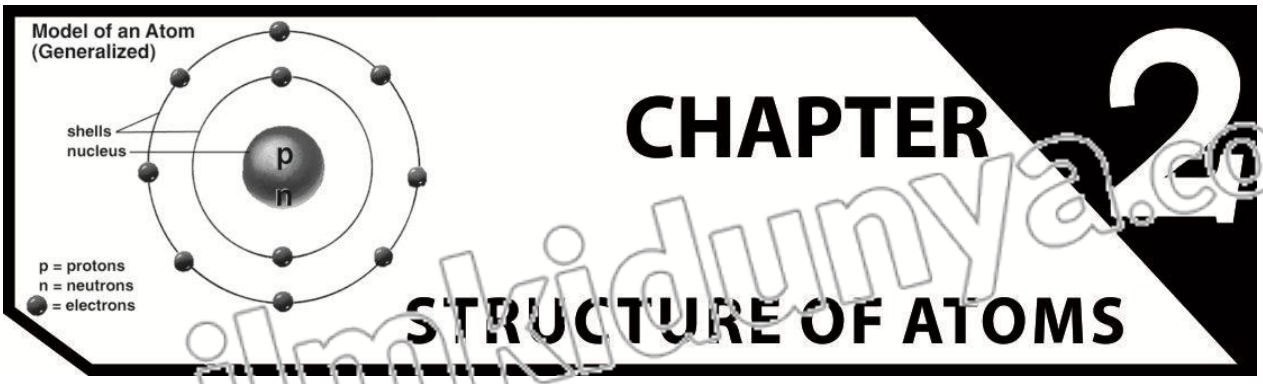


CHAPTER 2

STRUCTURE OF ATOMS

INTRODUCTION

Q.1 What was the idea of Greeks about matter and atom? *(K.B)*

Ans:

IDEA OF GREEKS ABOUT MATTER

Ancient Greek philosopher **Democritus** suggested that matter is composed of tiny **indivisible** particles called atoms.

Q.2 Where from the word atom was derived? *(K.B)*

Ans:

DERIVATION OF WORD ATOM

The name atom was derived from the Latin word **"Atomos"** meaning **indivisible**.

Q.3 Who gave the Atomic Theory? *(K.B)*

Ans:

ATOMIC THEORY

In the beginning of 19th century **John Dalton** gave Atomic Theory.

Q.4 Who revealed that atom is made up of subatomic particles? *(K.B)*

Ans:

SUBATOMIC PARTICLES

In 20th century **Goldstein**, **Rutherford**, **Bohr** and **J.J. Thomson** revealed that atom is made up of **subatomic** particles like **electron**, **proton** and **neutron**.

2.1 THEORIES AND EXPERIMENTS RELATED TO STRUCTURE OF ATOM

(A) DALTONS ATOMIC THEORY *(K.B)*

In the beginning of 19th century John Dalton put forward Atomic Theory. According to it all matter is made up of very small indivisible particles called atoms.

- All matter is composed of atoms.
- An atom is indivisible, hard, dense sphere.
- Atoms of the same element are alike.
- They combine in different ways to form compound.

Note:

In the light of Dalton's atomic theory scientist performed series of experiments, but in late 1800's and early 1900's scientist discovered new subatomic particles.

J.J. Thomson (1856-1940) was a British physicist. He was awarded the 1906 Noble Prize in Physics for the discovery of electron and for his work on the conduction of electricity in gases.

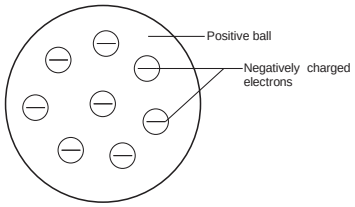
(B) CONTRIBUTION OF J.J THOMSON **(K.B)**

J.J. Thomson (1856 – 1940) was a British physicist. He was awarded the 1906 Noble Prize in physics for the discovery of electron and for his work on the conduction of electricity in gases.

- He discovered electron.
- He determined e/m ratio of electron.
- He put forth plum putting theory.

(C) PLUM PUDDING THEORY *(K.B)*

Thomson put forth his "plum pudding theory". He postulated that **atoms were solid structure of positively charge with tiny negative particles stuck inside. It is like plum in the pudding.**



Q.1 How the cathode rays were discovered? What are their major properties? *(U.B+K.B)*

OR

How are cathode rays produced? What are their five major characteristic?

(Ex-LQ. 1) (SGD 2016, 17, BWP 2016, MTN 2016)

OR

How was it proved that electrons are fundamental particles of an atom? (Ex-LQ. 2)

Sir William Crooks (1832-1919) was a British chemist and physicist. He was pioneer of a vacuum tubes. He worked on spectroscopy.

Ans: CATHODE RAYS AND DISCOVERY OF ELECTRON

Introduction:

In 1879 **Sir William Crooks** performed experiments by passing electric current through gases in a discharge tube at very low pressure.

Experiment:

He took a glass tube fitted with **two metallic electrodes**, which were connected to a high voltage battery. The **pressure** inside the tube was kept **10^{-4} atm**. When high voltage current was passed through the gas, shiny rays were emitted from the cathode surface move towards the anode.

Why Called Cathode Rays?

These rays were given the name of 'cathode rays' as these were **originated from the cathode**.

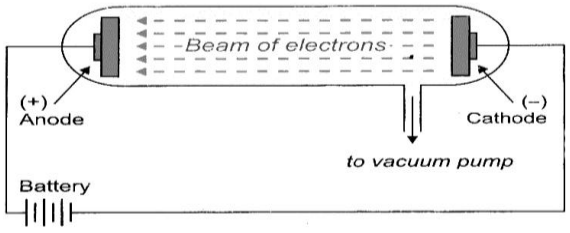


Figure: Discharge Tube Used for the Production of Cathode Rays

Properties of Cathode Rays:

The major characteristics of cathode rays are as follows:

(i) Travelling in Straight Line:

These rays travel in a straight line perpendicular to the cathode surface.

(ii) Casting of Shadow:

They can cast a sharp shadow of an opaque object if placed in their path.

(iii) Deflection in Electric Field:

They are deflected towards positive plate in an electric field showing that they are negatively charged.

(iv) Raise in Temperature:

They raise temperature of the body on which they fall.

(v) e/m Ratio:

J.J. Thomson discovered their charge/mass (e / m) 'ratio:

(vi) Production of Light:

Light is produced when these rays hit the walls of the discharge tube.

(vii) Nature of Cathode:

It was found that the same type of rays were emitted, no matter which gas and which cathode was used in the discharge tube.

Conclusions:

(i) All these properties suggested that the nature of cathode rays is **independent of the nature of the gas** present in the discharge tube or **material of the cathode**.

(ii) The fact that they cast the shadow of an opaque object suggested that these are not rays but they are **fast moving material particles**. They were given the name **electrons**.

(iii) Since all the materials produce same type of particles, it means all the materials contain electrons.

(iv) As we know materials are composed of atoms, hence the electrons are **fundamental** particles of atoms.

