LEARNING MATERIALS

ON

ENGINEERING CHEMISTRY

1ST SEMESTER

Prepared by

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Faculty in Chemistry

ATOMIC STRUCTURE

ATOM: -

- According to Dalton's atomic theory, atom is the smallest indivisible particle.
- Modern researches revealed that atoms have many small particles.
- These particles are called sub-atomic particles
- Among these particles we will learn about Electrons, Protons and Neutrons.
- An atom is a basic unit of matter.
- It consists of an atomic nucleus which contains positively charge protons and electrically neutral neutrons.
- This central nucleus is surrounded by negatively charged electrons.
- The electrons are moving rapidly around the nucleus. The distribution of electrons is in such a way that the atom has spherical shape.

THE FUNDAMENTAL PARTICLES: -

- Electron
- Proton
- Neutron

PROPERTIES OF FUNDAMENTAL PARTICLES: -

ELECTRON: -

a) It was discovered by J.J. Thomson.
b) Electrons have relative charge -1.
c) The charge of electron is $-1.6*10^{-19}$ coulomb. Electron is a negative charged particle.

d) Mass of electron is $9.11*10^{-31}$ Kg.
e) It is denoted as e^-.

PROTON: -

a) It was discovered by E. Goldstein.
b) Protons have relative charge +1.
c) The charge of proton is $+1.6*10^{-19}$ coulomb. Proton is a positive charged particle.
d) Mass of proton is $1.67*10^{-27}$ Kg.
e) It is denoted as p^+.

NEUTRON: -

a) It was discovered by Chadwick.
b) The relative charge of neutron is 0.
c) Mass of neutron is $1.6*10^{-27}$ Kg.
d) It is denoted as n.

ATOMIC NUMBER (Z): -

The number of proton(s) or the number of electron(s) present in the atom is called its atomic number.

Number of proton (p^+) =Number of electron (e^-) =Atomic number (Z)

$$P^+ = e^- = Z$$

MASS NUMBER(A): -

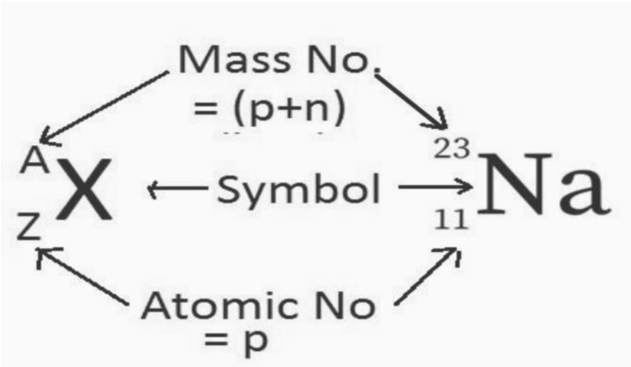
The sum of number of proton(s) and number of neutron(s) is collectively known as mass number.

A =number of protons (p^+) +number of neutrons (n)

$$A = p^+ + n$$

$$n = A - p^+$$

REPRESENTATION OF AN ATOM:-

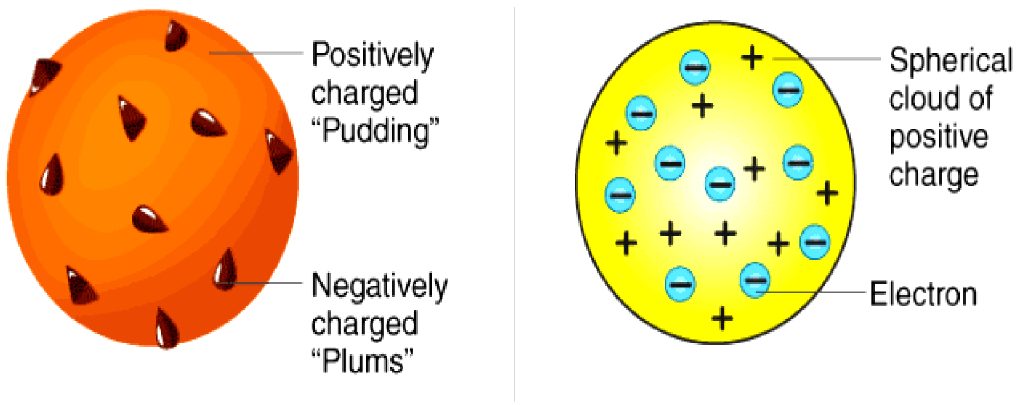


THOMSON'S ATOMIC MODEL: -

After the discovery of electrons and protons J.J.Thomson proposed an atomic model which is named after him as Thomson's atomic model.

