CHAPTER-1
ATOMIC STRUCTURE

* Atom- An atom is the smallest particle of an element that takes part in a chemical reaction. Dalton in 1808 was the first philosopher to propose his atomic theory of fundamental particle of an atom. Proton, electron and neutrons are the sub atomic particle of an atom.

* Atomic Number- The atomic number of an element is equal to the number of proton present in the atoms. Protons are the positively charged particles present in the nucleus of the atom.

Atomic Number of an element = total no. of proton in the nucleus = total no. of electrons present in the atoms.

* Atomic Mass Number- The mass number of an element is the sum of the number of protons and nutrons present in the nucleus of the atoms.

Mass number of an element = Number of protons + No. of Neutrons.

* Molecule - A group of two or more than two atoms of the same or different element that are chemically bonded together is called a momecule.
Ex- O_2, H_2, Br_2

* Atomicity - The number of atoms present in a molecule is called its atomicity. 2)

Q 1) Calculate the atomic number and atomic mass of an atom containing 19 electrons and 20 neutrons.

Sol :- Atomic no. (z) = No. of protons = No. of electron
= 19

Atomic mass (A) = No. of protons + No. of nutrons
= 19 + 20 = 39

2) Calculate the number of neutrons in the following isotopes of chloride. Q)

1) $^{35}_{17}Cl$ 2) $^{37}_{17}Cl$ 1)

Sol :- 1) Atomic number (z) = 17
Atomic mass (A) = 35 Sol 1)

we know that,
Atomic no. = No. of protons = No. of electrons
= 17

And,

Atomic mass = No. of protons + No. of neutrons

35 = 17 + No. of protons

No. of protons = 35 - 17

= 18

2) $_{17}^{37}Cl$

Atomic no. (z) = 17

Atomic mass (A) = 37

we know that,

Atomic no. = No. of protons = No. of neutrons

&

Atomic mass = No. of protons + No. of neutrons

37 = 17 + No. of neutrons

No. of neutrons = 37 - 17

= 20.

Q. Calculate the number of electrons, protons and neutrons in the following species.

1) $_{15}^{31}P$ 2) $_{15}^{31}P^{3-}$

Sol 1) $_{15}^{31}P$

Atomic no. = No. of protons = No. of electrons = 15

Atomic No. of neutrons = Atomic mass - No. of protons

= 31 - 15 = 16

2) $_{15}P^{31}$ $^{3-}$

$P^{3-} = P + e^-$

thus, phosphate ion contain same no. of proton and nutrons but contain three electrons more than phosphorus atom.

Hence,

No. of electrons = 15 + 3 = 18

No. of protons = 15

No. of neutrons = 31 - 15 = 16

* Isotopes - Isotopes are defined as different atoms of the same element having the same atomic number but different mass number

* Properties :-

1) Isotopes of an element have same atomic ~~mass~~ number due to different in the number of neutrons in the nucleous.

2) Isotopes occupy same place in the periodic table.

3) Isotopes ~~occupy same~~ have identical electronic configuration.

4) They have identical chemical properties (due to similar of electrons) but slightly different physical properties (due to different number of neutrons).

Isotopes of same common element :-

Element	Isotopes
Carbon (C)	$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$
Chlorine (Cl)	$^{35}_{17}Cl$ $^{37}_{17}Cl$
Nitrogen (N)	$^{13}_{7}N$ $^{14}_{7}N$ $^{15}_{7}N$

* Isobar — The atoms of different element which have the same mass number but different atomic number are called isobars.

Ex - (1) Argon $^{40}_{18}Ar$, Potassium $^{40}_{19}K$, Calcium $^{40}_{20}Ca$

(2) Lead $^{210}_{82}Pb$ and Bismuth $^{210}_{83}Bi$

* Characteristics of Isobars :-

1) Isobars have different atomic number and have they posses different number of protons and electrons.

2) Isobars have same mass number so the sum of proton and nutrons. ie number of nucleons is the same.