Q.2 How the protons were discovered? Write down their properties. **(Ex-LQ. 3)** ***(U.B+K.B)***
(MTN 2017, DGK 2017, RWP 2016, BWP 2017, SWL 2016, 17)

OR

Draw a labeled diagram to show the presence of protons in the discharge tube and explain how canal rays were produced.

Ans:

DISCOVERY OF PROTON

Introduction:

Protons were discovered by **Goldstein** in **1886**.

Experiment:

Goldstein observed that in addition to cathode rays, other rays were also present in the discharge tube. These rays were traveling in opposite direction to cathode rays. He used a discharge tube having **perforated cathode**. He found that these rays passed through holes present in the cathode and produced a glow on the walls of the discharge tube. He called these rays as **"canal rays"**.

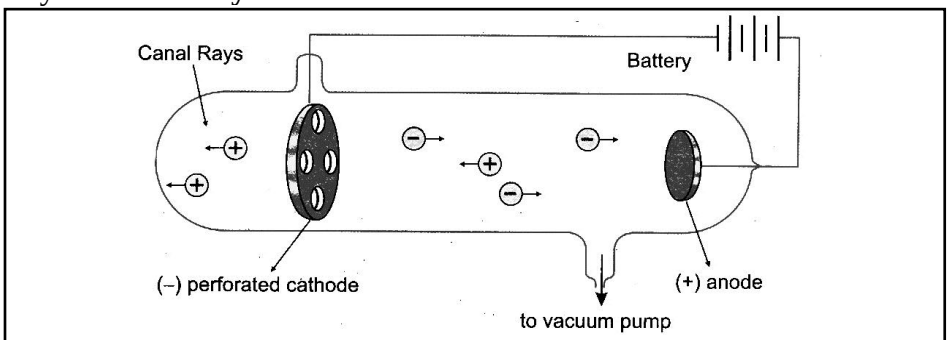


Figure: Discharge Tube Used for the Production of Canal Rays.

Properties of Positive Rays or Canal Rays:

(i) Travelling in Straight Line:

These rays travel in a straight line in a direction opposite to cathode rays.

(ii) Deflection in Electric Field:

Their deflection in electric and magnetic field proved that these were positively charged.

(iii) Dependence:

The nature of canal rays depends upon the nature of gas, present in the discharge tube.

(iv) Origin:

These rays do not originate from the anode. In fact these rays are produced when the cathode rays or electrons collide with the residual gas molecules present in the discharge tube and ionize them. $M + e^- \longrightarrow M^+ + 2e^-$

(v) Mass of Positive Rays:

Mass of these particles was found equal to that of a proton or simple multiple of it. The **mass of a proton is 1840 times more than that of an electron.**

Conclusion:

- These rays are made up of **positively charged particles**.
- The **mass and charge** of these particles **depend** upon the **nature of the gas** in the discharge tube. Hence, different gases produce different types of positive rays having particles of different masses and different charges.
- Positive particles produced by a gas will be of the same type i.e. positive rays produced by the **lightest gas hydrogen contain protons**.

Q.3 How were neutrons discovered? Write down their properties. ***(U.B+K.B)***
(FSD 2017, RWP 2017 G-I MTN 2016)

Ans:

DISCOVERY OF NEUTRON

Historical Backgrounds:

Rutherford observed that atomic mass of the element could not be explained on the basis of the masses of electron and proton only. He predicted in **1920** that some neutral particle having mass equal to that of proton must be present in an atom. Thus scientists were in search of such a neutral particle.

Experiment:

In **1932 Chadwick** discovered neutron, when he bombarded **alpha particles** on a **beryllium target**. He observed that **highly penetrating** radiations were produced. These radiations were called **neutron**.

$$^{9}_{4}Be + {}^{4}_{2}He \longrightarrow {}^{12}_{6}C + {}^{1}_{0}n$$

Properties:

The properties of neutrons are as follows:

i. **Charge:** Neutrons **carry no charge** i.e. they are neutral.
ii. **Penetration:** They are **highly penetrating**.
iii. **Mass: Mass** of these particles was **nearly equal** to the **mass of a proton**.

2.1 THEORIES AND EXPERIMENTS RELATED TO STRUCTURE OF ATOM

SHORT QUESTIONS

Q.1 What is plum pudding theory? **(RWP 2016,17) *(K.B)***

Ans: *Answer given on pg # 59*

Q.2 What is the contribution of Sir William Crookes? ***(K.B)***

Ans: *Answer given on pg # 60*

Q.3 What is Dalton's atomic theory? ***(K.B)***

Ans: *Answer given on pg # 59*

Q.4 How neutron were discovered? ***(K.B)***

Ans. *Answer given above (Experiment)*

Q.5 Write down the properties of neutron. ***(K.B)***

Ans: *Answer given above*

2.1 THEORIES AND EXPERIMENTS RELATED TO STRUCTURE OF ATOM

MULTIPLE CHOICE QUESTIONS

1. Matter is composed of tiny indivisible particles called: *(K.B)*
(A) Element (B) Atom (C) Compound (D) Substance

2. Which are three fundamental particles of an atom? *(K.B)*
(A) Ion, radical, free radical (B) Electron, neutron, ion
(C) Electron, proton, neutron (D) Canal rays, X-rays, γ-rays

3. Atoms of the same element are: *(K.B)*
(A) Different (B) Alike (C) Comparable (D) Active

4. In _____ Goldstein discovered positively charged particles. *(K.B)*
(A) 1886 (B) 1896 (C) 1876 (D) 1836

5. Who discovered cathode rays? *(K.B)*
(A) Goldstein (B) John Dalton (C) Sir William Crook (D) Neil Bohr

6. Gas discharge tube experiment was performed by: *(K.B)*
(A) J.J Thomson (B) Rutherford (C) Dalton (D) William Crook

7. The pressure inside the discharge tube for the discovery of electron was kept: *(K.B)*
(A) 10^{-4} atm (B) 10^{4} atm (C) 101^{4} atm (D) 10^{-14} atm

8. Who discovered the proton? (GRW 2014) (Ex-10) *(K.B)*
(A) Goldstein (B) J.J. Thomson (C) Neil Bohr (D) Rutherford

9. The mass of proton is _____ times more than that of an electron. *(K.B)*
(A) 1830 (B) 1840 (C) 2 (D) 3

10. Canal rays were discovered by: *(K.B)*
(A) Goldstein (B) Thomson (C) Dalton (D) William Crooks

11. Canal rays travel in straight lines in a direction _____ to cathode rays. *(U.B)*
(A) Opposite (B) Same (C) Parallel (D) None of these

12. Canal rays carry: *(K.B)*
(A) Positive charge (B) Negative charge (C) Neutral (D) None of these

13. Which one of the following is produced by the bombardment of the helium particles on beryllium? *(K.B)*
(A) Alpha particles (B) Beta particles (C) Neutron (D) Gamma rays

