ATOMIC STRUCTURE

LEARNING OBJECTIVES:

- Information about Electron
- Information about Proton
- Information about Neutron
- Atomic number and mass number
- Different types of atomic species
- Electromagnetic radiation
- Thomson model
- Rutherford model
- Bohrs model
- Electronic configuration principles
- Electronic configuration of elements

John Dalton 1808, believed that matter is made up of extremely minute indivisible particles, called *atom* which can takes part in chemical reactions. These can neither be created nor be destroyed. However, modern researches have conclusively proved that atom is no longer an indivisible particle. Modern structure of atom is based on Rutherford's scattering experiment on atoms and on the concepts of quantization of energy.

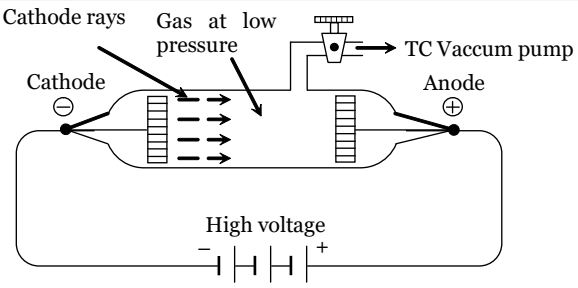
2.1 Composition of atom.

The works of J.J. Thomson and Ernst Rutherford actually laid the foundation of the modern picture of the atom. It is now believed that the atom consists of several *sub-atomic particles* like electron, proton, neutron, positron, neutrino, meson etc. Out of these particles, the electron, proton and the neutron are called *fundamental subatomic particles* and others are *non-fundamental particles*.

Electron ($_{-1}e^{o}$)

(1) It was discovered by ***J.J. Thomson*** (1897) and is *negatively charged particle*. Electron is a component particle of cathode rays.

(2) Cathode rays were discovered by ***William Crooke's*** & ***J.J. Thomson*** (1880) using a cylindrical hard glass tube fitted with two metallic electrodes. The tube has a side tube with a stop cock. This tube was known as ***discharge tube.*** They passed electricity (10,000*V*) through a discharge tube at very low pressure ($_{10^{-2}}$ to $10^{-3} mm\ Hg$). Blue rays were emerged from the cathode. These rays were termed as ***Cathode rays***.



Discharge tube experiment for production of cathode

(3) Properties of Cathode rays

(i) Cathode rays travel in st`raight line.
(ii) Cathode rays produce mechanical effect, as they can rotate the wheel placed in their path.
(iii) Cathode rays consist of negatively charged particles known as *electron*.
(iv) Cathode rays travel with high speed approaching that of light (ranging between 10^{-9} 10^{-11} to *cm/sec*)
(v) Cathode rays can cause fluorescence.
(vi) Cathode rays heat the object on which they fall due to transfer of kinetic energy to the object.
(vii) When cathode rays fall on solids such as Cu, X - rays are produced.
(viii) Cathode rays possess ionizing power i.e., they ionize the gas through which they pass.
(ix) The cathode rays produce scintillation the photographic plates.
(x) They can penetrate through thin metallic sheets.
(xi) The nature of these rays does not depend upon the nature of gas or the cathode material used in discharge tube.
(xii) The *e*/*m* (charge to mass ratio) for cathode rays was found to be the same as that for an e^- (-1.76×10^8 coloumb per *gm*). Thus, the cathode rays are a stream of electrons.

Note : When the gas pressure in the discharge tube is 1 atmosphere no electric current flows through the tube. This is because the gases are poor conductor of electricity.
The television picture tube is a cathode ray tube in which a picture is produced due to fluorescence on the television screen coated with suitable material. Similarly, fluorescent light tubes are also cathode rays tubes coated inside with suitable materials which produce visible light on being hit with cathode rays.

(4) ***R.S. Mullikan*** measured the charge on an electron by oil drop experiment. The charge on each electron is -1.602×10^{-19}C.

(5) Name of electron was suggested by ***J.S. Stoney***. The specific charge (*e*/*m*) on electron was first determined by ***J.J. Thomson***.

(6) Rest mass of electron is 9.1×10^{-28} gm = 0.000549 amu = 1/1837 of the mass of hydrogen atom.

(7) According to *Einstein's theory of relativity, mass* of electron in motion is, m'

$$= \frac{\text{Rest mass of electron(m)}}{\sqrt{[1-(u/c)^2]}}$$

Where u = velocity of electron, *c*= velocity of light.
When *u*=*c* than mass of moving electron =¥.

(8) Molar mass of electron = Mass of electron × Avogadro number = 5.483×10^{-4}.

(9) 1.1×10^{27} electrons =1gram.

(10) 1 mole electron = 0.5483 *mili gram*.

(11) Energy of free electron is ? 0. The minus sign on the electron in an orbit, represents attraction between the positively charged nucleus and negatively charged electron.

(12) Electron is universal component of matter and takes part in chemical combinations.

(13) The physical and chemical properties of an element depend upon the distribution of electrons in outer shells.

(14) The radius of electron is $4.28 \times 10^{-12}\ cm$.

(15) The density of the electron is = $2.17 \times 10^{-17}\ g/mL$.

Examples based on Einstein's theory of relativity

Example:1 The momentum of electron moving with 1/3*rd* velocity of light is (in *g cm sec*$^{-1}$)

(a) 9.69×10^{-8} (b) 8.01×10^{10} (c) 9.652×10^{-18} (d) None

Solution: (c) Momentum of electron, '*p*' = $m' \times u$

Where m' is mass of electron in motion $= \frac{m}{\sqrt{1-(u/c)^2}}$; Also $u = c/3$

Momentum $= \frac{9.108 \times 10^{-28}}{\sqrt{1-\left(\frac{c}{3 \times c}\right)^2}} \times \frac{3 \times 10^{10}}{3} = \frac{9.108 \times 10^{-28} \times 3 \times 10^{10}}{0.94 \times 3} = 9.652 \times 10^{-18}\ g\ cm\ \sec^{-1}$

Example: 2 An electron has a total energy of 2 *MeV*. Calculate the effective mass of the electron in *kg* and its speed. Assume rest mass of electron 0.511 *MeV.*

(a) 2.9×10^{8} (b) 8.01×10^{8} (c) 9.652×10^{8} (d) None

Solution: (a) Mass of electron in motion $= \frac{2}{931} amu$ (1 *amu* = 931 *MeV*)

$= \frac{2}{931} \times 1.66 \times 10^{-27}\ kg = 3.56 \times 10^{-30}\ kg$ (1 $amu = 1.66 \times 10^{-27}\ kg$)

Let the speed of the electron be *u*.

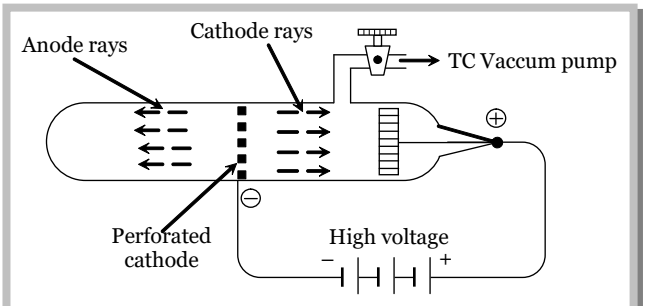
$m' = \frac{m}{\sqrt{1-(u/c)^2}}$ or $3.56 \times 10^{-30} = \frac{\frac{0.511}{931} \times 1.66 \times 10^{-27}}{\sqrt{1-\left(\frac{u}{3 \times 10^8}\right)^2}} = \frac{0.911 \times 10^{-30}}{\sqrt{1-\left(\frac{u}{3 \times 10^8}\right)^2}}$

or $1-\left(\frac{u}{3 \times 10^8}\right)^2 = 0.06548$ or $u^2 = 9 \times 10^{16} \times 0.93452$ or $u = 2.9 \times 10^8\ m$

Proton ($_1H^1$, H^+, P)

(1) Proton was discovered by ***Goldstein*** and is positively charged particle. It is a component particle of anode rays.

(2) **Goldstein (1886)** used perforated cathode in the discharge tube and repeated Thomson's experiment and observed the formation of anode rays. These rays also termed as *positive* or *canal rays*.



Perforated tube experiment for production of anode

(3) Properties of anode rays

(i) Anode rays travel in straight line.
(ii) Anode rays are material particles.
(iii) Anode rays are positively charged.
(iv) Anode rays may get deflected by external magnetic field.
(v) Anode rays also affect the photographic plate.
(vi) The *e*/*m* ratio of these rays is smaller than that of electrons.
(vii) Unlike cathode rays, their e/m value is dependent upon the nature of the gas taken in the tube. It is maximum when gas present in the tube is hydrogen.
(viii) These rays produce flashes of light on *ZnS* screen.

(4) Charge on proton= 1.602×10^{-19} *coulombs* = 4.80×10^{-10} e.s.u.