5) Isobars posses different chemical and physical properties.

4) They have different electronic configuration as they have different number of electron.

Q) Difference between Isotopes & Isobars:-

Isotopes	Isobars
1) They have the same atomic number but different mass.	1) They have same mass number but different atomic number.
2) They have same electronic configuration.	2) They have different electronic configuration.
3) They have same place in periodic table.	3) They occupy different places in the modern periodic table.
4) Their chemical properties are identical.	4) Their chemical properties are different.
5) Isotopes are atoms of the same element having different mass number and hence they have the	5) Isobars are atoms of different element having same mass number but different atomic number and hence they have

same number of protons	different number of proton, electrons & nutroons.
Ex- $^{16}_{8}O$ $^{17}_{8}O$ $^{18}_{8}O$	Ex- $^{40}_{18}Ar$ $^{40}_{19}K$ $^{40}_{20}Ca$

* Bohr's Atomic Model :-

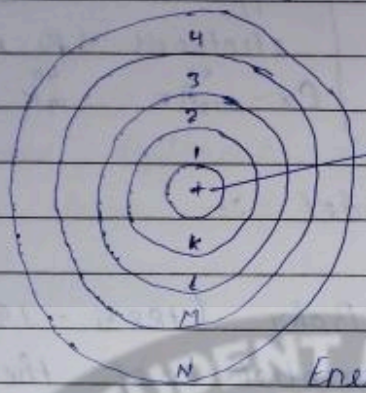
One of the Neil Bohr (1885 - 1962) was one of the greatest scientists of the 20th century. He won the 1922 Nobel prize in physics for his study of the structure and radiation of atoms.

Bohr tried to over come the defects in the Rutherford's Atomic model.

* Postulates of the Bohr's Atomic model :-

1) In an atom the electron revolve around the nucleus in certain definite circular path called orbits.

2) Each orbit is associated with a definite energy. So these orbits are also known as energy level or energy shells these energy are numbered as 1, 2, 3, 4 ... etc or called K, L, M, N ... etc shell starting from the nucleus these integers 1, 2, 3, 4 ... etc are termed quantum number of the orbits.



Energy level around the nucleus.

3) As long as an electron remains in any particular energy level, it does not radiate energy. However an electron can lose energy when it jumb from an orbit of higher energy (E_2) to no of lower energy (E_1): energy equal to $E_2 - E_1$ is given out in the form of radiation. In such a case 5) 4

$$\Delta E = E_2 - E_1 = h\nu$$

$$\nu = \frac{E_2 - E_1}{h} = \frac{\Delta E}{h}$$

Where h is the plank's constant and ν is the frequency of radiation emitted

4) Only the energy levels (orbit) in which the angular momentum of the electron is an intergral (whole number) multiple of $h/2\pi$ are permissible. 1) 2)

The angular momentum of an electron moving in a circular

orbit is equal to mvr, where m and v are the mass and velocity of the electron moving in an ~~circular~~ orbits of radius r. Then according to the Bohr's theory.

$$mvr = \frac{nh}{2\pi}$$

This postulate thus introduce the concept of quantization of angular ~~momp~~ momentum.

5) In an atom the centrifugal force acting on the moving electron is balanced by the attractive force between the nucleus and the electron.

* Limitation of Bohr's Theory :-

Bohr's theory incarporated the concept of quantisation of energy and predicted to existance of discreate atomic energy levels. The theory explained large number of features of spectroscopic data. It, however had some limitations.

1) It failed to explain the spectra of atoms or ions having more than one electron.

2) Bohr's theory suggested circular, planar orbits (two-dimensional), but actual atomic model has three-dimensional existance.

3) Bohr's theory could not explain the fine structure of lines in the spectra (Division of lines observed under a spectra scope of high resolution).

4) Shapes of molecules arising out of directional bonding could not be explained.

5) Bohr's theory could not explain Zeeman effect and Stark effect.

