University of Science and Technology

Engineering College - First year – Batch 31

Semester 1

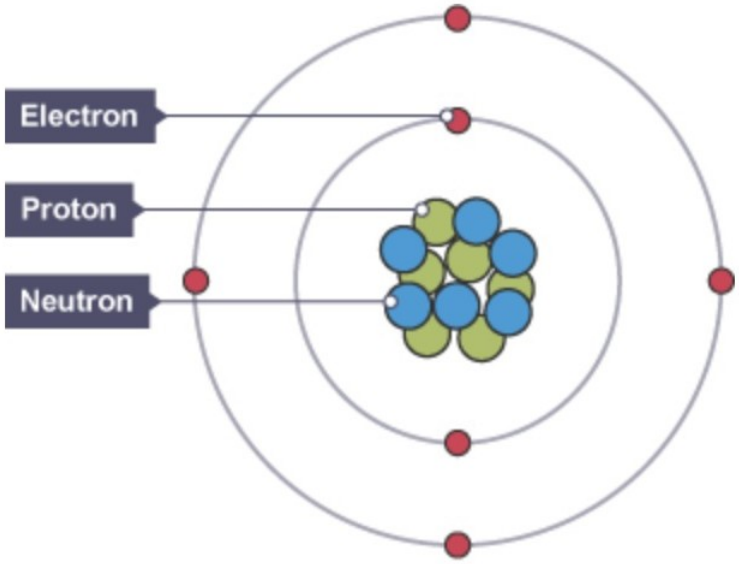
General Chemistry

Lecture 6

Structure of Atom

Atomic structure:

- **Atoms are the building blocks of the elements.**
- **Atoms consist of three fundamental particles:**
  - **The protons and neutrons form the nucleus, in the centre of the atom.**
  - **The electrons surround the nucleus in shells of increasing radius.**


Electron
Proton
Neutron

- **Most of the mass of an atom is concentrated in its nucleus.**
- **The number of protons in the nucleus is called the atomic number.**
- **The total number of protons plus neutrons is called the mass number.**


Mass number
Atomic number
AZX
Element symbol


mass number
atomic number
4
2
He
Element Symbol

Isotopes:

Atoms with the same number of protons but different numbers of neutrons.

Isotopes of Carbon: carbon-12;carbon-13; carbon-14.

$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

Symbol	$^{12}_{6}C$	$^{13}_{6}C$	$^{14}_{6}C$
Number of protons	6	6	6
Number of neutrons	6	7	8
Abundance	98.89%	1.11%	trace

Isotopes of Carbon

Name	Absolute charge／C	Relative charge	Mass／Kg	Mass／u	Approx. Mass／u
Electron	-1.602210^{-19}	−1	$9.10939\ 10^{-31}$	0.00054	1／1840
Proton	$+1.602210^{-19}$	+1	$1.67262\ 10^{-27}$	1.00727	1
Neutron	0	0	$1.67493\ 10^{-27}$	1.00867	1

Properties of the subatomic particles

Atomic models

Dalton atomic theory

Rutherford atomic model:

Bohr Model of the hydrogen atom:

Neils Bohr (1913) was the first to explain quantitatively the general features of hydrogen atom structure and its spectrum.

Postulates:

- **The electron in hydrogen atom revolve around the nucleus in a circular path of fixed radius and energy. These paths are called orbits or stationary states or allowed energy states. These orbits are arranged around the nucleus.**

- **Electrons can jump to higher levels by absorbing energy and move to lower energy levels by losing or emitting their energy.**

$$\Delta E = E_f - E_i$$

- **The frequency of radiation absorbed or emitted when transition occurs between two stationary states that differ in energy by ΔE, is given by:**

$$\nu = \frac{\Delta E}{h} = \frac{E_f - E_i}{h}$$

This expression known as Bohr's frequency rule.

Dual Nature of matter:

Louis de Broglie(1924) proposed that matter , like radiation, should also exhibit dual behavior i.e. both particle and wavelike properties.