(5) Mass of proton = Mass of hydrogen atom= 1.00728 amu = 1.673×10^{-27} gram=1837 of the mass of electron.

(6) Molar mass of proton = mass of proton x Avogadro number =1.008 (approx).

(7) Proton is ionized hydrogen atom (H^+) i.e., hydrogen atom minus electron is proton.

(8) Proton is present in the nucleus of the atom and it's number is equal to the number of electron.

(9) Mass of 1 mole of protons is $\approx$ 1.007 *gram*.

(10) Charge on 1 mole of protons is $\approx$ 96500 *coulombs*.

(11) The volume of a proton (volume = $\frac{4}{3}\pi r^3$) is $\approx 1.5 \times 10^{-38} cm^3$

(12) Specific charge of a proton is 9.58×10^4 Coulomb/gram.

Neutron ($_0n^1$, N)

$_4Be^9 + {}_2He^4 \rightarrow {}_6C^{12} + {}_0n^1$ or $_5B^{11} + {}_2He^4 \rightarrow {}_7N^{14} + {}_0n^1$

(1) Neutron was discovered by ***James Chadwick*** (1932) according to the following nuclear reaction,

$_4Be^9 + {}_2He^4 \rightarrow {}_6C^{12} + {}_0n^1$ or $_5B^{11} + {}_2He^4 \rightarrow {}_7N^{14} + {}_0n^1$

(2) The reason for the late discovery of neutron was its neutral nature.

(3) Neutron is slightly heavier (0.18%) than proton.

(4) Mass of neutron = $1.675 \times 10^{-24}\ gram = 1.675 \times 10^{-27}\ kg = 1.00899\ amu \approx$ mass of hydrogen atom.

(5) Specific charge of a neutron is zero.

(6) Density = $1.5 \times 10^{-14}\ gram/c.c.$

(7) 1 mole of neutrons is $\approx$ 1.008 *gram*.

(8) Neutron is heaviest among all the fundamental particles present in an atom.

(9) Neutron is an unstable particle. It decays as follows :

$$\underset{\text{neutron}}{{}_0n^1} \longrightarrow \underset{\text{proton}}{{}_1H^1} + \underset{\text{electron}}{{}_{-1}e^0} + \underset{\text{anti nutrino}}{{}_0\nu^0}$$

$$\underset{\text{neutron}}{{}_0n^1} \longrightarrow \underset{\text{proton}}{{}_1H^1} + \underset{\text{electron}}{{}_{-1}e^0} + \underset{\text{anti nutrino}}{{}_0\nu^0}$$

(10) Neutron is fundamental particle of all the atomic nucleus, except hydrogen or protium.

Comparison of mass, charge and specific charge of electron, proton and neutron

Name of constant	Unit	Electron(e^-)	Proton(p^+)	Neutron(n)
Mass (m)	amu	0.000546	1.00728	1.00899
	kg	9.109×10^{-31}	1.673×10^{-27}	1.675×10^{-24}
	Relative	1/1837	1	1
Charge(e)	Coulomb (C)	-1.602×10^{-19}	$+1.602 \times 10^{-19}$	Zero
	esu	-4.8×10^{-10}	$+4.8 \times 10^{-10}$	Zero
	Relative	-1	$+1$	Zero
Specific charge (e/m)	C/g	1.76×10^{8}	9.58×10^{4}	Zero

Atomic number or Nuclear charge

(i) The number of protons present in the nucleus of the atom is called *atomic number* (Z)

(ii) It was determined by **Moseley** as,

$$\sqrt{v} = a(Z-b) \text{ or } aZ - ab$$

where, v=X- rays frequency

Z= atomic number of the metal, a & b are constant.

(iii) Atomic number = Number of positive charge on nucleus = Number of protons in nucleus = Number of electrons in nutral atom.

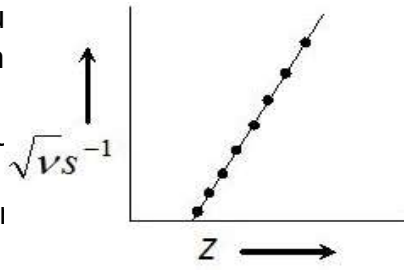
(iv) *Two different elements can never have identical atomic number*.

Mass number

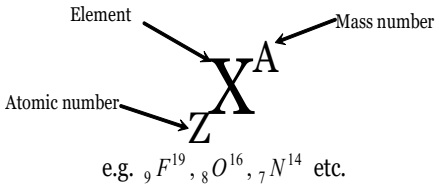
(i) The sum of proton and neutrons present in the nucleu
Mass number (A) = Number of protons + Number of n
or Number of neutrons = $A - Z$.

(ii) Since mass of a proton or a neutron is not a whole nu
scale), weight is not necessarily a whole number.

(iii) The atom of an element X having mass number (A) ai
represented by a symbol,



(Z)



e.g. ${}_9F^{19}$, ${}_8O^{16}$, ${}_7N^{14}$ etc.

Note : i. A part of an atom up to penultimate shell is a kernel or atomic core.

ii. Negative ion is formed by gaining electrons and positive ion by the loss of electrons.

iii. Number of lost or gained electrons in positive or negative ion =Number of protons $\pm$ charge on ion.

Different Types of Atomic Species

Atomic species	Similarities	Differences	Examples
Isotopes (Soddy)	(i) Atomic No. (Z) (ii) No. of protons (iii) No. of electrons (iv) Electronic configuration (v) Chemical properties (vi) Position in the periodic table	(i) Mass No. (A) (ii) No. of neutrons (iii) Physical properties	(i) ${}_{1}^{1}H, {}_{1}^{2}H, {}_{1}^{3}H$ (ii) ${}_{8}^{16}O, {}_{8}^{17}O, {}_{8}^{18}O$ (iii) ${}_{17}^{35}Cl, {}_{17}^{37}Cl$
Isobars	(i) Mass No. (A) (ii) No. of nucleons	(i) Atomic No. (Z) (ii) No. of protons, electrons and neutrons (iii)Electronic configuration (iv) Chemical properties (v) Position in the perodic table.	(i) ${}_{18}^{40}Ar, {}_{19}^{40}K, {}_{20}^{40}Ca$ (ii) ${}_{52}^{130}Te, {}_{54}^{130}Xe, {}_{56}^{130}Ba$
Isotones	No. of neutrons	(i) Atomic No. (ii) Mass No., protons and electrons. (iii) Electronic configuration (iv) Physical and chemical properties (v) Position in the periodic table.	(i) ${}_{14}^{30}Si, {}_{15}^{31}P, {}_{16}^{32}S$ (ii) ${}_{19}^{39}K, {}_{20}^{40}Ca$ (iii) ${}_{1}^{3}H, {}_{2}^{4}He$ (iv) ${}_{6}^{13}C, {}_{7}^{14}N$
Isodiaphers	Isotopic No. $(N-Z)$ or $(A-2Z)$	(i) At No., mass No., electrons, protons, neutrons. (ii) Physical and chemical properties.	(i) ${}_{92}U^{235}, {}_{90}Th^{231}$ (ii) ${}_{19}K^{39}, {}_{9}F^{19}$ (iii) ${}_{29}Cu^{65}, {}_{24}Cr^{55}$
Isoelectronic species	(i) No. of electrons (ii) Electronic configuration	At. No., mass No.	(i) $N_2O, CO_2, CNO^-(22e^-)$ (ii) $CO, CN^-, N_2(14e^-)$ (iii) $H^-, He, Li^+, Be^{2+}(2e^-)$ (iv) $P^{3-}, S^{2-}, Cl^-, Ar, K^+ and\ Ca^{2+}(18e^-)$
Isosters	(i) No. of atoms (ii) No. of electrons (iii) Same physical and chemical properties.		(i) N_2 and CO (ii) CO_2 and N_2O (iii) HCl and F_2 (iv) CaO and MgS (v) C_6H_6 and $B_3N_3H_6$

Note : In all the elements, tin has maximum number of stable isotopes (ten).

Average atomic weight/ The average isotopic weight

$$= \frac{\%\text{ of 1st isotope} \times \text{relative mass of 1st isotope} + \%\text{ of 2nd isotope} \times \text{relative mass of 2nd isotope}}{100}$$

Example :1 Atomic weight of Ne is 20.2. Ne is a mixutre of Ne^{20} and Ne^{22}. Relative abundance of heavier isotope is

(a)90 (b)20 (c)40 (d)10

Solution:(d) Average atomic weight/ The average isotopic weight

$$= \frac{\%\text{ of 1st isotope} \times \text{relative mass of 1st isotope} + \%\text{ of 2nd isotope} \times \text{relative mass of 2nd isotope}}{100}$$

$$\therefore\ 20.2 = \frac{a \times 20 + (100 - a) \times 22}{100};\ \therefore\ a = 90;$$

per cent of heavier isotope $= 100 - 90 = 10$

Example : 2 The relative abundance of two isotopes of atomic weight 85 and 87 is 75% and 25% respectively. The average atomic weight of element is

(a)75.5 (b)85.5 (c)87.5 (d)86.0

Solution:(b) Average atomic weight/ The average isotopic weight

$$= \frac{\%\text{ of 1st isotope} \times \text{relative mass of 1st isotope} + \%\text{ of 2nd isotope} \times \text{relative mass of 2nd isotope}}{100}$$

$$= \frac{85 \times 75 + 87 \times 25}{100} = 85.5$$

Electromagnetic Radiations

(1) Light and other forms of radiant energy propagate without any medium in the space in the form of waves are known as *electromagnetic radiations*. These waves can be produced by a charged body moving in a magnetic field or a magnet in a electric field. e.g. α – rays, γ – rays, cosmic rays, ordinary light rays etc.