14. The highly penetrating rays are: *(U.B+K.B)*
(A) Alpha particles (B) Beta particles (C) Neutron (D) Both A and B

15. Neutrons was discovered by: (RWP 2017 G-II) *(K.B)*
(A) Rutherford (B) Chadwick (C) Bohr (D) William Crooks

16. Which one of the following is most penetrating? (Ex-2) *(U.B+K.B)*
(A) Proton (B) Neutron (C) Electron (D) Alpha particles

17. Canal rays are actually *(K.B)*
(A) Electrons (B) Protons (C) Neutrons (D) X-rays

18. Which one of the following is the most penetrating? *(K.B)*
(A) Protons (B) Electrons (C) Neutrons (D) Alpha particles

19. The concept of orbit was used by: *(K.B)*
(A) J.J Thomson (B) Rutherford (C) Bohr (D) Planck

2.1 TEST YOURSELF

i. Do you know any element having no neutrons in its atoms? *(K.B)*

ATOMS HAVING NO NEUTRONS

Ans: Yes the isotope of hydrogen (Protium, $^{1}_{1}H$) has no neutron. It has one proton in its nucleus and one electron revolving around it.

ii. Who discovered electron, proton and neutron? **(BWP 2016,17)** *(K.B)*

Ans: **DISCOVERY**

Electron:

In 1897, J.J. Thomson discovered the negatively charged particles called **electrons**.

Proton:

In 1886, Goldstein discovered positively charged particles called **proton**.

Neutron:

In 1932, James Chadwick discovered the neutral particles called **neutrons**.

iii. How does electron differ from a neutron? *(U.B)*

Ans: **DIFFERENTIATION**

The differences between electron and neutron are as follows:

Electron	Neutron
Charge	
• Electron is the negatively charged particle.	• Neutron is the neutral particle.
Location	
• Electron revolves around the nucleus.	• Neutron is present in the nucleus.
Mass	
• Mass of electron is 5.486×10^{-4} amu.	• Mass of neutron is 1.0087 amu.

iv. Explain how anode rays are formed from the gas taken in the discharge tube. *(U.B)*

Ans: **FORMATION OF ANODE RAYS**

Anode rays do not originate from the anode. In fact these rays are produced when the cathode rays or electrons collide with the residual gas molecules present in the discharge tube.

$$M + 1e^- \longrightarrow M^+ + 2e^-$$

2.1.1 RUTHERFORD'S ATOMIC MODEL

Q.1 How Rutherford discovered that atom has a nucleus located at the centre of the atom? *(LB, KB)*

OR

Explain the Rutherford's atomic structure experiment and atomic model in detail.

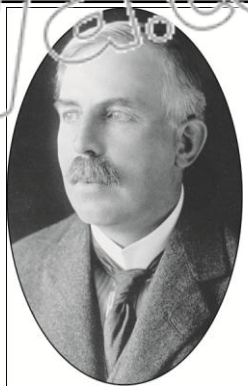
OR

Write down postulates of Rutherford's Atomic Model.

Ans:

RUTHERFORD'S EXPERIMENT

(Gold Foil Experiment / α-Scattering Experiment / Atomic Structure Experiment).



Rutherford was a British New Zealand chemist. He performed a series of experiments using α-particles. He won the 1908 Noble Prize in Chemistry. In 1911, he proposed the nuclear model of the atom and performed the first experiment to spilt atom. Because of his great contributions, he is considered the father of nuclear science.

Introduction:

This experiment was performed by **Lord Rutherford** and his **co-worker** in **1911**. For his work he was awarded |Nobel prize for chemistry in 1908.

Objectives:

Rutherford performed 'Gold Foil' experiment to understand how negative and positive charges could coexist in an atom.

Experiment:

He bombarded **alpha particles** on a **0.00004 cm thick gold foil**. Alpha particles are emitted by radioactive elements like **radium** and **polonium**. These are actually **helium nuclei (He^{2+})**. They can penetrate through matter to some extent.

He observed the effects of alpha-particles on a **photographic plate** or a **screen coated with zinc sulphide**. He proved that the 'plum-pudding' model of the atom was not correct.

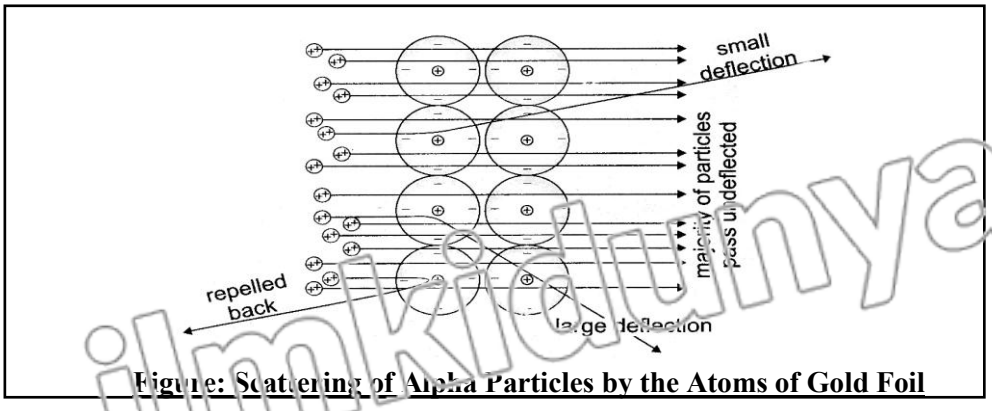


Figure: Scattering of Alpha Particles by the Atoms of Gold Foil

Observations:

The observation made by Rutherford were as follows:

- Almost all the particles passed through the foil **un-deflected**.
- Out of **20000** particles, only a few were deflected at **fairly large angles** and very few **bounced back** on hitting the gold foil.

Results of the Experiment (Postulates of Rutherford's Atomic Model):

Rutherford proposed planetary model for an atom and concluded following results:

(i) Empty Part:

Since most of the particles passed through the foil un-deflected, therefore most of the volume occupied by an atom is empty.

(ii) Center of Positive Charges:

The deflection of a few particles proved that there is a **'center of positive charges'** in an atom, which is called '**nucleus**' of an atom.

(iii) Dense and Hard Nucleus:

The complete rebounce of a few particles show that the nucleus is very dense and hard.

(iv) Size of Nucleus:

Since a few particles were deflected it shows that the size of the nucleus is **very small** as compared to the volume of an atom.

(v) Revolving of Electron:

The electrons revolve **around the nucleus**.

(vi) Number of Electrons and Protons:

An atom as a whole is neutral, therefore the number of electrons in an atom is equal to the number of protons.

(vii) Nucleon Number:

Except electrons, all other fundamental particles that lie within a nucleus are known as nucleons.

DEFECTS OF RUTHERFORD'S MODEL

Although Rutherford's experiment proved that the plum pudding model of an atom was not correct, yet it had following defects:

Stability of Atom:

According to classical theory of radiations, electrons being the charged particles should release or emit energy continuously and they should ultimately fall into the nucleus.

Nature of Spectrum:

If the electrons emit energy continuously, they should form a **continuous spectrum** but in fact, **line spectrum** was observed.