6) Bohr's model could not explain the Heisenberg's uncertainty principle.

24/11/2021

* Shell (Energy Level):-

⇒ The electron revolve around the nucleus in various stationary energy levels called as orbits or principal energy level or shell.

Each shell has different energy level. The first shell nearest to the nucleus is known as the 'K' shell. It is followed by L, M, N.... shells. The energy of shell increases with increase in distance of the shell from the nucleus. The energies of electrons present in the shells also increase from K shell on wards.

The energy levels or shells are also designated using principal quantum number (n). Where n = 1, 2, 3, 4.... corresponds to K, L, M, N, O, P.... shells respectively. Each shell can accomodate maximum of $2n^2$ electron (where n is the principal quantum number). Thus, K shell accomodate maximum of 2 electrons. L shells can accomodate maximum of 8 electrons. M shell can accomodate maximum of 18 electrons and N shell can accomodate maximum of 32 electrons.

This can be summarised as show in the following table :-

Principal shell	n	Maximum no. of electrons that can be accomodated $2n^2$
K	1	$2 \times 1^2 = 2$
L	2	$2 \times 2^2 = 8$
M	3	$2 \times 3^2 = 18$
N	4	$2 \times 4^2 = 32$

* Sub. Energy ~~shell~~ levels (sub. shells) :-

⇒ A close grouping of number of energy level in the main energy levels in the main energy level (or main shells) are known as sub energy level or sub. shells. Each shell is divided into sub. shells which are designated as s, p, d, f.

* For sub. shells some points are given as follows :-

1) The sub. shells are denoted by s (sharp), p (principal), d (diffuse) and f (fundamental).

2) The number of sub. shell is equal to the shell no. i.e.

(i) Sub. shell in first shell K is one (s)

(ii) Sub-shell in second L are two (s,p).

(iii) Sub-shell in third M are three (s,p,d).

(iv) Sub-shell in fourth shell N are four (s,p,d,f).

3) The order of energy in subshells can be given by.

$$s < p < d < f.$$

4) The maximum number of electrons in a sub-shell is given as follows:-

s = 2 electrons , p = 6 electrons

d = 10 electrons , f = 14 electrons

5) Number of sub-shells (sub energy levels) in a shell (energy level) is given by n^2 and maximum numbers of electrons in each shell is given by $2n^2$. Where n is the number of shells from nucleus (principal quantum number). Following table illustrates this well.

Shell or Energy Level (n)	No. of sub shell (n^2)	Sub-shell or sub Energy levels	Maximum no. of electrons ($2n^2$).
n = 1 (K)	$1^2 = 1$	1S	$2 \times 1^2 = 2$
n = 2 (L)	$2^2 = 4$	2S, 2p	$2 \times 2^2 = 8$
n = 3 (M)	$3^2 = 9$	3S, 3p, 3d	$2 \times 3^2 = 18$
n = 4 (N)	$4^2 = 16$	4S, 4p, 4d, 4f	$2 \times 4^2 = 32$

* Orbitals :- The region of space around the nucleus where the probability of finding the electrons maximum is called orbital.

* Orbit :- An orbit is a circular path in which the electrons revolve.

Difference between orbit and orbital :-

Orbit	Orbital
1) An orbit is well defined circular path around the nucleus in which electrons revolve according to Bohr's model of an atom.	1) An orbital is a three dimensional space around the nucleus in which the probability of finding an electron is maximum. This is in accordance with the quantum mechanical model of an atom.
2) An orbit can accomodate maximum of $2n^2$ electrons where n represents the number of the orbit.	2) An orbital can accomodate maximum of 2 electron only.
3) The concept of revolution of electrons in an orbit is not in accordance with the heisenberg's uncertainly principle.	3) The concept of an orbital is in accordance with the Heisenberg's uncertainly principle.