(2) **Characteristics :**

(i) All electromagnetic radiations travel with the velocity of light.

(ii) These consist of electric and magnetic fields components that oscillate in directions perpendicular to each other and perpendicular to the direction in which the wave is travelling.

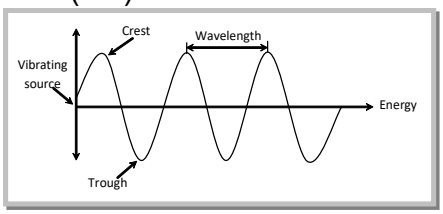
(3) A wave is always characterized by the following five characteristics:

(i) *Wavelength* : The distance between two nearest crests or nearest troughs is called the wavelength. It is denoted by λ (lambda) and is measured is terms of centimeter(cm), angstrom(Å), micron(μ) or nanometre (nm).

$1\mathring{A} = 10^{-8}\ cm = 10^{-10}\ m$

$1\mu = 10^{-4}\ cm = 10^{-6}\ m$

$1nm = 10^{-7}\ cm = 10^{-9}\ m$



$$1cm = 10^8 \AA = 10^4 \mu = 10^7 nm$$

(ii) *Frequency* : It is defined as the number of waves which pass through a point in one second. It is denoted by the symbol ν (nu) and is expressed in terms of cycles (or waves) per second (cps) or hertz (Hz).

$\lambda\nu =$ distance travelled in one second = velocity =c

$$\nu = \frac{c}{\lambda}$$

(iii) *Velocity* : It is defined as the distance covered in one second by the wave. It is denoted by the letter 'c'. All electromagnetic waves travel with the same velocity, i.e., 3 x 10^{10} cm / sec

$$c = \lambda\nu = 3 \times 10^{10}\ cm / \sec$$

Thus, a wave of higher frequency has a shorter wavelength while a wave of lower frequency has a longer wavelength.

(iv) *Wave number* : This is the reciprocal of wavelength, i.e., the number of wave lengths per centimetre. It is denoted by the symbol $\bar{\nu}$ (nu bar). It is expressed in cm^{-1} or m^{-1}.

$$\bar{\nu} = \frac{1}{\lambda}$$

(v) *Amplitude* : It is defined as the height of the crest or depth of the trough of a wave. It is denoted by the letter 'A'. It determines the intensity of the radiation.

The arrangement of various types of electromagnetic radiations in the order of their increasing or decreasing wavelengths or frequencies is known as ***electromagnetic spectrum***.

Name	Wavelength (Å)	Frequency (Hz)	Source
Radio wave	$3\times10^{14} - 3\times10^{7}$	$1\times10^{5} - 1\times10^{9}$	Alternating current of high frequency
Microwave	$3\times10^{7} - 6\times10^{6}$	$1\times10^{9} - 5\times10^{11}$	Klystron tube
Infrared (IR)	$6\times10^{6} - 7600$	$5\times10^{11} - 3.95\times10^{16}$	Incandescent objects
Visible	$7600 - 3800$	$3.95\times10^{16} - 7.9\times10^{14}$	Electric bulbs, sun rays
Ultraviolet (UV)	$3800 - 150$	$7.9\times10^{14} - 2\times10^{16}$	Sun rays, arc lamps with mercury vapours
X-Rays	$150 - 0.1$	$2\times10^{16} - 3\times10^{19}$	Cathode rays striking metal plate
γ – Rays	$0.1 - 0.01$	$3\times10^{19} - 3\times10^{20}$	Secondary effect of radioactive decay
Cosmic Rays	0.01- zero	3×10^{20} – infinity	Outer space

TEACHING TASK

Level - I

1. The fundamental particles present in the nucleus of an atom are
   (a) Alpha particles and electrons (b)Neutrons and protons
   (c) Neutrons and electrons (d)Electrons, neutrons and protons
2. Cathode rays were discovered by
   (a) William Crookes (b) J. Stoney (c)Rutherford (d)None of these
3. Cathode rays are
   (a) Protons (b)Electrons (c)Neutrons (d) *a*-particles
4. Mass of an electron is
   (a) $9.1\times10^{-28}\,g$ (b) $9.1\times10^{-25}\,g$ (c) $9.1\times10^{-10}\,g$ (d) $9.1\times10^{-18}\,g$
5. The mass of a mole of proton and electron is
   (a) $6.023\times10^{23}\,g$ (b) $1.008\,g$ and $0.55\,mg$ (c) $9.1\times10^{-28}\,kg$ (d)2 *gm*
6. Anode rays were discovered by
   (a)Goldstein (b) J. Stoney (c) Rutherford (d)J.J. Thomson
7. The proton and neutron are collectively called as
   (a)Deutron (b)Positron (c)Meson (d)Nucleon
8. Who discovered neutron
   (a)James Chadwick (b)William Crooks
   (c)J. J. Thomson (d)Rutherford
9. Which of the following reactions led to the discovery of the neutron
   (a) $^{14}_{6}C+^{1}_{1}p\rightarrow{}^{14}_{7}N+{}^{1}_{0}n$ (b) $^{11}_{5}B+{}^{2}_{1}D\rightarrow{}^{12}_{6}C+{}^{1}_{0}n$
   (c) $^{9}_{4}Be+{}^{4}_{2}He\rightarrow{}^{12}_{6}C+{}^{1}_{0}n$ (d) $^{8}_{4}Be+{}^{4}_{2}He\rightarrow{}^{11}_{6}C+{}^{1}_{0}n$
10. Heaviest particle is
    (a)Meson (b) Neutron (c) Proton (d) Electron
11. Which one of the following pairs is not correctly matched
    (a)Rutherford-Proton (b) J. J. Thomson-Electron
    (c)J. H. Chadwick-Neutron (d) Bohr-Isotope
12. An elementary fundamental particle is
    (a)An element present in a compound (b)An atom present in an element
    (c)A sub-atomic particle (d)A fragment of an atom
13. The number of electrons in Cl^{-} ion is
    (a)19 (b)20 (c)18 (d)35
14. The number of neutron in tritium is
    (a)1 (b)2 (c)3 (d)0
15. The total number of protons in one molecule of nitrogen dioxide
    (a)23 (b)46 (c)69 (d)92
16. Number of neutrons in heavy hydrogen atom is
    (a)0 (b)1 (c)2 (d)3
17. The nucleus of helium contains
    (a) Four protons (b)Four neutrons
    (c)Two neutrons and two protons (d) Four protons and two electrons

18. An atom has 26 electrons and its atomic weight is 56. The number of neutrons in the nucleus of the atom will be
(a)26 (b)30 (c)36 (d)56

19. The atomic number of an element represents
(a) Number of neutrons in the nucleus (b)Number of protons in the nucleus
(c) Atomic weight of element (d)Valency of element

20. The mass of an atom is constituted mainly by
(a)Neutron and neutrino (b)Neutron and electron
(c)Neutron and proton (d)Proton and electron

LEVEL-II

I. Single answer type questions

1. The charge on an electron is
(a) -4.8×10^{-10} *esu* (b) -1.6×10^{-19} *C* (c)Unit negative (d)All

2. The *e*/*m* for positive rays in comparison to cathode rays is
(a)Very low (b)High (c)Same (d)None of these

3. Which is correct statement about proton
(a)Proton is nucleus of deuterium (b) Proton is ionized hydrogen molecule
(c)Proton is ionized hydrogen atom (d) Proton is a-particle

4. The mass of neutron is nearly
(a) $10^{-23}\,kg$ (b) $10^{-24}\,kg$ (c) $10^{-26}\,kg$ (d) $10^{-27}\,kg$

5. Sodium atom differs from sodium ion in the number of
(a) Electron (b) Protons (c) Neutrons (d)Does not differ

6. The number of electrons in one molecule of CO_2 are
(a)22 (b)44 (c)66 (d)88

7. Six protons are found in the nucleus of
(a)Boron (b)Lithium (c)Carbon (d)Helium

8. The number of electrons and neutrons of an element is 18 and 20 respectively. Its mass number is
(a)17 (b)37 (c)2 (d)38

9. The number of electrons in $[^{40}_{19}K]^{-1}$ is
(a)19 (b)20 (c)18 (d)40

10. Iso-electronic species is
(a) F^-, O^{-2} (b) F^-, O (c) F^-, O^+ (d) F^-, O^{+2}

II. Multi answer type questions

11. Pick out the isoelectronic structure from the following
i) CH_3^+ ii) H_3O^+ iii) NH_3 iv) CH_3^-
a) i & iii b) i & ii c) iii & iv d) ii, iii & iv

12. Among the following, unpaired electrons present in
i) KO_2 ii) Al_2O^{-2} iii) BaO_2 iv) NO_2^+
a) i & iii b) i & ii c)iii & iv d) ii, iii & iv

III. Assertion and reasoning type questions

1. Both A & R are true and R is the correct explanation of A
2. Both A & R are true and R is not the correct explanation of A
3. A is true, R is false. 4. A is false, R is true.