Quantum Mechanical Model of the atom:

- **Erwin Schrodinger refined the wave-particle theory proposed by de Broglie, developed an equation that treated an electron like a wave and predicted the probable location of an electron around the nucleus called the atomic orbital. For a system whose energy does not change with time the Schrodinger equation can be written as:**

$$\hat{H}\psi = E\psi$$

- **Schrodinger thought of the electron in term of three dimensional stationary waves, or wave function, represented by the Greek letter psi ψ.**

Orbitals and Quantum Numbers:

An electron in an atom is completely described by four quantum numbers : n, l , m_l and m_s.

The first three quantum numbers define the orbital and the fourth quantum number m_s describes the intrinsic electron property called spin.

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General Chemistry

Lecture 7

Structure of Atom-2

Orbitals and Quantum Numbers:

An electron in an atom is completely described by four quantum numbers :

1- Principal Quantum Numbers(n).

2- Angular momentum quantum number (l).

3- Magnetic Quantum Number (m_l).

4- Electron Spin Quantum Number (m_s).

Principal Quantum Numbers(n):

It is a positive integer with value of (1, 2, 3,……).

It determines the size and to large extent the energy of the orbital. Orbitals of the same quantum state are said to belong to the same shell. Shells can be designated by the following letters:

letter	K	L	M	N
n	1	2	3	4

Azimuthal Quantum Numbers(l) ;

Angular momentum quantum number:

It defines the three dimensional shape of the orbital. For a given value of n, l can have values ranging from 0 to (n-1). The different subshells are usually denoted by letters as follows:

Value of l	0	1	2	3
Sub- shell	s	p	d	f

Magnetic Quantum Number (m_l):

Gives information about the spatial orientation of the orbital with respect to standard set of co-ordinate axis.

For any sub-shell defined by l value , $2l+1$ values of m_l are possible. All orbitals of a given subshell have the same shape and energy.

Value of ι	0	1	2	3
Sub-shell	s	p	d	f
Number of orbitals	1	3	5	7

Maximum No of electrons	2	6	10	14

Electron Spin Quantum Number (m_s):

An electron spins around its own axis. m_s refers to orientation of the spin of the electron. m_s can take the values of + ½ or –½.

n	ι	$m_ι$	m_s	*Orbitals*	Shell
1	0	0	+ ½ , −½	1s	K
2	0 1	0 − 1 ,0, +1	+ ½ , −½ +½ , −½	2s 2p	L