4) Orbits are circular.	4) The shapes of differents orbital are different.
5) Orbits are non-directional	5) Except the s-orbitals all other orbitals are directional in nature.
6) An orbit represents the plane motion of an electron around the nucleus.	6) An orbital represents the three dimensional motion of an electron around the nucleus.

Hund's Rule of maximum multiply :-

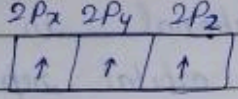
⇒ On the basis of magnetic measurement. Hund proposed an empirical rule known as Hund's rule of maximum multiplicity. This helps a lot in filling of the orbitals of an atom.

This can be started as follows :-

While filling different orbitals of a sub-shell the electrons prefer to remain unpaired as possible and posses the same direction of spin. pairing of electrons takes place only when all the orbitals of a sub-shell are singly occupied.

The rule implies that during the fillings of orbitals of sub-shell electrons are distributed in such a way as to have the maximum number of unpaired electrons in the given sub-shell.

For example :- Suppose three electrons enter a 2p sub shell they will be filled as shown below.



* Aufbau principle :-

=> Aufbau principle is a German word which means to build up or to construct. This principle is given to explain the building up of an atom by the fillings of electrons in its various orbitals. the principle can stated as follows :-

In the ground state of an atom, the electrons enter into the available orbitals in the increasing order of energies and fill up the orbitals of lower energy first.

The increasing order of energies of various orbitals is 1s, 2s, 2p, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s. the order of energies of various orbitals can easily be kept in mind with the help of a simple diagram shown in figure :-

* Valency - The bonding capacity of an element is represented by its valency. Word valency is derived from a latin word valenta, which means power or capacity. For the first time, Frankland used the word 'valency' for bonding capacity of electrons.

The no. of bonds formed by an atom in a molecule is known as its valency.

Ex - N_7 = 2, 5 (3 Valency) O_8 = 2, 6 (2 Valency)

* Valence electrons :- Electrons presents in outer most shell of an element or atom participate in the formation of chemical bond. The outer most shell of an atom is called valence electron shell and elements present in valency shell are called valence electrons.

Ex - $_6C$ - 2, 4

(4) Valence electrons

Fg - 2, 7

(7) Valence electrons.

* Duplet Rule :-

=> Helium a rare gas atom is also stable and exists as a monoatomic gas its atom does not have the octet structure but has 2 electrons in the valence shell. The structure of 2 electrons in the first and outermost orbit is called the duplet rule.

E.g - He_2 - 2
Mg_{12} - 2, 8, 2

* Octet Rule - It was based on the electronic configuration of noble gases. The ~~octet~~ noble gases like neon, argon etc. have 8 electron in ~~like~~ their outermost shell. They do not have any tendency to take part in chemical combination the chemical enertness of noble gases was related to the presence of octet of electron because other elements which were chemically reactive has less than 8 electrons in their outermost shell. These observation led Kossal and Lewis to put forward a generalisation known as octet Rule.

E.g. Ne_{10} - 2, 8
Ar_{18} - 2, 8, 8

* Chemical Bonding - Chemical bond is defined as a force that bonds two or more atoms together as a stable molecule in the beginning of the development of modern theory. Bonding was treated as the concept of valency which means combining capacity.

There are three different ways by which an atom may attain the stable configuration -

(i) By donating or accepting electrons (electrovalent or ionic bonding).

(ii) By sharing of electron (Covalent bond)

(iii) By donation of electron pair (Co-ordinate theory).

* Electrovalency -

=> The number of electron that an atom of an element gain or loses so as to acquire stable electronic configuration is called electrovalency.

Types of electrovalency :-

Electrovalency of Ionic valency are of two types :-

(i) Positive Electrovalency - The number of electrons that an atom of an element losses so as to acquire stable electrons configuration is called as its positive electrovalency.

(a) Sodium (Na) atoms loses one valance electrons to complete its octet (valence shell). It attains the stable electronic configuration of the nearest noble gas Neon (2,8). Hence, sodium electropositive and its electrovalency is +1.