13 A: Atom is electrically neutral
R: A nuetral particle, neutron is present in the nucleus of an atom.

14. A: Cathode rays are deflected towards positive plate in an electrical feild
R: These consist of negatively charged particles.

15. A: Electromagnetic radiations around 1015 Hz are called as visible light.
R: This is the only part of electromagnetic radiation which is visible to eyes.

IV. Matching type

16.

Column-I	**Column-II**
a) J.J. Thomson	1) Discovery neutron
b) Mosley	2) Nuclear model of atom
c) Chadwick	3) Cathode rays
d) Rutherford	4) X-ray spectra
	5) Radioactivity

17.

Column I	**Column II**
a) Electron	1) Atom is electrically neutral
b) Proton	2) Negative charge
c) Thomson model of atom	3) Positive charge
d) Muliken's oil drops experiment	4) Quantization of charge

V. Comprehension type:

Cathode rays consists of negatively charged material particles called electrons. These electrons are fundamental sub atomic particles carrying negative charge and having mass 9.1×10^{-31} kg. Discovered by J.J Thomson.Charge to mass $(\frac{e}{m})$ ratio of an electron is 1.76×10^{8} C/g. Charge to mass $(\frac{e}{m})$ ratio for an proton is 9.55×10^{4} C/g.

18. Particles in cathode rays have same charge to mass ratio as:
a) α - particles b) β - particles c) γ - rays d) Protons

19. The ratio of specific charge of a proton and that of an α - particle is:
a) 1 : 2 b) 1 : 1 c) 2 : 1 d) 1 : 4

20. Which of the following particles has maximum charge to mass ratio?
a) Electrons b) Protons c) α - particles d) Neutons

LEVEL-III

1. Which of the following statement is not correct regarding cathode rays
(a) Cathode rays originate from the cathode
(b) Charge and mass of the particles constituting cathode rays depends upon the nature of the gas
(c) Charge and mass of the particles present does not depend upon the material of the cathode
(d) The ratio charge/mass of the particles is much greater than that of anode rays

2. Density of the electron is

(a) $2.17 \times 10^{-17}\ g/mL$ (b) $4.38 \times 10^{-17}\ g/mL$ (c) $2.17 \times 10^{-14}\ g/mL$ (d)None of these

3. The minimum real charge on any particle which can exist is

(a) $1.6 \times 10^{-19}\ Coulomb$ (b) $1.6 \times 10^{-10}\ Coulomb$ (c) $4.8 \times 10^{-10}\ Coulomb$ (d)Zero

4. What is false to say about anode rays

(a) Their *e*/*m* ratio depends upon the nature of residual gas
(b) They are deflected by electrical and magnetic field
(c) Their *e*/*m* ratio is constant
(d) These are produced by ionization of molecules of the residual gas

5. Neutron is a fundamental particle carrying

(a) A charge of +1 unit and a mass of 1 unit (b) No charge and a mass of 1 unit
(c) No charge and no mass (d) A charge of –1 and a mass of 1 unit

6. The nitrogen atom has 7 protons and 7 electrons, the nitride ion (N^{3-}) will have

(a)7 protons and 10 electrons (b)4 protons and 7 electrons
(c)4 protons and 10 electrons (d)10 protons and 7 electrons

7. The electronic configuration of a dipositive metal M^{2+} is 2, 8, 14 and its atomic weight is 56 a.m.u. The number of neutrons in its nuclei would be

(a)30 (b)32 (c)34 (d)42

8. If *W* is atomic weight and *N* is the atomic number of an element, then

(a) Number of $e^{-1} = W - N$ (b) Number of ${}_0n^1 = W - N$

(c) Number of ${}_1H^1 = W - N$ (d) Number of ${}_0n^1 = N$

9. Tritium is the isotope of

(a)Hydrogen (b)Oxygen (c)Carbon (d)Sulphur

LEVEL-IV

1. The charge of an electron is $-1.6 \times 10^{-19}\ C$. The value of free charge on Li^+ ion will be

(a) $3.6 \times 10^{-19}\ C$ (b) $1 \times 10^{-19}\ C$ (c) $1.6 \times 10^{-19}\ C$ (d) $2.6 \times 10^{-19}\ C$

2. The increasing order (lowest first) for the values of *e*/*m* (charge/mass) for

(a) *e*, *p*, *n*, *a* (b) *n*, *p*, *e*, *a* (c) *n*, *p*, *a, e* (d)*n*, *a, p, e*

3. The number of atoms in 0.004 *g* of magnesium are

(a) 4×10^{20} (b) 8×10^{20} (c) 10^{20} (d) 6.02×10^{20}

4. In an X-ray experiment, different metals are used as the target. In each case, the frequency (*n*) of the radiation produced is measured. If Z= atomic number, which of the following plots will be a straight line

(a) ν against *Z* (b) $\frac{1}{\nu}$ against *Z* (c) $\sqrt{\nu}$ against *Z* (d) ν against $\sqrt{Z}$

5. Atoms consists of protons, neutrons and electrons. If the mass of neutrons and electrons were made half and two times respectively to their actual masses, then the atomic mass of ${}_6C^{12}$

(a) Will remain approximately the same
(b) Will become approximately two times
(c) Will remain approximately half
(d)Will be reduced by 25%

LEARNER'S TASK

BEGINNERS (Level - I)

1. Cathode rays are
(a)Protons (b)Electrons (c)Neutrons (d)*Alpha*-particles

2. Cathode rays have
(a)Mass only (b)Charge only
(c)No mass and charge (d)Mass and charge both

3. Cathode rays are produced when the pressure in the discharge tube is of the order of
(a)76 *cm* of *Hg* (b) $_{10^{-6}\,cm}$ of *Hg*
(c)1 *cm* of *Hg* (d) $_{10^{-2}}$ to $_{10^{-3}}$ *mm* of *Hg*

4. Which one is not true for the cathode rays
(a)They have kinetic energy
(b)They cause certain substances to show fluorescence
(c)They travel in straight line (d)They are electromagnetic waves

5. The electron is
(a)*a*-rays particle (b)*b*-ray particle (c)Hydrogen ion (d)Positron

6. Proton is
(a) An ionized hydrogen molecule (b) An *a*-ray particle
(c) A fundamental particle (d) Nucleus of heavy hydrogen

7. Penetration power of proton is
(a)More than electron (b) Less than electron
(c)More than neutron (d) None of these

8. Which of the following is always a whole number
(a)Atomic weight (b)Atomic radii
(c)Equivalent weight (d)Atomic number

9. Chlorine atom differs from chloride ion in the number of
(a) Proton (b) Neutron (c) Electrons (d)Protons and electrons

10. The number of electrons in the atom which has 20 protons in the nucleus is
(a) 20 (b) 10 (c) 30 (d) 40

11. A sodium cation has different number of electrons from
(a) $_{O^{2-}}$ (b) $_{F^{-}}$ (c) $_{Li^{+}}$ (d) $_{Al^{+++}}$

12. The nucleus of the element having atomic number 25 and atomic weight 55 will contain
a) 25 protons and 30 neutrons (b)25 neutrons and 30 protons
(c)55 protons (d) 55 neutrons

13. The number of electrons in an atom of an element is equal to its
(a)Atomic weight (b)Atomic number
(c)Equivalent weight (d)Electron affinity

14. Number of electrons in $-CONH_2$ is
(a) 22 (b) 23 (c) 20 (d) 28

15. In the nucleus of $_{20}Ca^{40}$ there are
(a) 40 protons and 20 electrons (b)20 protons and 40 electrons
(c) 20 protons and 20 neutrons (d)20 protons and 40 neutrons

16. Na^+ 1. ion is iso-electronic with
(a) Li^+ (b) Mg^{2+} (c) Ca^{2+} (d) Ba^{2+}

17. Iso-electronic species are
(a) K^+, Cl^- (b) Na^+, Cl^- (c) Na, Ar (d) Mg^+, Ar

18. Which of the following is iso-electronic with carbon atom
(a) Na^+ (b) Al^{3+} (c) O^{2-} (d) N^+

19. Be^{2+} is iso-electronic with
(a) Mg^{2+} (b) Na^+ (c) Li^+ (d) H^+

20. Be^{2+} is iso-electronic with
(a) Mg^{2+} (b) Na^+ (c) Li^+ (d) H^+

ACHIEVERS (Level - II)

