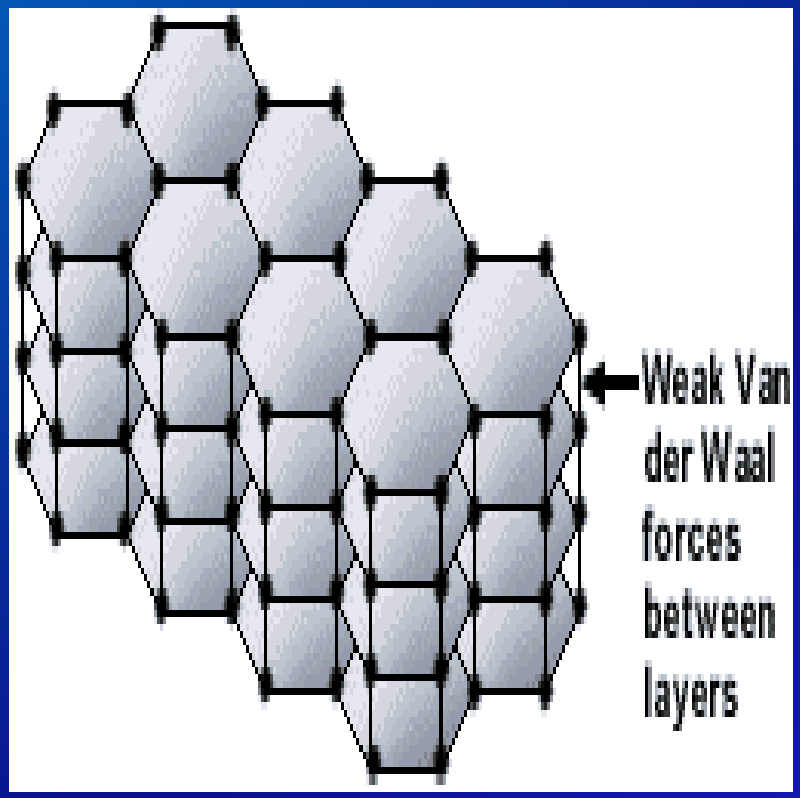
A covalent network is when atoms are bonded together **covalently** to form giant **macro-molecular** structures.

The element Carbon can form Covalent Network Structures

Two examples are: Diamond & Graphite



- Each Carbon atom bonds to **4** others
- Strong **covalent** bonds throughout
- **High** melting points and Boiling points
- No free electrons so **does not conduct** electricity.

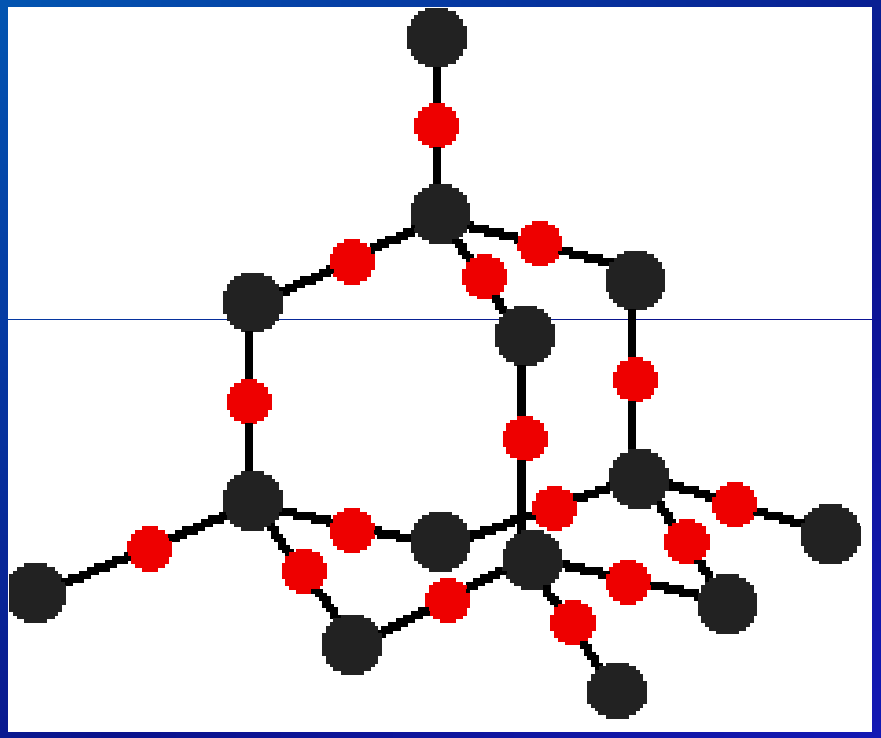


- Each Carbon atom is bonded to **3** others

- The bonding **within** the layers is strong **covalent.**

- The spare fourth electron of each C atom is **de-localised** so graphite can **conduct** electricity

- There are **weak intermolecular forces** of attraction **between** the layers.



- Another example of a covalent network is silicon di oxide.

This is a compound though it resembles diamond.

Properties of covalent compounds

- Covalent compounds exist as **molecules** and not as ions.
- Covalent compounds are generally gases, liquids or solids with **low melting points**.
- They are generally **insoluble** in polar solvents like water but soluble in non-polar solvents like benzene and ether.

- They do not conduct electricity because they contain neutral molecules (no ions).

- The covalent bonds are directional and covalent molecules have definite geometrical shape. Hence they may show **isomerism.**