According to this model, "the atom is a positive sphere where electrons are embedded like plum in pudding. "Therefore this model is also known as 'PLUM PUDDING MODEL'.

In this model the number of electrons is equal to number of protons.



Thomson's model of an atom

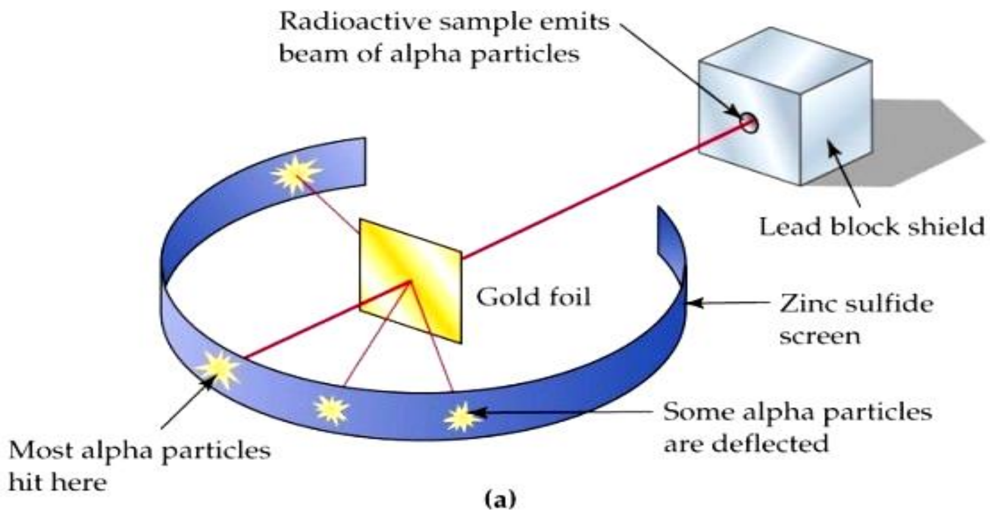
RUTHERFORD'S ATOMIC MODEL: -

An atom consists of two particles;

1. Negatively charged particles (electrons)
2. Positively charged particles (protons)

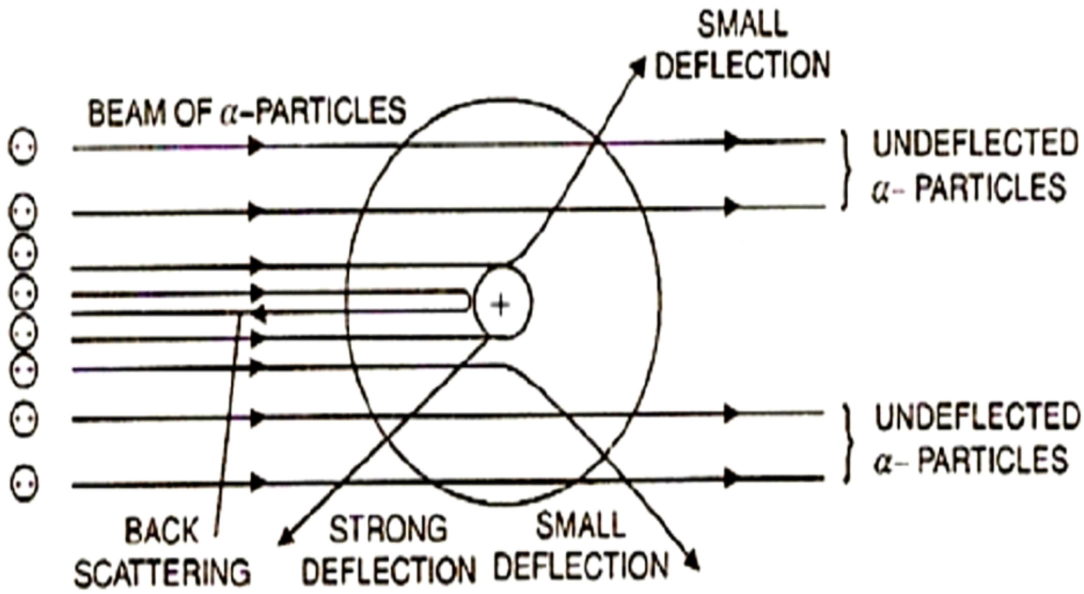
EXPERIMENT: -

Rutherford bombarded a number of α- particles on a thin gold foil of thickness 0.00004 cm. α-particles commonly known as He^{2+} ions were emitted from a radioactive element named Radium. The radioactive element was kept inside a lead block. A circular Zinc sulphide (ZnS) screen was placed around the gold foil which acts as a fluorescent screen.