1. The ratio of specific charge of a proton and an a-particle is
(a)2 : 1 (b)1 : 2 (c)1 : 4 (d)1 : 1

2. The density of neutrons is of the order
(a) $10^{-3} kg/cc$ (b) $10^{-6} kg/cc$ (c) $10^{-9} kg/cc$ (d) $10^{-12} kg/cc$

3. The discovery of neutron becomes very late because
(a) Neutrons are present in nucleus
(b)Neutrons are highly unstable particles
(c) Neutrons are chargeless
(d)Neutrons do not move

4. The electronic configuration of a dipositive metal M^{2+} is 2, 8, 14 and its atomic weight is 56 a.m.u. The number of neutrons in its nuclei would be
(a)30 (b)32 (c)34 (d)42

5. The nucleus of the atom consists of
(a)Proton and neutron (b)Proton and electron
(c)Neutron and electron (d)Proton, neutron and electron

6. Which of the following atom has more electrons than neutrons
(a) *C* (b) F^- (c) O^{2-} (d) Al^{3+}

7. The ratio between the neutrons in *C* and *Si* with respect to atomic masses 12 and 28 is
(a) 2 : 3 (b) 3 : 2 (c) 3 : 7 (d) 7 : 3

8. *CO* has same electrons as or the ion that is iso-electronic with *CO* is
(a) N_2^+ (b) CN^- (c) O_2^+ (d) O_2^-

9. Which one of the following grouping represents a collection of iso-electronic species
(a) Na^+, Ca^{2+}, Mg^{2+} (b) N^{3-}, F^-, Na^+ (c) Be, Al^{3+}, Cl^- (d) Ca^{2+}, Cs^+, Br

10. ***Assertion (A)*** **:** The atoms of different elements having same mass number but different atomic number are known as isobars
Reason (R) : The sum of protons and neutrons, in the isobars is always different
(a) Both *A* and *R* are true and *R* is a correct explanation of *A*
(b) Both *A* and *R* are true but *R* is not a correct explanation of *A*
(c) *A* is true but the *R* is false (d) *A* is false but *R* is true

II. Multi answer type questions:

11. 1 angstrom = ?
    a) 10^{-10} m b) 10^{-8} cm c) 10^{-6} m d) None
12. Which of the following are the units of wavelength ?
    a) Angstrom b) Nanometer c) Picometer d) Microns
13. Which of the following properties are proportional to the energy of electromanagement wave
    i) wave length ii) wave number
    iii) number of photons iv) frequency
    a) i & iii b) i & ii c) iii & iv d) ii, iii & iv
14. Which of the following two ions have the same number of unpaired electrons
    i) Mn^{+2} ii) Fe^{+3} iii) Cr^{+3} iv) Ti^{+3}
    a) i & iii b) i & ii c) iii & iv d) ii, iii & iv

III. Assertion and reasoning type questions:

1. Both A & R are true and R is the correct explanation of A
2. Both A & R are true and R is not the correct explanation of A
3. A is true,R is false. 4. A is false, R is true.

15. **A:** Atomic weights of elements are non-intergal
    R: Elements contain isotopes of different masses.
16. **A:** The atoms of different elements having same mass number but different atomic number are known as isobars.
    R:The sum of protons and neutrons in the isobars is always different.
17. **A:** The mass of the nucleus can be either less than or more than the sum of masses of nucleons present in it
    R: The whole mass of the atom is considered in the nucleus
18. **A:** Electrons in the atoms are held due to coulumb forces
    R: The atom is stable only becuase the centripetel force due to columb's law is balanced by the centrifugal force

IV. Matching type

19.

Column-I	**Column-II**
a) Electron	1) Goldstein
b) Proton	2) Thomson
c) Neutron	3) Mosely
d) Atomic number	4) Chadwick
	5) Neils Bohr

20.

Column-I	**Column-II**
a) Nucleus	1) cm
b) Electro magnetic radiation	2) Visible light
c) Wave length	3) Rutherford
d) Frequency	4) Sec^{-1}
	5) Einstein

V. Comprehension type

The frequency (ν), wavelength (λ) and velocity of light (c) are related by the equations $c = \nu\lambda$. The other commonly used quantity specially in spectroscopy is the wavenumber ($\bar{\nu}$).

21. Which of the following relations are correct?

a) Frequency × wavelength = Velocity of light b) $\bar{\nu} = \frac{1}{\lambda}$

c) $\lambda = \frac{c}{\nu}$ d) All of these

22. Light or any electro magnetic radiation travels in vaccum or air with a speed of :
a) 3×10^8 m/s b) 3×10^2 m/s c) 2×10^8 m/s d) 1×10^8 m/s

23. The wave number of a radiation is 97540 cm^{-1}. Calculate its frequency.
a) $2.926 \times 10^{10} s^{-1}$ b) $2.926 \times 10^{15} s^{-1}$ c) $2.926 \times 10^{2} s^{-1}$ d) $2.926 \times 10^{20} s^{-1}$

EXPLORERS (Level - III)

1. Which of the following has the same mass as that of an electron
(a)Photon (b)Neutron (c)Positron (d)Proton

2. A strong argument for the particle nature of cathode rays is that they
(a)Produce fluorescence (b)Travel through vacuum
(c)Get deflected by electric and magnetic fields (d)Cast shadow

3. Ratio of masses of proton and electron is
(a)Infinite (b) $1.8 \times 10^{+3}$ (c)1.8 (d)None of these

4. Nitrogen atom has an atomic number of 7 and oxygen has an atomic number 8. The total number of electrons in a nitrate ion will be
(a)8 (b)16 (c)32 (d) 64

5. The total number of unpaired electrons in d-orbitals of atoms of element of atomic number 29 is
(a)10 (b)1 (c)0 (d) 5

6. The number of electrons in the nucleus of C^{12} is
(a) 6 (b) 12 (c) 0 (d) 3

7. The hydride ions (H^-) are iso-electronic with
(a)*Li* (b) He^+ (c) *He* (d) *Be*

8. Which of the following atoms and ions are iso-electronic *i.e*. have the same number of electrons with the neon atom
(a)F^- (b)Oxygen atom (c)*Mg* (d)$N^- {}_{N^-}$

9. CO_2 is isostructural with
(a)$SnCl_2$ (b)SO_2 (c)$HgCl_2$ (d)All the above

RESEARCHERS (Level - IV)

1. The charge on an electron is $4.8 \times 10^{-10} esu$. What is the value of charge in Li^+ ion
(a) $4.8 \times 10^{-10} esu$ (b) $9.6 \times 10^{-10} esu$ (c) $1.44 \times 10^{-9} esu$ (d) $2.4 \times 10^{-10} esu$

2. The specific charge of proton is $9.6 \times 10^7 \, C kg^{-1}$ then for an a-particle it will be
(a) $38.4 \times 10^7 \, C kg^{-1}$ (b) $19.2 \times 10^7 \, C kg^{-1}$ (c) $2.4 \times 10^7 \, C kg^{-1}$ (d) $4.8 \times 10^7 \, C kg^{-1}$

3. If molecular mass and atomic mass of sulphur are 256 and 32 respectively, its atomicity is
(a) 2 (b) 8 (c) 4 (d) 16

4. ***Assertion (A)*** **:** The atoms of different elements having same mass number but different atomic number are known as isobars

Reason (R) : The sum of protons and neutrons, in the isobars is always different

(a) Both *A* and *R* are true and *R* is a correct explanation of *A*
(b) Both *A* and *R* are true but *R* is not a correct explanation of *A*
(c) *A* is true but the *R* is false
(d) *A* is false but *R* is true

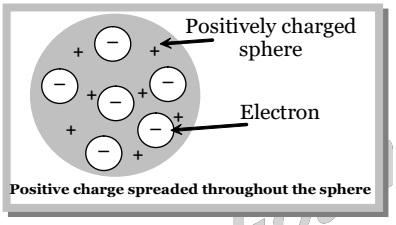
5. Atoms consists of protons, neutrons and electrons. If the mass of neutrons and electrons were made half and two times respectively to their actual masses, then the atomic mass of $_6c^{12}$

(a) Will remain approximately the same (b) Will become approximately two times
(c) Will remain approximately half (d) Will be reduced by 25%

Atomic Models

Thomson's model.

Thomson regarded atom to be composed of positively charged protons and negatively charged electrons. The two types of particles are equal in number thereby making atom electrically neutral.



(2) He regarded the atom as a positively charged sphere in which negative electrons are uniformly distributed like the seeds in a water melon.

(3) This model failed to explain the line spectrum of an element and the scattering experiment of Rutherford.