2.1.1 RUTHERFORD'S ATOMIC MODEL

SHORT QUESTIONS

Q.1 Give two observations of Rutherford's atomic model *(SGD 2017 G-I) (U.E)*

Ans: *Answer given on pg # 65*

Q.2 How it is proved that the nucleus dense and hard? *(U.B)*

Ans: The complete rebounce of a few particles show that the nucleus is very dense and hard.

2.1.1 RUTHERFORD'S ATOMIC MODEL

MULTIPLE CHOICE QUESTIONS

1. In α-scattering experiment Rutherford used the foil made up of: *(K.B)*

(A) Silver (B) Tin (C) Platinum (D) Gold

2. Alpha particles are emitted by radioactive element: *(K.B)*

(A) Carbon (B) Polonium (C) Neon (D) Vanadium

3. Rutherford used the photographic plate coated with: *(K.B)*
(A) Zinc sulphide (B) Zinc sulphite (C) Zinc oxide (D) Zinc sulphate

4. According to quantum theory which type of spectrum is shown: *(K.B)*
(A) Continuous spectrum (B) Line spectrum
(C) Emission spectrum (D) Absorption spectrum

5. Rutherford used a thin layer of gold of thickness: *(K.B)*
(A) 0.00004 cm (B) 0.004 cm (C) 0.0004 cm (D) 0.04 cm

6. Rutherford won Noble Prize in: *(K.B)*
(A) 1909 (B) 1906 (C) 1908 (D) 1910

2.1.2 BOHR'S ATOMIC THEORY

Q.1 Write down the postulates of Bohr's Atomic Theory. *(U.B+K.B)*
(LHR 2016 G-II, DGK 2016, SGD 2016, RWP 2016, 17)
OR
How Bohr proved that an atom must exist? **(Ex-LQ.6)**

Ans:

BOHR'S ATOMIC THEORY

Introduction:

Neils Bohr presented another model of atom in **1913**, keeping in view the defects in Rutherford's Atomic Model.

Basis of Bohr's Atomic Theory:

The **Quantum Theory of Max Planck** was used as foundation for this model.

Energy of an Electron:

According to Bohr's Model, revolving electron in an atom does not absorb or emit energy continuously. The energy of a revolving electron is **'quantized'** as it revolves only in **orbits of fixed energy**, called **'energy levels'** by him.

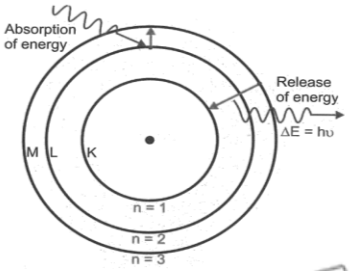
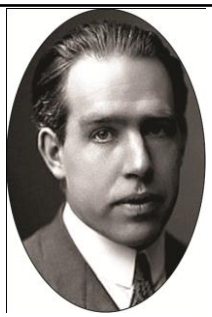


Figure: Bohr's Atomic Model Showing Orbits



Neils Bohr was a Danish physicist who joined Rutherford in 1912 for his post doctoral research. In 1913, Bohr presented his atomic model based upon Quantum theory. He won the 1922 Noble Prize for Physics for his work on the structure of an atom.

Postulates of Bohr's Atomic Theory:

The Bohr's Atomic Model was based upon the following postulates:

(i) Structure of Hydrogen Atom:

The hydrogen atom consists of a **tiny nucleus** and electrons are revolving in one of circular orbits of radius **'r'** around the nucleus.

(ii) Energy of Orbit:

Each orbit has a fixed energy that is **quantized**.

(iii) Emission or Absorption of Energy:

As long as electron remains in a particular orbit it does not radiate or absorb energy. The energy is emitted or absorbed only when an electron jumps from one orbit to another.

(iv) Change in Energy:

When an electron jumps from lower orbit to higher orbit it absorbs energy and when it jumps back from higher orbit to lower orbit it radiates energy.

This change in energy, ΔE is given by following Planck's equation:

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

Where, **h** is **Planck's constant** equal to $\mathbf{6.63 \times 10^{-34}\ J\ s}$, and **v** is **frequency of light**.

(v) Angular Momentum:

Electron can revolve only in orbits of a **fixed angular moment mvr**, given as:

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

Where 'n' is the quantum number or orbit number having values 1, 2, 3 and so on.

Q.2 What are differences between Rutherford's Atomic Theory and Bohr's Atomic Theory? (SWL 2016, MTN 2017, BWP 2017, GRW 2017 G-II, LHR 2016 G-II 2017 G-I)*(U.B)*

Ans: **DIFFERENTIATION**

The differences between Rutherford's Atomic Theory and Bohr's Atomic Theory are as follows:

Rutherford's Atomic Theory	Bohr's Atomic Theory
Basis	
• It was based on classical theory.	• It was based upon quantum theory.
Revolution	
• Electrons revolve around the nucleus.	• Electrons revolve around the nucleus in orbits of fixed energy.
Idea of Orbit	
• No idea about orbits was introduced.	• Orbits had angular momentum.
Nature of Spectrum	
• Atoms should produce continuous spectrum.	• Atoms should produce line spectrum.
Stability of Atom	
• Atoms should collapse.	• Atoms should exist.

2.1.2 BOHR'S ATOMIC THEORY

SHORT QUESTIONS

Q.1 What is meant by quantum? **(Do you know Text Book Pg. # 34)*(K.B)***

Ans:

QUANTUM

"Quantum means fixed energy. It is the smallest amount of energy that can be emitted or absorbed as electromagnetic radiation. Quanta is plural quantum".

Q.2 Who was Max Planck? **(Do you know Text Book Pg. # 34)*(K.B)***

Ans:

MAX PLANCK

He was a German physicist (1858–1947).

Contribution:

In 1918 Noble Prize in physics was awarded to German physicist Max Planck (1858–1947) for his work on the quantum theory.

2.1.2 BOHR'S ATOMIC THEORY

MULTIPLE CHOICE QUESTIONS

1. Quantum means: ***(K.B)***

(A) Fixed volume (B) Fixed energy (C) Fixed pressure (D) Fixed temperature

2. The concept of orbit was introduced by: **(Ex-3)*(K.B)***

(A) J.J. Thomson (B) Rutherford (C) Bohr (D) Planck

3. The value of Planck's constant is: ***(K.B)***

(A) 6.62×10^{-34} Js (B) 6.62×10^{-24} Js (C) 6.62×10^{-19} Js (D) 6.62×10^{-12} Js

4. When an electron jumps from lower orbit to higher orbits it _____ energy. ***(U.B)***

(A) Absorbs (B) Emits (C) Radiates (D) None of these

5. The value of mvr is equal to: ***(K.B)***

(A) $n\frac{h}{2r}$ (B) $n\frac{h}{2}$ (C) $n\frac{2h}{\pi}$ (D) $n\frac{h}{2\pi}$

2.2 TEST YOURSELF

i. How was it proved that the whole mass of an atom is located at its centre? ***(U.B+K.B)***

Ans:

LOCATION OF MASS OF AN ATOM

Rutherford bombarded alpha particles on a 0.00004 cm thick gold foil. Almost all the particles passed through the foil undeflected, only few were bounced back. The complete rebounce of few alpha particles showed that the nucleus is an extremely small positively charged part. It is situated at the center of an atom and it carries nearly the whole mass of an atom.

ii. How was it shown that atomic nuclei are positively charged? ***(U.B)***

Ans:

POSITIVE CHARGE ON ATOMIC NUCLEI

Alpha particles are helium nuclei $(He)^{2+}$ i.e. doubly positively charged particles. The deflection and rebounding of a few particles showed that atomic nuclei (Centre of an atom) are positively charged.

iii. Name the particles which determine the mass of an atom? ***(U.B+K.B)***

Ans:

PARTICLES DETERMINING MASS OF ATOM

Protons and neutron present in the nucleus determine the mass of an atom. The sum of number of protons and neutrons is equal to mass of an atom.

iv. What is the Classical Theory of Radiation? How does it differ from Quantum Theory? *(U.B)*

Ans:

DIFFERENTIATION

The differences between Classical Theory of Radiation and Quantum Theory of Radiation are as follows:

Classical Theory of Radiation	Quantum Theory of Radiation
• According to classical theory of radiation electrons being the charged particles should release or emit energy continuously and they should ultimately fall into the nucleus.	• According to quantum theory of radiation, energy is not emitted or absorbed continuously but it is emitted or absorbed in the form of small energy packets or bundles known as quantum or photons in case of light energy. Quantum means fixed energy.

v. How can you prove that angular momentum is quantized? *(U.B+A.B)*

Hint: Let angular momentum (mvr) of 1st orbit is mvr = nh/2π

$$\mathbf{mvr = \frac{6.63\times10^{-34}}{2\times3.14} = 1.0 \times 10^{-34}\ kgm^2s^{-1}}$$

Ans:

QUANTIZED ANGULAR MOMENTUM

According to Bohr's Model:

Angular momentum (mvr) = $\frac{nh}{2\pi}$ (where n=1, 2, 3,….. and it is equal to number of orbit)

For n = 1, Angular momentum of electron = $\frac{1\times h}{2\pi}$

For n = 2, Angular momentum of electron = $\frac{2\times h}{2\pi}$

For n = 3, Angular momentum of electron = $\frac{3\times h}{2\pi}$

The angular momentum of an electron for n = 2 is twice the angular momentum for n=1 whereas the angular momentum of an electron for n = 3 is thrice the angular momentum for n = 1.
Moreover the electron is bound to remain in one of these orbits and not in between them. Hence the angular momentum of electron is quantized.

2.2 ELECTRONIC CONFIGURATION

Q.1 Write a detailed note on shells and subshells. *(U.B+K.B)*

Ans:

SHELL

"*The **circular path of an electron around the nucleus** is called shell or principal energy level*".

Examples:

K, L, M, N etc.

Properties of a Shell:

The properties of a shell are as follows.

(i) Shells are the **main energy levels** that electrons can occupy.
(ii) Shells are **represented by circles** around the nucleus.
(iii) The number of electron that a shell can accommodate is given by $\mathbf{2n^2}$, where **'n'** is the **shell number**.
(iv) A shell also consists of **subshells** or **orbitals**.
(v) Energy levels are represented by **'n'** values **1, 2, 3** and so on.
(vi) Shells are designated by the **alphabets** or shells **K, L, M** and so on.

(vii) A shell closer to the nucleus is of **minimum energy**.

(viii) Since K shell is closest to the nucleus, the energy of shells increases from K shell and onwards.

Shells and Their Energies:

1st energy level is **K shell**; it has the **lowest energy**

2nd energy level is **L shell**, it has **more** energy **than K shell**.

3rd energy level is **M shell**; it has **more** energy than K and L shell.

4th energy level is **N shell**; it has **more** energy than **K, L and M shell.**

Maximum Capacity of Shells to Accommodate Electrons:

The **number of electron that a shell can accommodate is given by $2n^2$**, where **'n'** is the **shell number**.

K shell: $2n^2 = 2(1)^2 = 2\times1 = \mathbf{2}$

L shell: $2n^2 = 2(2)^2 = 2\times4 = \mathbf{8}$

M shell: $2n^2 = 2(3)^2 = 2\times9 = \mathbf{18}$

N shell: $2n^2 = 2(4)^2 = 2\times16 = \mathbf{32}$

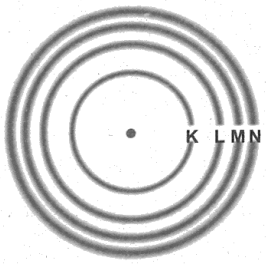


Figure: Showing Different Energy Levels Or Shells Counted From the Centre Outwards

SUBSHELL

*"**Each shell consists of one or more subshells or orbitals**. Each subshell is designated by a **small alphabet** called letter **s, p, d, f** etc."*

Properties of Subshells:

- First energy level or **K** shell has only **one subshell** called s subshell.
- Second energy level **L**, shell has **two subshells s** and **p**.
- Third energy level **M** shell has **three subshells s**, **p** and **d**.
- Fourth energy level or N shell has **four subshells s**, **p**, **d** and **f**.

n value	Shell	Subshell
1	K	Only s
2	L	s, p
3	M	s, p ,d
4	N	s, p, d, f

Q.2 What do you mean by electronic configuration? What are basic requirements while writing electronic configuration of an element? **(Ex. 1.Q.7)** ***(U.B+K.B)***

OR

Explain electronic configuration and give the rules for electronic configuration.

Ans:

ELECTRONIC CONFIGURATION

Definition:

*"The **distribution of electrons around the nucleus in various shells and subshells** according to their **increasing energy** is called electronic configuration".*

Principle:

"In filling the subshells, electrons always enter in lower energy subshell first."

The increasing order in which the electrons will enter into subshell is:

$1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$, $4s^2$, $3d^{10}$, $4p^6$, $5s^2$ etc.

Where,

(i) 'n' represents the shell number

(ii) Letters (s and p) represent subshells

(iii) Superscript shows the number of electrons in a subshell.

The sum of superscripts number is the total number of electrons in an atom i,e. atomic number of an element as follows:

$1s^2$, $2S^2$, $2p^6$, $3s^2$, $2p^6$……..

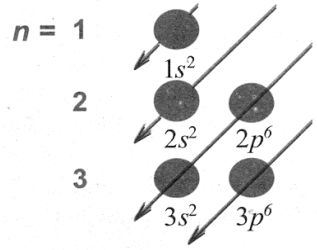


Figure: Filling Sequence of Electrons in Subshells According to Energy Levels

Rules for Electronic Configuration:

(i) The most stable or ground state electronic configuration of an atom is the one in which electrons are present in the lowest possible energy level.

(ii) The electrons fill the shells in order of their increasing energy, i.e. lower energy level is occupied first then the higher energy level and so on as indicated earlier.

The Maximum Capacity of Subshells to Accommodate Electrons:

's' subshell can accommodate **2** electrons.

'p' subshell can accommodate **6** electrons.

'd' subshell can accommodate **10** electrons.