[Rutherford's gold foil experiment]

OBSERVATION: -



[Rutherford's α-particle scattering experiment]

It was observed that,

a) Most of the α-particles passed straight through the gold foil and caused illumination on ZnS screen.
b) A few α-particles were deflected at some angle after passing through the gold foil.
c) A very few α-particle (1 in 10000) even retracted their path.

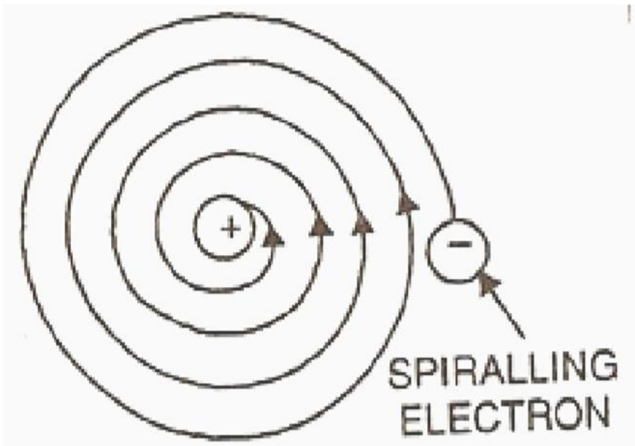
CONCLUSION: -

From the observation following conclusions were drawn

a) Most of the space in an atom is empty.
b) There is a heavy positive charge at the centre of an atom which is called nucleus.
c) Protons are placed inside the nucleus.
d) An atom consists of two parts; they are
    1. Nucleus
    2. Extra nuclear part
e) Electrons are revolving around the nucleus in the extra nuclear part of the atom. They are revolving like planets in the solar system; therefore, they are also called as "Planetary electrons."

DRAWBACKS: -

a) According to Clark Maxwell, as electrons are revolving around the nucleus. So, they continuously lose their energy. As the energy decreases it gets attracted by nucleus and follows a spiral path. The electron ultimately falls into the nucleus and the atom collapses. However, this is contradictory as we know atom is stable. Thus, Rutherford's picture of atom is faulty.



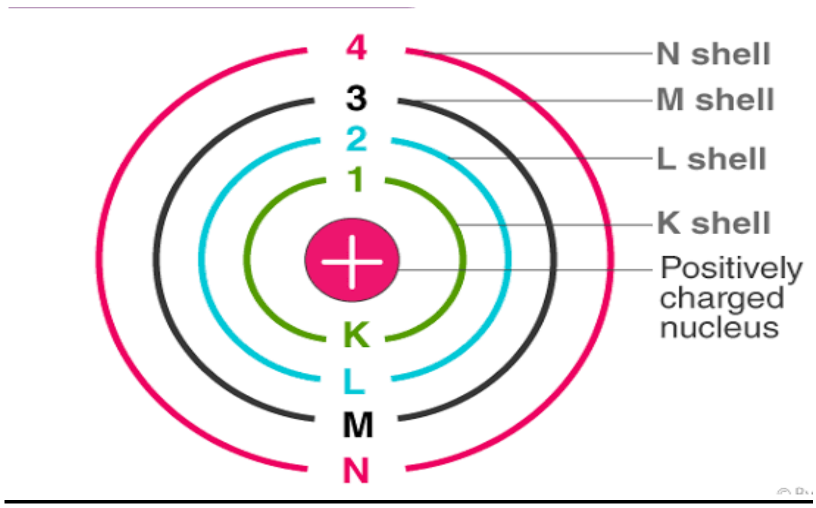
[Spiral path followed by an electron]

b) This theory fails to explain atomic spectra.
c) It fails to explain the energy and distribution of electrons.

BOHR'S ATOMIC MODEL: -

POSTULATES: -

a. Every atom consists of a heavy positive charge body at the center called nucleus.
b. Electrons revolve around the nucleus in certain circular path called shell, orbit, and stationary state.
c. The shells are named as K, L, M, and N for 1^{st}, 2^{nd}, $3^{rd}$and 4^{th} shells respectively. Each shell has a definite amount of energy; therefore, they are also named as energy levels.



d. Energy of a shell,

$$E_n = -\frac{1312}{n^2}$$ For Hydrogen atom

Where, n=number of shells

e. Only those shells have permission to allow electrons to revolve on them, whose angular momentum value is an integral multiple of h/2π.