$Na\ (2,8,1) \rightarrow Na^{+} + e^{-}$
$(2,8)$

(b) Calcium (Ca) atoms loses two valence electrons to complete its octet (valence shell). It attains the stable electronic configuration of the nearest noble gases argon. Hence, calcium is electrophilic and its electrovalency is +2.

$Ca \rightarrow Ca^{2+} + 2e^{-}$
$(2,8,8,2) \rightarrow (2,8,8)$

(c) Aluminium (Al) atom loses three valence electrons to complete its octet (Valence shell). It attains the stable electronic configuration of the nearest noble gas neon (2,8). Hence, Aluminium is

electropositive and its electrovalency is +3.

$Al \longrightarrow Al^{3+} + 3e^-$

(2,8,3) (2,8)

* Negative Electrovalency :-

⇒ The number of electrons that an atom of an element gain so as to acquire stable electronic configuration is called its negative electrovalency.

(i) Chlorine (Cl) atom gains one electrons in order to complete (Valence shell). It attains the stable electronic configuration of the nearest noble gas argon (2,8,8). Hence, Chlorine is electronegative and its electrovalency is -1.

(ii) Oxygen (O) atom gains two electrons in order to complete its orbit (Valence shell). It attains the stable electronic configuration of the nearest noble gas neon (2,8). Hence, oxygen is electronegative and its electrovalency is -2.

$O + 2e^- \longrightarrow O^{2-}$

(2,6) ⟶ (2,8)

(iii) Sulphur (S) atom gains two electrons in order to complete its octet (Valence shell). It attain the stable electronic configuration of the nearest noble gas argon (2,8,8). Hence sulphur is electronegative and electrovalency is -2

$$S + 2e^- \longrightarrow S^{2-}$$
$$(2,8,6) \longrightarrow (2,8,8)$$

* Difference between positive electrovalency and negative electrovalency

Positive Electrovalency	Negative electrovalency
• The number of electrons that an atom of an element loses as to acquire stable electronic configuration is called its positive electrovalency	• The number of electrons that an atom of an element gain as to acquire stable electronic configuration is called its negative electrovalency.
• Atoms that shows positive electrovalency form cations (positive ions).	• Atoms that show negative electrovalency form anions (negative ions).
• Elements with positive electrovalency are known as electropositive elements.	• Elements with negative electrovalency are known as electronegative elements
• Metals like Na, Ca, etc.	• Non-metals like Cl, S, etc.

* Formation of Sodium Chloride :-

① A molecule of sodium chloride ($NaCl$), formed by development of electrovalent or Ionic bond between sodium (Na^+) ion and Chloride (Cl^-) ion.

E.g :-

$Na_{11} \longrightarrow 2, 8, 1$

$Cl_{17} \longrightarrow 2, 8, 7$

$Na^+ + :\dot{C}l: \longrightarrow [Na]^+ + [:\dot{C}l:]^-$

(2,8,1) (2,8,7) (2,8) (2,8,8)

Neon confi. Argon configuration

② Formation of potassium chloride (KCl) :-

⇒ A molecule of potassium chloride (KCl) is formed by development of electrovalent or ionic bond between potassium (k^+) ion and Chloride (Cl^-) ion.

$K_{19} \rightarrow 2, 8, 8, 1$

$Cl_{17} \rightarrow 2, 8, 7$

$K^+ + :\dot{C}l: \longrightarrow [K]^+ + [:\dot{C}l:]^- \longrightarrow KCl$

(2,8,8,1) (2,8,7) (2,8,8) (2,8,8) Potassium Chloride

Argon Confi. Argon Confi.

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③ Formation of Magnesium oxide (MgO) :-

⇒ A molecule of magnesium oxide (MgO) is formed by development of electrovalent or ionic bond between magnesium (Mg^{2+}) ion and oxide (O^{2-}) ion.