'f' subshell can accommodate **14** electrons.

The Maximum Capacity of Shells to Accommodate Electrons:

The maximum capacity of shells to accommodate electrons is as follows:

K shell: $2n^2 = 2(1)^2 = 2\times1 =$ **2**

L shell: $2n^2 = 2(2)^2 = 2\times4 =$ **8**

M shell: $2n^2 = 2(3)^2 = 2\times9 =$ **18**

N shell: $2n^2 = 2(4)^2 = 2\times16 =$ **32**

As we know there is a slight difference between the energies of the sub shells or orbitals within a shell, therefore, filling of electrons in sub shells of a shell is such as that 's' subshell is **filled first** and then its **p** sub shell and then other sub shells are filled.

Q.3 Draw electronic configuration of first 18 elements. ***(U.B+A.B)***

Ans: **ELECTRONIC CONFIGURATION OF 1st 18 ELEMENTS**

Element	Symbol	Atomic Number	Electronic Configuration
Hydrogen	H	1	$1s^1$
Helium	He	2	$1s^2$
Lithium	Li	3	$1s^2, 2s^1$
Beryllium	Be	4	$1s^2, 2s^2$
Boron	B	5	$1s^2, 2s^2, 2p^1$
Carbon	C	6	$1s^2, 2s^2, 2p^2$
Nitrogen	N	7	$1s^2, 2s^2, 2p^3$
Oxygen	O	8	$1s^2, 2s^2, 2p^4$
Fluorine	F	9	$1s^2, 2s^2, 2p^5$
Neon	Ne	10	$1s^2, 2s^2, 2p^6$
Sodium	Na	11	$1s^2, 2s^2, 2p^6, 3s^1$
Magnesium	Mg	12	$1s^2, 2s^2, 2p^6, 3s^2$
Aluminium	Al	13	$1s^2, 2s^2, 2p^6, 3s^2, 3p^1$
Silicon	Si	14	$1s^2, 2s^2, 2p^6, 3s^2, 3p^2$
Phosphorus	P	15	$1s^2, 2s^2, 2p^6, 3s^2, 3p^3$
Sulphur	S	16	$1s^2, 2s^2, 2p^6, 3s^2, 3p^4$
Chlorine	Cl	17	$1s^2, 2s^2, 2p^6, 3s^2, 3p^5$
Argon	Ar	18	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6$
Potassium	K	19	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$
Calcium	Ca	20	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$

2.2 ELECTRONIC CONFIGURATION

SHORT QUESTIONS

Q.1 Write down the electronic configuration of chlorine. ***(U.B+A.B)***

Ans: *Answer given above*

Q.2 Write down the electronic configuration of boron and argon. **(MTN 2017)** ***(U.B+A.B)***

Ans: *Answer given above*

Q.3 What is meant by electronic configuration? ***(K.B)***

Ans: *Answer given on pg # 70*

Q.4 Write electronic configuration of carbon. ***(U.B+A.B)***

Ans: *Answer given above*

2.2 ELECTRONIC CONFIGURATION

MULTIPLE CHOICE QUESTIONS

1. **The p-subshell has:** **(Ex-7)*(K.B)***

(A) One orbital (B) Two orbitals (C) Three orbitals (D) Four orbitals

2. M-shell can accommodate: **(GRW 2016 G-II, LHR 2014)*(K.B)***

(A) 2 electrons (B) 8 electrons (C) 18 electrons (D) 32 electrons

3. Which one of the following shell consist of three subshells? **(Ex-4)*(K.B)***

(A) O shell (B) N shell (C) L shell (D) M shell

4. How many electrons can K-shell accommodate? **(GRW 2014)*(K.B)***

(A) 3 (B) 2 (C) 4 (D) 5

5. Maximum number of electrons accommodated by N-shell is: ***(K.B)***

(A) 8 (B) 2 (C) 18 (D) 32

6. Which is the electronic configuration of Cl^{1-}? ***(U.B+A.B)***

(A) $1s^2, 2s^2, 2p^6, 3s^1$ (B) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$

(C) Both a and b (D) None of these

7. Energy level is represented by: ***(K.B)***

(A) m (B) n (C) M (D) N

8. A shell closest to the nucleus is of: ***(U.B)***

(A) Same energy (B) Minimum energy (C) High energy (D) Maximum energy

EXAMPLE 2.1

Q.1 Write the electronic configuration of an element having 11 electrons. ***(U.B+A.B)***

Solution:

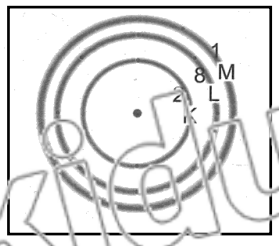
The electronic configuration will be written as:

K	L	M
2	8	1

Further distribution of electrons in subshells will be: $1s^2, 2s^2, 2p^6, 3s^1$.

Example:

Electronic configuration of Na: $1s^2, 2s^2, 2p^6, 3s^1$



EXAMPLE 2.2

Q.2 Write down the electronic configuration of Cl^- ion. ***(U.B+A.B)***

ELECTRONIC CONFIGURATION OF Cl^-

Solution:

We know that chlorine has 17 electrons and chloride ion (Cl^-) has 17 + 1 = 18 electrons. Its electronic configuration will be 2, 8, 8, which is presented in the figure. The further distribution of electrons in subshells will be $1s^2, 2s^2, 2p^6, 3s^2. 3p^6$.

EXAMPLE 2.3

Q.3 An element has 5 electrons in M shell. Find out its atomic number. *(U.B)*

ELEMENT WITH 5 ELECTRON IN M-SHELL

Solution:

When there are 5 electrons in M shell, it means K and L shell are completely filled with their maximum capacity of 10 electrons. Hence the electronic configuration of the element is.

K L M
2, 8, 5

So, the total number of electrons is 2 + 8 + 5 = 15

The number of electrons in an atom is equal to its atomic number.

Therefore, atomic number of this element is 15.

2.3 TEST YOURSELF

i. What is the maximum number of electrons that can be accommodated in p-subshell? *(K.B)*

Ans: **NUMBER OF ELECTRON IN P-SUBSHELL**

The maximum number of electron that can be accommodated in a p subshell is 6.

ii. How many subshells are there in second shell? *(K.B)*

Ans: **NUMBER OF SUBSHELL**

There are two subshells in second shell i.e. s and p subshells.

iii. Why does an electron first fill 2p orbital and then 3s orbital? *(U.B)*

Ans: **FILLING OF ELECTRON**

Electrons are filled around the nucleus in various shells and subshells according to increasing energy. The energy of 2p orbital is less than that of 3s orbital. Therefore 2p orbital is filled first than that of 3s orbital.

iv. If both K and L shells of an atom are completely filled; what is the total number of electrons present in them? *(U.B)*

Ans: **NUMBER OF ELECTRON IN K AND L SHELL**

The maximum capacity of shells to accommodate electrons is:

K shell = 2 electrons

L shell = 8 electrons

Therefore, the total number of electrons present in K and L shell = 2+8=10 electrons.

v. How many electrons can be accommodated in M shell? *(U.B+K.B)*

Ans: **ACCOMMODATION OF ELECTRON IN M-SHELL**

The maximum number of electrons that can be accommodated in M shell is 18. It can be calculated by the formula $2n^2$. As for M shell value 'n' is 3.