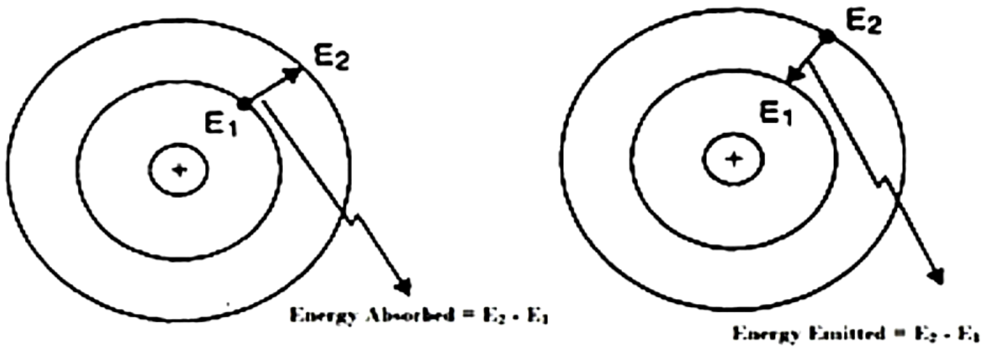
$$mvr = \frac{nh}{2\pi}$$

Where m= mass of the electron
v=velocity of the electron
r= radius of the shell
h= Planck's constant
n= 1, 2, 3……

f. Energy increases from lower energy level to higher energy level. Distance between shell decreases as the distance increases from the nucleus.

g. Electrons do not lose energy in their ground state.

h. If electron absorbs energy it jumps from lower energy state to higher energy state and vice-versa.
i. The energy difference, $\Delta E = E_2 - E_1$



[Energy difference between shells]

LIMITATION: -

a. It fails to explain the multi-electron spectra.
b. It fails to explain the intensity of spectral lines.
c. It fails to explain splitting of spectral line.
d. It fails to explain the cause of chemical combination.

ISOTOPE: -

Atoms having same atomic number but different mass number are called isotopes. These atoms have similar physical and chemical properties.

e.g., $_1H^1$, $_1H^2$, $_1H^3$

ISOBAR: -

Atoms having different atomic number but same mass number are called isobars.

e.g., $_{18}Ar^{40}$, $_{20}Ca^{40}$

ISOTONE:-

Atoms having same number of neutrons are called isotones.

e.g., $_{11}Na^{23}$, $_{12}Mg^{24}$

BOHR-BURY SCHEME:-

a. A shell contains maximum $2n^2$ numbers of electron, where n=number of shells

Shell	Number of shell(n)	$2n^2$
K	1	$2*1^2 = 2*1 = 2$
L	2	$2*2^2 = 2*4 = 8$
M	3	$2*3^2 = 2*9 = 18$
N	4	$2*4^2 = 2*16 = 32$

Therefore K, L, M and N shell contains 2, 8, 18 and 32 electrons respectively.

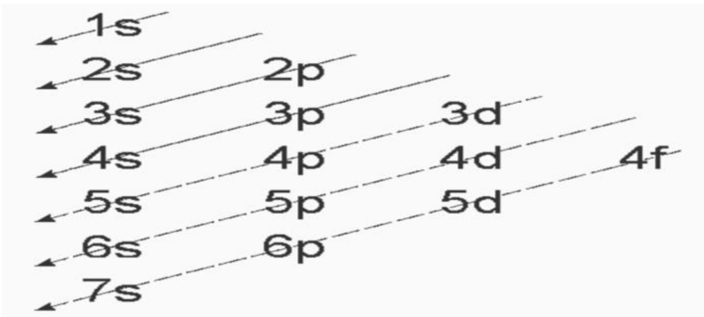
b. The outermost shell / valence shell cannot hold more than 8 electrons.
c. The penultimate shell (the shell just before the outermost shell) cannot hold more than 18 electrons.

Sub shell	n	l	n+l
1s	1	0	1+0=1
2s	2	0	2+0=2
2p	2	1	2+1=3
3s	3	0	3+0=3
3p	3	1	3+1=4
3d	3	2	3+2=5

4s	4	0	4+0=4
4p	4	1	4+1=5

AUF-BAU PRINCIPLE: -

a. It states that, "Electrons are filled in the sub shells in order of their increasing energy or (n+l) value."
b. The sub shells having lower (n+l) value filled first.
c. If (n+l) value is same for some sub shells then the sub shell having less 'n' value will be filled first.
d. So, the order of sub shell is 1s 2s 2p 3s 3p 4s 3d 4p and so on.