2.6 Rutherford's nuclear model.

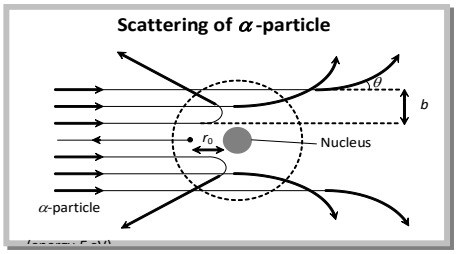
(1) Rutherford carried out experiment on the bombardment of thin (10^{-4} *mm*) *Au* foil with high speed positively charged $\alpha-$ particles emitted from *Ra* and gave the following observations, based on this experiment :

(i) Most of the $\alpha-$ particles passed without any deflection.

(ii) Some of them were deflected away from their path.

(iii) Only aS few (one in about 10,000) were returned back to their original direction of propagation.

(iv) The scattering of $\alpha-$ particles $\propto \frac{1}{\sin^4\left(\frac{\theta}{2}\right)}$.



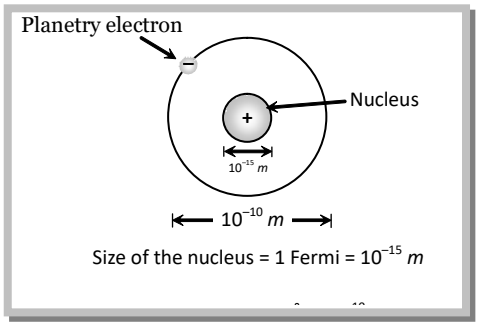
(2) From the above observations he concluded that, an atom consists of

(i) ***Nucleus*** which is small in size but carries the entire mass i.e. contains all the neutrons and protons.

(ii) ***Extra nuclear part*** which contains electrons. This model was similar to the solar system.

Size of the nucleus = 1 Fermi = 10^{-15} *m*

Size of the atom 1 Å = 10^{-10} *m*



(3) **Properties of the Nucleus**

(i) Nucleus is a small, heavy, positively charged portion of the atom and located at the centre of the atom.

(ii) All the positive charge of atom (i.e. protons) are present in nucleus.

(iii) Nucleus contains neutrons and protons, and hence these particles collectively are also referred to as ***nucleons.***

(iv) The ***size*** of nucleus is measured in ***Fermi*** (1 Fermi = 10^{-13} *cm*).

$$r_n = r_o (= 1.4 \times 10^{-13}\ cm) \times A^{1/3}$$

(v) The ***radius*** of nucleus is of the order of 1.5 X 10^{-13} cm to 6.5 X 10^{-13} cm i.e. 1.5 to 6.5 Fermi. Generally the radius of the nucleus (r_n) is given by the following relation, This exhibited that nucleus is 10^{-5} times small in size as compared to the total size of atom.

(vi) The ***Volume*** of the nucleus is about 10^{-39} cm^3 and that of atom is 10^{-24} cm^3 i.e., volume of the nucleus is 10^{-15} times that of an atom.

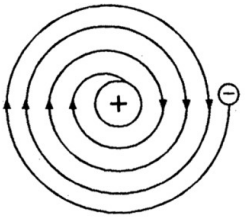
(vii) The **density** of the nucleus is of the order of 10^{15} gcm^{-3} or 10^8 tonnes cm^{-3} or 10^{12} kg/cc. If nucleus is spherical than,

$$\text{Density} = \frac{\text{mass of the nucleus}}{\text{volume of the nucleus}} = \frac{\text{mass number}}{6.023 \times 10^{23} \times \frac{4}{3}\pi r^3}$$

(4) **Drawbacks of Rutherford's model**

(i) It does not obey the ***Maxwell theory of electrodynamics,*** according to it "A small charged particle moving around an oppositely charged centre continuously loses its energy". If an electron does so, it should also continuously lose its energy and should set up spiral motion ultimately failing into the nucleus.

(ii) It could not explain the line spectra of H^- atom and discontinuous spectrum nature.



Continuous loss of energy of revolving electron

Unstability of atom

Bohr's atomic model

(1) This model was based on the quantum theory of radiation and the classical law of physics. It gave new idea of atomic structure in order to explain the stability of the atom and emission of sharp spectral lines.

(2) ***Postulates*** of this theory are :

(i) The atom has a central massive core nucleus where all the protons and neutrons are present. The size of the nucleus is very small.

(ii) The electron in an atom revolve around the nucleus in certain discrete orbits. Such orbits are known as *stable orbits* or *non – radiating* or *stationary orbits*.

(iii) The force of attraction between the nucleus and the electron is equal to centrifugal force of the moving electron.

Force of attraction towards nucleus = centrifugal force

(iv) An electron can move only in those permissive orbits in which the angular momentum (mvr) of the electron is an integral multiple of $h/2\pi$. Thus

$$mvr = n\frac{h}{2\pi}$$

Failure of Bohr Model

(i) Bohr theory was very successful in predicting and accounting the energies of line spectra of hydrogen i.e. one electron system. It could not explain the line spectra of atoms containing more than one electron.

(ii) This theory could not explain the presence of multiple spectral lines.

(iii) This theory could not explain the splitting of spectral lines in magnetic field (Zeeman effect) and in electric field (Stark effect). The intensity of these spectral lines was also not explained by the Bohr atomic model.

(iv) This theory was unable to explain of dual nature of matter as explained on the basis of De broglies concept.

(v) This theory could not explain uncertainty principle.

(vi) No conclusion was given for the concept of quantisation of energy.

Electronic configuration principles

The distribution of electrons in different orbitals of atom is known as electronic configuration of the atoms. Filling up of orbitals in the ground state of atom is governed by the following rules:

(1) **Aufbau principle**

(i) Auf bau is a German word, meaning 'building up'.

(ii) According to this principle, "In the ground state, the atomic orbitals are filled in order of increasing energies i.e. in the ground state the electrons first occupy the lowest energy

orbitals available".

(iii) In fact the energy of an orbital is determined by the quantum number *n* and *l* with the help of (*n*+*l*) rule or Bohr Bury rule.

(iv) According to this rule

(a) Lower the value of *n* + *l*, lower is the energy of the orbital and such an orbital will be filled up first.

(b) When two orbitals have same value of (*n*+*l*) the orbital having lower value of "*n*" has lower energy and such an orbital will be filled up first .

Thus, order of filling up of orbitals is as follows:

1s < 2s < 2p < 3s < 3p < 4s < 4p < 5s < 4d < 5p < 6s < 6f < 5d

(2) **Pauli's exclusion principle**

(i) According to this principle, "No two electrons in an atom can have same set of all the four quantum numbers *n*, *l*, *m* and *s* .

(ii) In an atom any two electrons may have three quantum numbers identical but fourth quantum number must be different.

(iii) Since this principle excludes certain possible combinations of quantum numbers for any two electrons in an atom, it was given the name exclusion principle. Its results are as follows :

(a) The maximum capacity of a main energy shell is equal to $2n^2$ electron.

(b) The maximum capacity of a subshell is equal to 2(2*l*+1) electron.

(c) Number of sub-shells in a main energy shell is equal to the value of *n*.

(d) Number of orbitals in a main energy shell is equal to n^2

(e) One orbital cannot have more than two electrons.

(iv) According to this principle an orbital can accomodate at the most two electrons with spins opposite to each other. It means that an orbital can have 0, 1, or 2 electron.

(v) If an orbital has two electrons they must be of opposite spin.


Correct


Incorrect

(3) **Hund's Rule of maximum multiplicity**

(i) This rule provides the basis for filling up of degenerate orbitals of the same sub-shell.

(ii) According to this rule "Electron filling will not take place in orbitals of same energy until all the available orbitals of a given subshell contain one electron each with parallel spin".

(iii) This implies that electron pairing begins with fourth, sixth and eighth electron in *p*, *d* and *f* orbitals of the same subshell respectively.

(iv) The reason behind this rule is related to repulsion between identical charged electron present in the same orbital.

(v) They can minimise the repulsive force between them serves by occupying different orbitals.

(vi) Moreover, according to this principle, the electron entering the different orbitals of subshell have parallel spins. This keep them farther apart and lowers the energy through electron exchange or resonance.

(vii) The term maximum multiplicity means that the total spin of unpaired e^- is maximum in case of correct filling of orbitals as per this rule.