Quantum numbers

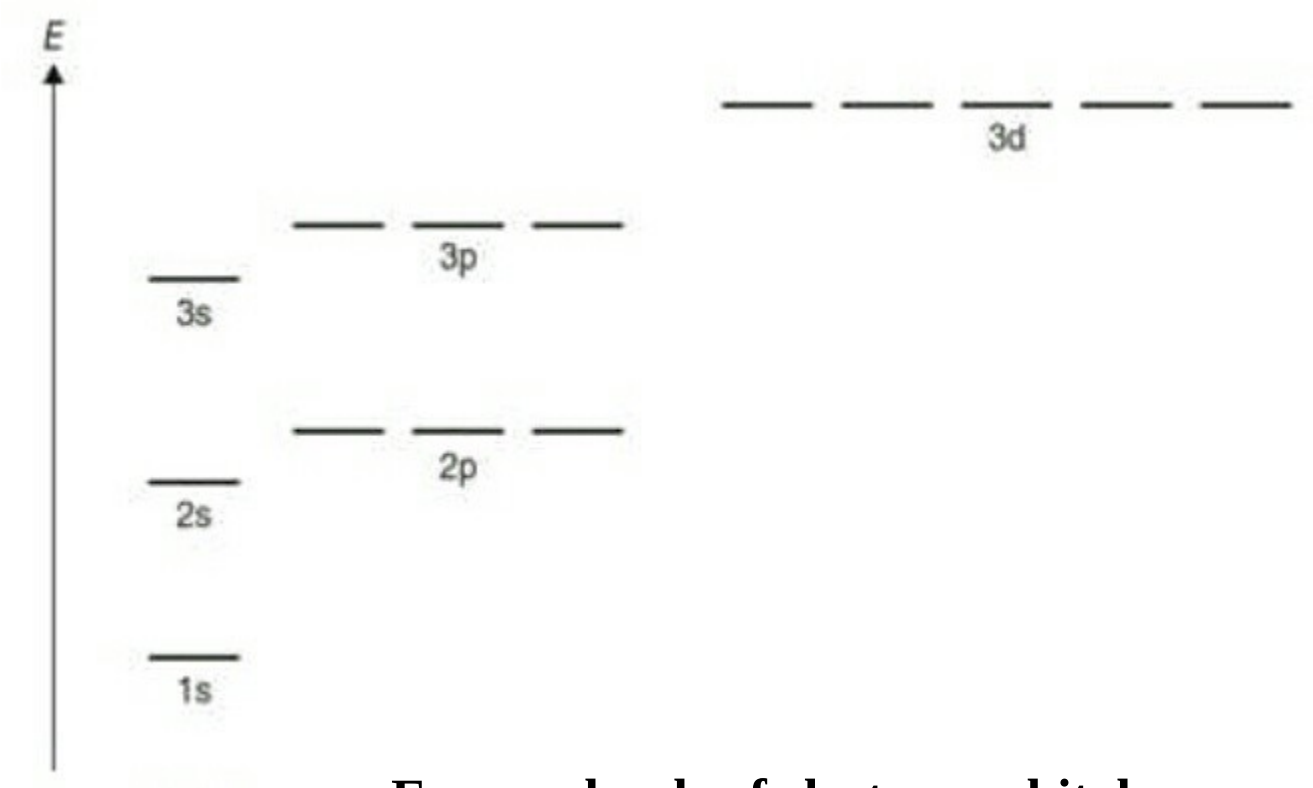
Electronic configuration of an atom:

The electrons have to be filled in the s, p, d and f in accordance with the following rules:

1- Aufbau's principle:

The filling of electrons should take place in accordance with the ascending order of energy of orbitals:

- **Each electron must occupy the lowest energy level available before going onto the next higher energy level.**
- **Ascending order of energy 1s, 2s, 2p, 3s, 3p, 4s, 3d,…….**



Energy levels of electron orbitals

2- Pauli's exclusion principle:

No two electrons can have all four quantum numbers to be the same, or if two electrons have to be placed in an energy state, they should be placed with opposite spin.

3- Hund’s rule of maximum multiplicity:

In the case of filling degenerate(same energy) orbitals, all the degenerate orbitals have to be singly filled first, and then, only pairing has to happen.

† **The electronic configuration of different atoms can be represented in two ways:**

1- s^a p^b d^c……. notation.

2- Orbital diagram.



Example:

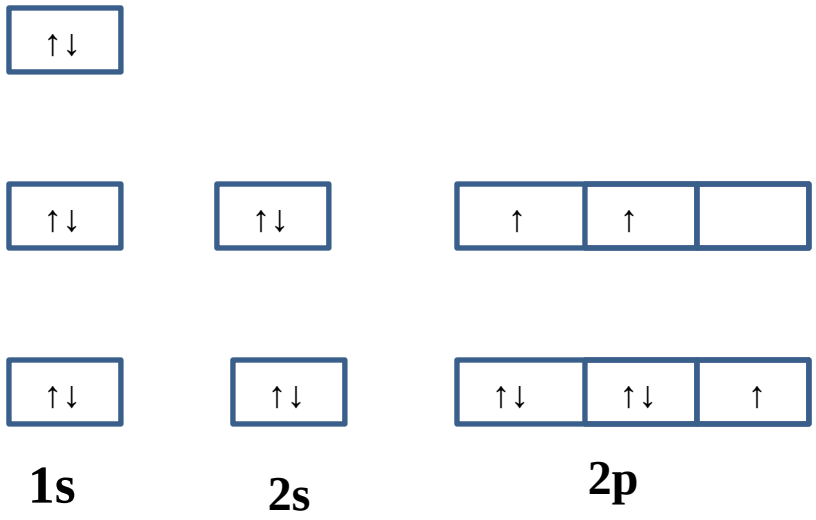
Write the electronic configuration for Helium($_2$He), carbon ($_6$C) and fluorine ($_9$F) using both s p d notation and orbital diagram method.