Therefore,

Maximum number of electrons in M shell = $(2n^2) = 2\times3^2 = 2\times9 = 18$ electrons.

vi. What is the electronic configuration of a hydrogen atom? *(U.B+A.B)*

Ans: **HYDROGEN ATOM**

The electronic configuration of hydrogen atom is $1s^1$.

vii. What is atomic number of phosphorus? Write down its electronic configuration. *(U.B+A.B)*

Ans: **PHOSPHOROUS**

Atomic Number:

Atomic number of phosphorous (P) =15

Electronic Configuration:

Electronic configuration of phosphorous (P) = $1s^2, 2s^2, 2p^6, 3s^2, 3p^3$

viii. If an element has atomic number 13 and atomic mass 27; how many electrons are there in each atom of the element? *(U.B)*

Ans: **ELEMENT WITH ATOMIC NUMBER 13 AND MASS 27**

In a neutral atom, atomic number = number of protons = number of Electrons = 13.

Therefore,

Each atom of this element has 13 electrons.

ix. How many electrons will be in M shell of an atom having atomic number 15? *(U.B)*

Ans: **ELECTRON IN M SHELL**

Atomic number = Number of electrons =15

Electronic configuration = $1s^2, 2s^2, 2p^6, 3s^2, 3p^3$.

Therefore, M shell contains electrons = 2+3=5 electrons.

x. What is maximum capacity of a shell? **(LHR 2017 G-I)***(U.B)*

Ans: **MAXIMUM CAPACITY OF A SHELL**

The maximum capacity of a shell to accommodate electrons can be calculated by the formula = $2n^2$

Where

n = 1, 2, 3, 4 ……. and it represents the shell

Maximum capacity of K shell = 2 electrons

Maximum capacity of L shell = 8 electrons

Maximum capacity of M shell = 18 electrons

Maximum capacity of N shell = 32 electrons

2.3 ISOTOPES

Q.1 Define isotopes. Explain the isotopes of hydrogen. *(K.B)*

OR

What is an isotope? Describe the isotopes of hydrogen with diagram.

Ans: **ISOTOPES**

Definition:

"*The **atoms of an element** that have **same atomic number** but **different mass number** are called isotopes".*

Isotope was discovered by **Soddy**.

Properties:

The properties of isotopes are as follows:

- They have same electronic configuration and number of protons
- They differ in the number of neutrons.
- Isotopes have **similar chemical properties** because they depend upon electronic configuration.
- They have **different physical properties** because these properties depend upon atomic masses.
- Most of the elements show isotopes.
- All isotopes of an element occupy **same position in the periodic table**.

Example:

Hydrogen has **three** isotopes i.e., **protium** $\left({}_{1}^{1}\mathrm{H}\right)$**, deuterium** $\left({}_{1}^{2}\mathrm{H}\right)$ **and tritium** $\left({}_{1}^{3}\mathrm{H}\right)$.

ISOTOPES OF HYDROGEN

Number of Isotopes:

The naturally occurring hydrogen is combination of its three isotopes present in different abundances. The **three** isotopes of hydrogen are:

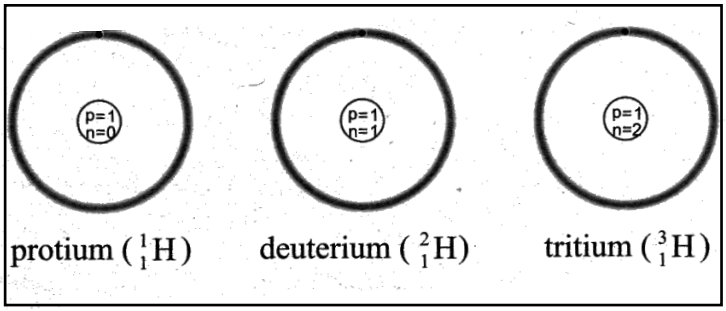
- Protium $\left({}_{1}^{1}\text{H or P}\right)$
- Deuterium $\left({}_{1}^{2}\text{H or D}\right)$
- Tritium $\left({}_{1}^{3}\text{H or T}\right)$

Number of Protons, Electrons and Neutrons in Isotopes:

Each one of these isotopes has 1 proton and 1 electron but number of **neutrons are different**.

Representation:

The isotopes are represented as:



Natural Abundance:

	Isotopes	Natural Abundance	Atomic Number	Mass Number	No. of Proton	No. of Electron	No. of Neutron
(i)	Protium ($^{1}_{1}$H or P)	99.985%	1	1	1	1	0
(ii)	Deutrium ($^{2}_{1}$H or D)	0.015%	1	2	1	1	1
(iii)	Tritium ($^{3}_{1}$H or T)	In trace amount	1	3	1	1	2

Q.2 Explain isotopes of carbon, chlorine and uranium. **(SGD 2017 G-I)(Z.B)**

Ans:

ISOTOPES OF ELEMENTS

(a) Isotopes of Carbon:

Number of Isotopes:

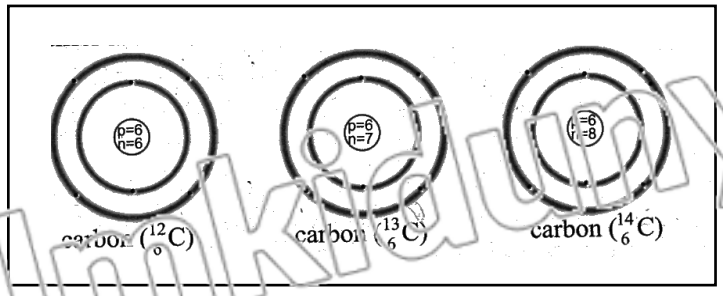
There are **three** isotopes of carbon. **Two** isotopes of carbon are **stable** which are ^{12}**C** and ^{13}**C**. **Third** isotope of carbon is **radioactive** isotope, ^{14}**C**.

Natural Abundance:

The isotope ^{12}**C** is present in abundance of **98.9%,** while ^{13}**C** and ^{14}**C** are both present only **1.1%** in nature.

Number of Protons, Electrons and Neutrons in Isotopes:

All of them have the same number of protons and electrons but **differ in number of neutrons**. The isotopes are represented as:



(B) Isotopes of Chlorine:

There are **two** isotopes of chlorine $^{35}_{17}$**Cl** and $^{37}_{17}$**Cl.**

Natural Abundance:

The isotope **Cl-35** is present in abundance of **75%** while **Cl-37** is present in abundance of **25%**.

Number of Protons, Electrons and Neutrons in Isotopes:

All of them have same number of protons and electrons but differ in number of neutrons.

(C) Isotopes of Uranium:

There are **3** isotopes of uranium i.e. $^{234}_{92}$U, $^{235}_{92}$U and $^{238}_{92}$U

Natural Abundance:

The isotope $^{238}_{92}$**U** is found in nature nearly **99%** while **other two** isotopes are found in nature nearly **1%**.