ELECTRONIC CONFIGURATION OF ELEMENTS

Element	Atomic Number	1*s*	2*s*	2*p*	3*s*	3*p*	3*d*	4*s*	4*p*	4*d*	4*f*
H	1	1									
He	2	2									
Li	3	2	1								
Be	4	2	2								
B	5	2	2	1							
C	6	2	2	2							
N	7	2	2	3							
O	8	2	2	4							
F	9	2	2	5							
Ne	10	2	2	6							
Na	11	2	2	6	1						
Mg	12				2						
Al	13				2	1					
Si	14		10		2	2					
P	15		electrons		2	3					
S	16				2	4					
Cl	17				2	5					
Ar	18	2	2	6	2	6					
K	19	2	2	6	2	6		1			
Ca	20							2			
Sc	21						1	2			
Ti	22						2	2			
V	23						3	2			
Cr	24						5	1			
Mn	25						5	2			
Fe	26						6	2			
Co	27		18				7	2			
Ni	28		electrons				8	2			
Cu	29						10	1			
Zn	30						10	2			
Ga	31						10	2	1		
Ge	32						10	2	2		
As	33						10	2	3		
Se	34						10	2	4		
Br	35						10	2	5		
Kr	36	2	2	6	2	6	10	2	6		

TEACHING TASK - II

LEVEL-I

1. Rutherford's *a*-particle scattering experiment proved that atom has
   (a) Electrons (b) Neutron (c)Nucleus (d) Orbitals
2. Experimental evidence for the existence of the atomic nucleus comes from
   (a) Millikan's oil drop experiment (b) Atomic emission spectroscopy
   (c)The magnetic bending of cathode rays (d)Alpha scattering by a thin metal foil
3. The size of nucleus is measured in
   (a) amu (b)Angstrom (c)Fermi (d)cm
4. Rutherford's scatting experiment is related to the size of the
   (a) Nucleus (b) Atom (c) Electron (d) Neutron
5. Remaining part of atom except outer orbit is called
   (a) Kernel (b)Core (c)Empty space (d)None
6. Existence of positively charged nucleus was established by
   (a) Positive ray analysis (b) a-ray scattering experiments
   (c) *X*-ray analysis (d) all
7. Which of the following statements does not form part of Bohr's model of the hydrogen atom
   (a) Energy of the electrons in the orbit is quantized
   (b) The electron in the orbit nearest the nucleus has the lowest energy
   (c) Electrons revolve in different orbits around the nucleus
   (d) The position and velocity of the electrons in the orbit cannot be determined simultaneously
8. Bohr's model can explain
   (a) The spectrum of hydrogen atom only
   (b) Spectrum of atom or ion containing one electron only
   (c)The spectrum of hydrogen molecule (d)The solar spectrum
9. Zeeman effect refers to the
   (a) Splitting up of the lines in an emission spectrum in a magnetic field
   (b) Splitting up of the lines in an emission spectrum in the presence of an eternal electrostatic field
   (c) Emission of electrons from metals when light falls upon them
   (d) Random scattering of light by colloidal particles
10. The shape of *s*-orbital is
    (a)Pyramidal (b)Spherical (c)Tetrahedral (d)Dumb-bell shaped
11. The number of orbitals in *d* sub-shell is
    (a)1 (b)3 (c)5 (d)7
12. Which of the following represents the electronic configuration of an element with atomic number 17
    (a) $1s^2,2s^2\,2p^6,3s^1\,3p^6$ (b) $1s^2,2s^2\,2p^6,3s^2\,3p^4,4s^1$ (c) $1s^2,2s^2\,2p^6,3s^2\,3p^5$ (d) $1s^2,2s^2\,2p^6,3s^1\,3p^4,4s^2$
13. Correct configuration of Fe^{+3} [26] is
    (a) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^5$ (b) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^3,4s^2$

(c) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^6,4s^2$ (d) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^5,4s^1$

14. The number of electrons in the valence shell of calcium is
(a)6 (b)8 (c)2 (d)4

15. The number of unpaired electrons in $1s^2$, $2s^2$, $2p^4$ is
(a)4 (b)2 (c)0 (d)1

16. Electronic configuration of $Sc^{(21)}$ is
(a) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^1$ (b) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^1\,3d^2$
(c) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^0\,3d^3$ (d) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^2$

17. The atomic orbitals are progressively filled in order of increasing energy. This principle is called is
(a)Hund's rule (b)Aufbau principle
(c)Exclusion principle (d)De–Broglie rule

18. The electronic configuration of calcium ion (Ca^{2+}) is
(a) $1s^2,2s^2\,2p^6,3s^2\,3p^6,4s^2$ (b) $1s^2,2s^2\,2p^6,3s^2\,3p^6,4s^1$
(c) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^2$ (d) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^5$

19. The electronic configuration of an element is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$. This represents its
(a)Excited state (b)Ground state (c)Cationic form (d)Anionic form

LEVEL-II

1. Who modified Bohr's theory by introducing elliptical orbits for electron path
a)Hund (b)Thomson (c)Rutherford (d)Sommerfeld

2. As electron moves away from the nucleus, its potential energy
(a)Increases (b)Decreases (c)Remains constant (d)None

3. The value of the energy for the first excited state of hydrogen atom will be
a)– 13.6 *eV* (b)– 3.40 *eV* (c)– 1.51 *eV* (d)– 0.85 *eV*

4. Dual nature of particle is given by
(a) Bohr theory (b)Thomson model
(c)Heisenberg principle (d)De–Broglie equation

5. Which orbital is dumb-bell shaped
(a) *s*-orbital (b) *p*-orbital (c) *d*-orbital (d) *f*-orbital

6. Which of the following orbitals will be dumb-bell shaped
(a)1*s* (b)2*s* (c)$2p_x$ (d)$3d_{xy}$

7. Which of the following orbitals does not make sense
(a)7*s* (b)5*p* (c)2*d* (d)4*f*

II. Multi answer type questions

8. To Which of the following is bohr;s theory applicable
1.He^+ 2.Li^{+2} 3.Tritium 4.Be^{+3}

9. Bohr's theory is not applicable to
1.Helium 2.Li^{+2} 3.He^{+2} 4.H-atom

10. Bohr could not explain the--------
1) Zeeman effect 2) Stark effect
3) Wave nature of electron
4) Spectra of atoms having more than one electron

III. Assertion and reasoning type questions

1) Both (A) and (R) are true and (R) is the correct explanation of(A)
2) Both (A) and (R) are ture and (R) is not the correct explanation of (A)
3) (A) is true but (R) is false 4) (A) is false but (R) is true

11. **A:** In an atom, the velocity of electrons in the higher orbits keeps on decreasing
R: Velocity of electron is inversely prportional to the radius of the orbit.

12. **A:** Each principal level of quantum number n contains a total of n sub levels
R: Each orbital can hold two electrons and each sub level of quantum number l contains a total of 2l +1 orbitals

13. **A:**Bohr's orbits are called stationary orbits.
R:Electrons remain stationary in these orbits for some time.

14. **A:** Bohr theory is not applicable to ionised hydrogen atom
R: H^+ is devoid of electron

IV. Matching type

	Column I	**Column II**
15.	a) Bohr model of atom	1) Electrons are present in extra nuclear region
	b) According to Sommerfeld model L =	2) $(kh/2\pi)$
	c) Azimuthal quantum number	3) k
	d) Principal quantum number	4) n
		5) *l*

V. Comprehension type

Bohr's theory could not explain the wave nature of electron estblished later by de Broglie.It could not explain the Zeeman and stark effects.Bohr's theory correlates velocity of light,electronic mass,plancks constant and electronic charge.

16. Splitting of spectral lines in a strong electric field is known as:
a) Zeeman effect b)Stark effect c) Fine spectrum d) All of these

17 Who established the wave nature of electron ?
a) Bohr b) de-Broglie c)Sommerfeld d) Thomson

18. Bohr's theory correlates the _____
a)Velocity of light b)Electronic mass c)Plancks constant d)All of these

LEVEL-III

1. When an electron jumps from '*L*' level to '*M*' level, there occurs
(a)Emission of energy (b)Emission of *X*-rays
(c)Absorption of energy (d) Emission of g-rays

2. p_x orbital can accommodate
(a) 4 electrons (b) 6 electrons
(c) 2 electrons with parallel spins (d) 2 electrons with opposite spins

3. Which of the following have the same number of unpaired electrons in '*d*' orbitals
(a) *Cr* (b) *Mn* (c) Fe^{3+} (d)Co^{3+}

4. The number of *d* electrons in Fe^{2+} (atomic number of *Fe* = 26) is not quite equal to that of the
(a) *p*-electrons in *Ne* (At. No. = 10) (b) *s*-electrons in *Mg* (At. No. = 12)
(c) *d*-electrons in *Fe* (d) *p*-electrons in Cl^- (At. No. of *Cl* = 17)

5. The atomic number of an element having the valency shell electronic configuration $4s^2 4p^6$ is
(a) 35 (b) 36 (c) 37 (d) 38

LEARNER'S TASK - II

BEGINNERS (Level - I)