$Mg^{*} + \dot{\underset{\cdot\cdot}{O}}: \longrightarrow [Mg]^{2+} + [:\underset{\cdot\cdot}{\overset{\cdot\cdot}{O}}:]^{2-} \longrightarrow MgO$

(2,8,2) (2,6) (2,8) (2,8) Magnesium

Mg atom O atom Neon Neon Oxide.

Confi. Confi.

④ Formation of calcium oxide (CaO) :-

⇒ A molecule of calcium oxide (CaO) is formed by development of electrovalent or ionic bond between calcium (Ca^{2+}) ion and oxide (O^{2-}) ion.

$Ca^{**} + O \longrightarrow [Ca]^{2+} + [O]^{2-} \longrightarrow CaO$

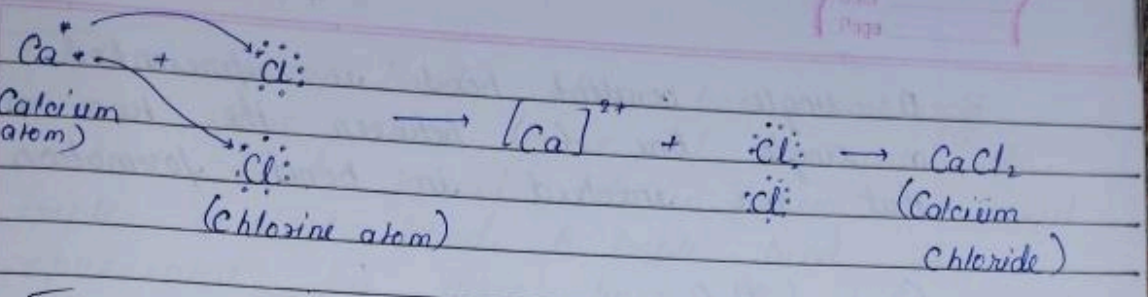
(2,8,8,2) (2,6) (2,8,8) (2,8) Calcium

Argon Neon Oxide.

Configuration Configuration

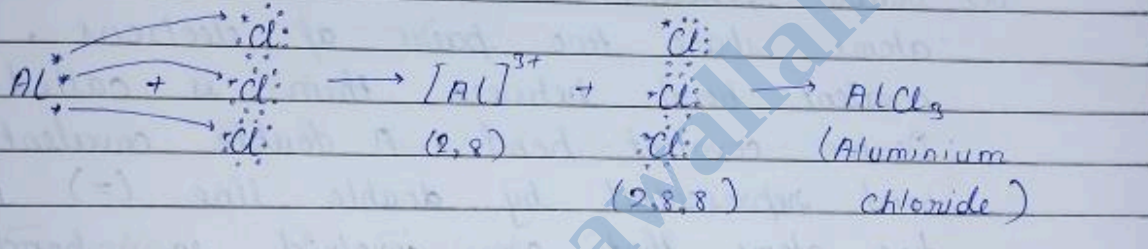
⑤ Formation of calcium chloride ($CaCl_2$) :-

⇒ A molecule of calcium chloride ($CaCl_2$) is formed by development of electrovalent or ionic between calcium (Ca^{2+}) ion and chloride (Cl^{-}) ion.



(b) Formation of Aluminium Chloride ($AlCl_3$) :-

=> A molecule of aluminium chloride ($AlCl_3$) is formed by development or ionic bond between aluminium (Al^{3+}) ion and Chloride (Cl^-) ions.



2) Covalent Bond :-

=> A chemical bond that is formed between two combining atoms by mutual sharing of electrons is called a covalent bond or molecular bond.

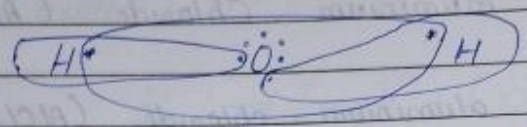
Types of Covalent Bond

Depending on the number of electron pairs shared between two atoms there are three types of bonds.

(i) Single Covalent Bond :- When two combining atom share one electrons pairs, the covalent bond between them is called single covalent bond.