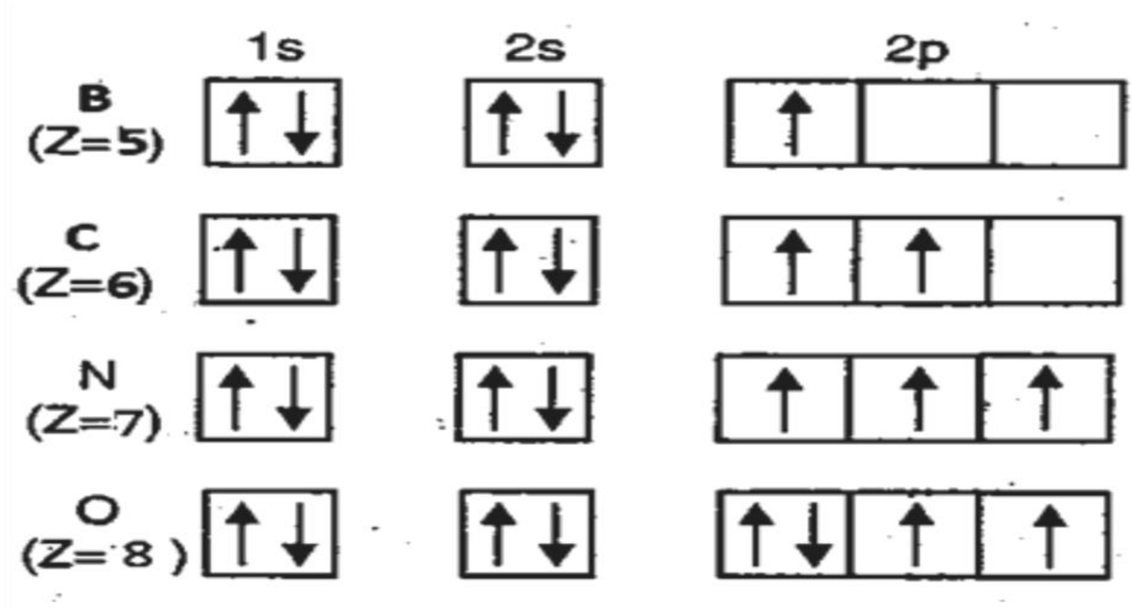
e. Each orbital contains 2 electrons.

Sub shell	l value	Box representation	electrons
s	0		2*1=2
p	1		2*3=6
d	2		2*5=10
f	3		2*7=14

HUND'S RULE: -

a. This is also known as rule of maximum multiplicity.
b. It states that, "electrons do not pair up in the orbitals of degenerate sub-shells until each available orbital in the given sub-shell contains one electron."(or) "In the

degenerate orbitals of p, d and f sub shells electron filled in each orbital first then pairing takes place."
e.g.



ELECTRONIC CONFIGURATION: -

According to the above rules/principles, electronic configuration of elements up to 30 is given below,

Elements	Electronic configurations	Elements	Electronic configurations
$_1H$	$1s^1$	$_{16}S$	$1s^2 2s^2 2p^6 3s^2 3p^4$
$_2He$	$1s^2$	$_{17}Cl$	$1s^2 2s^2 2p^6 3s^2 3p^5$
$_3Li$	$1s^2 2s^1$	$_{18}Ar$	$1s^2 2s^2 2p^6 3s^2 3p^6$
$_4Be$	$1s^2 2s^2$	$_{19}K$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

$_{5}B$	$1s^2 2s^2 2p^1$	$_{20}Ca$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
$_{6}C$	$1s^2 2s^2 2p^2$	$_{21}Sc$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$
$_{7}N$	$1s^2 2s^2 2p^3$	$_{22}Ti$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$
$_{8}O$	$1s^2 2s^2 2p^4$	$_{23}V$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
$_{9}F$	$1s^2 2s^2 2p^5$	**$_{24}Cr$**	**$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$**
$_{10}Ne$	$1s^2 2s^2 2p^6$	$_{25}Mn$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
$_{11}Na$	$1s^2 2s^2 2p^6 3s^1$	$_{26}Fe$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
$_{12}Mg$	$1s^2 2s^2 2p^6 3s^2$	$_{27}Co$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$
$_{13}Al$	$1s^2 2s^2 2p^6 3s^2 3p^1$	$_{28}Ni$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
$_{14}Si$	$1s^2 2s^2 2p^6 3s^2 3p^2$	**$_{29}Cu$**	**$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$**
$_{15}P$	$1s^2 2s^2 2p^6 3s^2 3p^3$	$_{30}Zn$	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$