1. The element used by Rutherford in his famous scattering experiment was
(a) Gold (b) Tin (c) Silver (d) Lead
2. The volume of the nucleus is
(a) 10^{-4} times smaller than the volume of an atom
(b) 10^{-8} times smaller than the volume of an atom
(c) 10^{12} times smaller than the volume of an atom
(d) Two-third the volume of the nucleus
3. Nucleus of an atom is
(a) Neutral (b) Negatively charged (c) Positively charged (d) None of them
4. The positive charge of an atom is
(a) Spread all over the atom (b) Distributed around the nucleus
(c) Concentrated at the nucleus (d) All of these
5. Discovery of the nucleus of an atom was due to the experiment carried out by
(a) Bohr (b) Mosley (c) Rutherford (d) Thomson
6. The size of nucleus is of the order of
(a) 10^{-12}m (b) 10^{-8}m (c) 10^{-15}m (d) 10^{-10}m
7. Which one of the following is considered as the main postulate of Bohr's model of atom
(a) Protons are present in the nucleus
(b) Electrons are revolving around the nucleus
(c) Centrifugal force produced due to the revolving electrons balances the force of attraction between the electron and the protons
(d) Angular momentum of electron is an integral multiple of $\frac{h}{2\pi}$
8. The postulate of Bohr theory that electrons jump from one orbit to the other, rather than flow is according to
(a) The quantisation concept (b) The wave nature of electron
(c) The probability expression for electron (d) Heisenberg uncertainty principle
9. The first use of quantum theory to explain the structure of atom was made by
(a) Heisenberg (b) Bohr (c) Planck (d) Einstein
10. The shape of 2p orbital is
(a) Spherical (b) Ellipsoidal (c) Dumb-bell (d) Pyramidal
11. The shape of p-orbital is
(a) Elliptical (b) Spherical
(c) Dumb-bell d) Complex geometrical
12. Which one is the electronic configuration of Fe^{+2}
(a) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6$ (b) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^4, 4s^2$
c) $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2 4p^6$ d) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$
13. The electronic configuration of copper ($_{29}Cu$) is

(a) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^9,4s^2$ (b) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^{10},4s^1$

(c) $1s^2,2s^2\,2p^6,3s^2\,3p^6,4s^2\,4p^6$ (d) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^{10}$

14. The configuration $1s^2 2s^2 2p^5 3s^1$ shows
(a)Ground state of fluorine atom (b)Excited state of fluorine atom
(c)Excited state of neon atom (d)Excited state of ion O_2^-

15. Which of the following configuration is correct for iron

(a) $1s^2,2s^2\,2p^6,3s^2\,3p^6\,3d^5$ (b) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^5$

(c) $1s^2,2s^2\,2p^6,3s^2\,3p^6,4s^2\,3d^7$ (d) $1s^2,2s^2\,2p^6,3s^2\,3p^6,4s^2\,3d^6$

ACHIEVERS (Level - II)

II. Multi answer type questions

1. Consider the following statement
i) A hallow sphere coated inside with platinum black with an aperture in the wall is perefect black body.
ii) λ_{max} in black body shifts towards the lower side with increase in temperature
iii) Radiations emitted from black body is not continuous
a) i,ii & iii b) ii, iii c) i , iii d) i, ii

2. According to Ruther ford's model
i) The size of the nuecleus is very large in comparision of the size of the atom.
ii) Electrons revolve around the nucleus like planets revolve round the sun
iii) It fails to explain the atomic spectrum or line spectrum
a) i,ii & iii b) ii, iii c) i , iii d) i, ii

III. Assertion and reasoning type questions

1. Both A & R are true and R is the correct explanation of A
2. Both A &R are true and R is not the correct explanation of A
3. A is true, R is false. 4. A is false, R is true.

3. **A:** The energy of quantum of radiation is given by E=hV.
R: Quantum in the energy equation signifies the principal quantum number

4. **A:** The kinetic energy of the photo electron ejected increases with increase in intensity of incident light
R: Increase in intensity of incident of light increases the rate of emission

5. **A:** Threshold frequency is a characteristic for a metal
R: Threshold frequency is a maximum frequency required for the ejection of electron from the metal surface

6 **A:** The kinetic energy of the photo electron ejected increases with increase in intensity of incident light.
R: Increase in intensity of incident light increases the rate of emission.

IV. Matching type

7.

List - I	List -II
A) Velocity of light	1) Energy particle
B) Plank's constant	2) Energy packet
C) Wave number	3) 3×10^8 m/sec
D) Photon	4) 6.625×10^{-34} J -sec
	5) cm^{-1}

8.

List - I	List -II
A) a-ray scattering experiment	1) mosely
B) Quantum theory	2) Planck
C) Theory of photo electric effect	3) deBroglie
D) a-particle equal to	4) He^{+2}
	5) Rutherford

EXPLORERS (Level - III)

1. An atom has 2 electrons in *K* shell, 8 electrons in *L* shell and 6 electrons in *M* shell. The number of *s*-electrons present in that element is
(a)6 (b)5 (c)7 (d)10
2. The maximum number of electrons that can be accommodated in '*f* sub shell is
(a)2 (b)8 (c)32 (d)14
3. Which of the following orbital is not possible
(a)3*f* (b)4*f* (c)5*f* (d)6*f*
4. Quantum numbers of an atom can be defined on the basis of
(a) Hund's rule (b) Aufbau's principle
(c) Pauli's exclusion principle (d) Heisenberg's uncertainty principle
5. The azimuthal quantum number is related to
(a)Size (b)Shape (c)Orientation (d)Spin
6. In a potassium atom, electronic energy levels are in the following order
(a)4*s* > 3*d* (b)4*s* > 4*p* (c)4*s* < 3*d* (d)4*s* < 3*p*

RESEARCHERS (Level - IV)

1. The frequency of yellow light having wavelength 600 nm is
(a) $5.0\times10^{14}\ Hz$ (b) $2.5\times10^{7}\ Hz$ (c) $5.0\times10^{7}\ Hz$ (d) $2.5\times10^{14}\ Hz$
2. The nucleus of an atom can be assumed to be spherical. The radius of the nucleus of mass number A is given by $1.25\times10^{-13}\times A^{1/3} cm$. Radius of atom is one Å. If the mass number is 64, then the fraction of the atomic volume that is occupied by the nucleus is
(a) 1.0×10^{-3} (b) 5.0×10^{-5} (c) 2.5×10^{-2} (d) 1.25×10^{-13}
3. In a Bohr's model of atom when an electron jumps from n = 1 to n = 3, how much energy will be emitted or absorbed
(a) $2.15\times10^{-11} ergs$ (b) $0.1911\times10^{-10} ergs$ (c) $2.389\times10^{-12} ergs$ (d) $0.239\times10^{-10} ergs$
4. An ion has 18 electrons in the outermost shell it is
(a)Cu^{+} (b)Th^{4+} (c)Cs^{+} (d)K^{+}

KEY

ΦΦ TEACHING TASK :

LEVEL-I

1-B 2-A 3-B 4-A 5-B 6-A 7-D 8-A 9-C 10-B 11-D 12-C 13-C 14-B 15-A 16-B 17-C 18-B 19-B 20-C

LEVEL-II

1-D 2-A 3-C 4-D 5-A 6-A 7-C 8-D 9-A 10-A 11-D 12-D 13-B 14-A 15-A 16-C,B,A 17-B,C,A,D 18-B 19-A 20-A

LEVEL-III : 1-B 2-A 3-A 4-C 5-B 6-A 7-A 8-B 9-A

LEVEL-IV : 1-C 2-D 3-C 4-C 5-D

ΦΦ LEARNER'STASK :

LEVEL-I : 1-B 2-D 3-D 4-D 5-B 6-C 7-B 8-D 9-C 10-A 11-C 12-A 13-B 14-B 15-C 16-B 17-A 18-D 19-C 20-B

LEVEL-II : 1-A 2-D 3-C 4-A 5-A 6-C 7-C 8-B 9-B 10-C 11-AB 12-ABC 13-D 14-D 15-D 16-C 17-D 18-A 19-BADC 20-CBAD 21-D 22-A 23-B

LEVEL-III :1-C 2-C 3-B 4-C 5-C 6-B 7-D 8-A 9-C

LEVEL-IV :1-A 2-D 3-C 4-B 5-C

ΦΦ TEACHING TASK :

LEVEL-I :1-C 2-D 3-C 4-A 5-A 6-B 7-D 8-B 9-A 10-B 11-C 12-C 13-A 14-C 15-B 16-A 17-B 18-C 19-B

LEVEL-II :1-D 2-A 3-B 4-D 5-B 6-C 7-C 8-ABCD 9-A 10-ABCD 11-A 12-B 13-C 14-A 15-BAED 16-B 17-B 18-D

LEVEL-III :1-C 2-D 3-ABC 4-B 5-B

ΦΦ LEARNER'STASK :

LEVEL-1 :1-A 2-C 3-C 4-C 5-C 6-C 7-D 8-A 9-B 10-C 11-C 12-A 13-B 14-C 15-D

LEVEL-II :1-C 2-B 3-A 4-D 5-A 6-B 7-CDEA 8-EBBD

LEVEL-III :1-A 2-D 3-A 4-C 5-B 6-C

LEVEL-IV :1-A 2-D 3-B 4-A