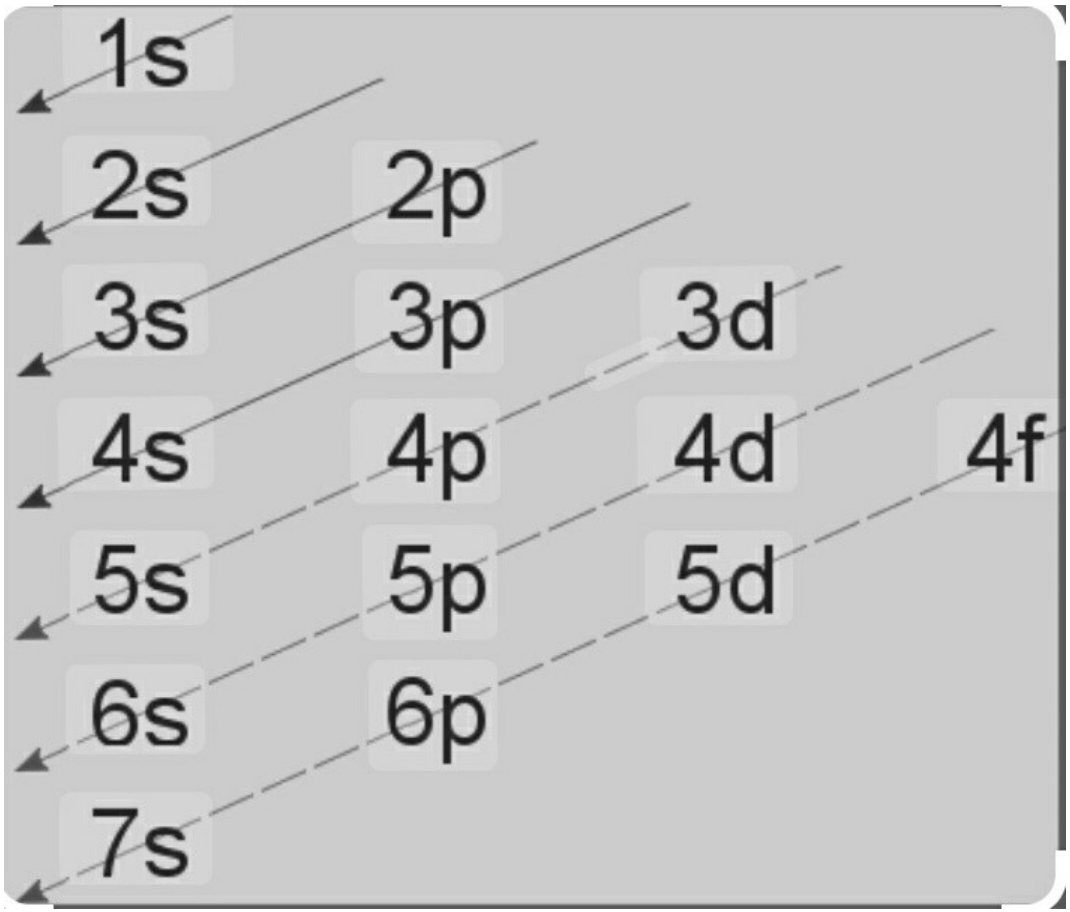
Solution:

1- $1s^2$

2- $1s^2\ 2s^2\ 2p^2$

3- $1s^2\ 2s^2\ 2p^5$





Order of filling of orbitals