A single covalent bond is represented by a single line (-) between the two atoms that are involved in bond formation.

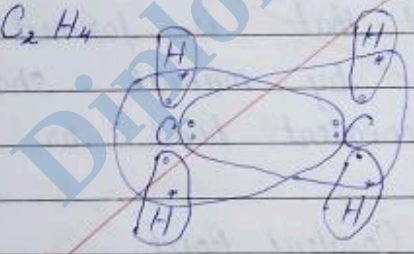
Ex - H_2O

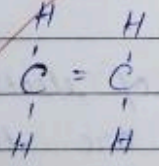


H - O - H (Single Covalent Bond)

(ii) Double covalent Bond :- When two combining atoms share two pairs of electrons, the covalent bond between them is called Double covalent bond. A double covalent bond represented by double line (=) between two atoms that are involved in bond formation.

Ex :- C_2H_4

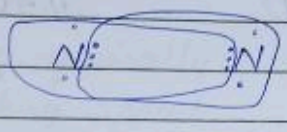




Double covalent bond

(iii) Triple covalent Bond - When two combining atoms share three pairs of electrons the covalent bond formed between them is called triple covalent Bond. A triple bond is represented by three lines (≡) between the two atoms that are involved in bond formation.

Ex- N_2



$N \equiv N$

Triple Covalent bond

Formation of Covalent Bond

(i) Formation of chlorine (Cl_2) molecule :-

$Cl_{17} \rightarrow 2,8,7$

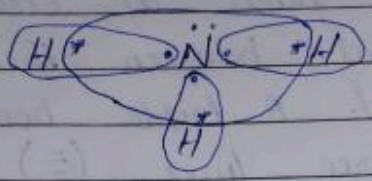
$Cl - Cl$

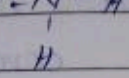
(ii) Formation of water (H_2O)

$O_8 \rightarrow 2,6$ $H \rightarrow 1$

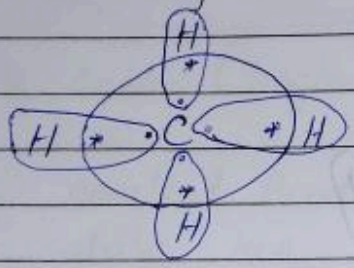
$H - O - H$

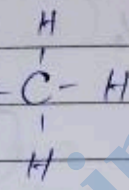
(iii) Formation of Ammonia (NH_3).



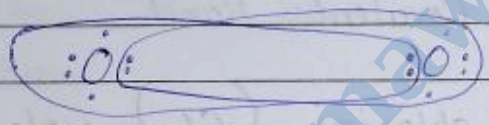


(iv) Formation of methane (CH_4) :-



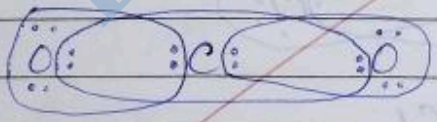


(v) Formation of Oxygen (O_2).



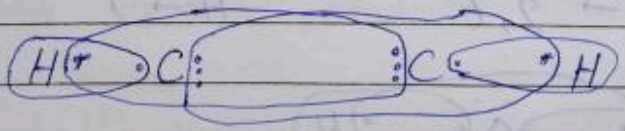
O = O

(vi) Formation of CO_2



O = C = O

(vii) Formation of (C_2H_2) or Acetylene.



H - C ≡ C - H

* Difference between Electrovalent Compound and Covalent Compound.

Ionic Compound	Covalent Compound
• They are formed by complete transfer of electrons from one atom to another.	• They are formed by sharing of electrons between the two atoms.
• These compounds are generally solids.	• These compounds are may be solid, liquid or gas.
• They have generally high melting point and boiling point.	• They have generally low melting point and boiling point.
• They conduct electricity in molten or dissolved state.	• They are generally bad conductor of electricity.
• They are generally non-volatile.	• They are generally volatile.