Number of Protons, Electrons and Neutrons in Isotopes:

All of them have same number of protons and electrons but different number of neutrons.

Table 2.2: Atomic number, mass number, number of protons and neutrons of isotopes of H, C, Cl and U

Symbol	Atomic Number	Mass Number	Number of Proton	Number of Neutron
$_{1}H$	1	1	1	0
$_{2}H$	1	2	1	1
$_{3}H$	1	3	1	2
$_{12}C$	6	12	6	6
$_{13}C$	6	13	6	7
$_{14}C$	6	14	6	8
$_{35}Cl$	17	35	17	18
$_{37}Cl$	17	37	17	20
$2_{34}U$	92	234	92	142
$_{235}U$	92	235	92	143
$_{238}U$	92	238	92	146

Q.3 Give the uses or applications of isotopes in the field of radiotherapy, medicines, archaeology, structure determination and power generation. **(GRW 2016 G-I)*(A.B)***

OR

Give the application of isotopes in the field of radiotherapy and medicines. **(Ex.LQ.9)*(A.B)***

Ans:

USES OR APPLICATION OF ISOTOPES

The major fields in which isotopes have vast applications are the following:

(i) Radiotherapy (Treatment of Cancer):

- For the **treatment of skin cancer**, isotopes like **P-32** and **Sr-90** are used because they emit **less penetrating beta radiations**.
- For **cancer, affecting inside the body Co-60**, is used because it emits **strongly penetrating gamma rays**.

(ii) Tracer for Diagnosis and Medicine.

The radioactive isotopes are used as tracers in medicine to diagnose the presence of tumor in the human body.

Examples:

- Isotopes of **Iodine-131** are used for diagnosis of **goiter** in thyroid gland.
- **Technetium** is used to monitor the **bone growth**.

(iii) Archaeological and Geological Uses:

The radioactive isotopes are used to estimate the age of fossils like dead plants and animals and stones etc.

Radioactive-isotope Dating:

*"The **age determination of very old objects based on the half-lives of the radioactive isotope** is called radioactive-isotope dating."*

Carbon Dating:

"*Age determination of old carbon containing objects **(fossils) by measuring the radioactivity of C-14 in them** is called **radio-carbon dating** or simply **carbon dating**. This is an important method of age determination of old objects"*

(iv) Chemical Reaction and Structure Determination:

The radioisotopes are used in a chemical reaction to follow a radioactive element during the reaction and ultimately to determine the structure.

Tracer Element:

C-14 is used to **label CO_2**. As CO_2 is used by the plants for photosynthesis to form glucose, its movement is detected through the various intermediate steps up to glucose.

(v) Applications in Power Generation:

Radioactive isotopes are used to generate electricity by carrying out **controlled nuclear fission** reactions in nuclear reactors.

Example:

When **U-235** is bombarded with **slow moving neutrons,** the uranium nucleus breaks up to produce **Barium-139** and **Krypton** and **three neutrons**.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3{}^{1}_{0}n + energy$$

A large amount of energy is released which is used to convert water into steam in boilers. The steam then drives the turbines to generate electricity. This is the peaceful use of atomic energy for development of a nation.

2.3 ISOTOPES

SHORT QUESTIONS

Q.1 What is carbon dating? ***(K.B)***

Ans: *Answer given above*

Q.2 Explain isotopes of hydrogen. ***(K.B)***

Ans: *Answer given on pg # 77*

Q.3 Explain isotopes of chlorine. ***(K.B)***

Ans: *Answer given on pg # 78*

Q.4 Write the uses of isotopes in radiotherapy. ***(A.B)***

Ans: *Answer given above*

Q.5 Explain how isotopes are uses as tracer for diagnosis and medicine? *(A.B)*

Ans: *Answer given on pg # 79*

Q.6 Define isotopes. Give an example: *(K.B)*

Ans: *Answer given on pg # 76*

Q.7 Why isotopes of an element have same chemical properties? *(U.B)*

Ans: *Answer given on pg # 76*

Q.8 How electricity is generated by U-235? *(U.B+A.B)*

Ans: *Answer given on pg # 79*

Q.9 For what purpose I-131 is used: **(SGD 2017 G-I)***(K.B)*

Ans:

PURPOSE OF I–131

Isotopes of I-131 are used for diagnosis of goiter in thyroid gland.

Q.10 Which element has not any neutron in its atom? **(SWL 2016 G-II)***(U.B+K.B)*

Ans:

ELEMENT WITH NO NEUTRON

The element hydrogen (protium) has not any neutron in its atom.

2.3 ISOTOPES

MULTIPLE CHOICE QUESTIONS

1. Uranium has number of isotopes: **(LHR 2016 G-II, GRW 2016)***(K.B)*

(A) 1 (B) 3 (C) 4 (D) 5

2. Which isotope of carbon is in abundance? **(BWP 2016 G-I)***(K.B)*

(A) ^{12}C (B) ^{13}C (C) ^{14}C (D) None of these

3. Isotopes have different: *(K.B)*

(A) Atomic number (B) Mass number (C) Atomic volume (D) None of these

4. Number of protons in ^{238}U are: *(U.B+K.B)*

(A) 92 (B) 90 (C) 91 (D) 89

5. Isotopes have same _____ and different _____. *(K.B)*

(A) Mass number, atomic number (B) Atomic number, mass number

(C) Neutrons, protons (D) None of these

6. Which one of the following is used for cancer treatment in the body? **(GRW 2017 G-II, FSD 2017 G-II)***(A.B)*

(A) P-32 (B) Sr-90 (C) I-131 (D) Co-60

7. The isotope used to generate electricity in nuclear reactor is: **(LHR 2017 G-II)***(A.B)*

(A) C-12 (B) U-235 (C) Co-60 (D) P-32

2.4 TEST YOURSELF

i. Why do the isotopes of an element have different atomic masses? *(U.B)*

Ans:

ISOTOPES HAVING DIFFERENT ATOMIC MASSES

The isotopes of an element have same number of electrons and protons while different number of neutrons. Therefore the isotopes of an element have different atomic masses due to different number of neutrons.

ii. How many neutrons are present in C-12 and C-13? *(U.B+K.B)*

Ans:

NUMBER OF NEUTRONS IN C-12, C-13

Number of neutrons present in C-12=12-6=6 neutrons

Number of neutrons present in C-13=13-6=7 neutrons

(The atomic number of carbon is 6).

iii. Which of the isotopes of hydrogen contains greater number of neutrons? ***(U.B+K.B)***

Ans: **GREATER NUMBER OF NEUTRONS**

Tritium isotope of hydrogen contains greater number of neutrons. It has 2 neutrons.

iv. Give one example each of the use of radioactive isotope in medicine and radiotherapy. ***(A.B)***

Ans: **USE OF ISOTOPES IN MEDICINE AND RADIOTHERAPY**

In Medicine:

The radioactive isotope iodine-131 is used as a tracer in medicine. It is used to diagnose presence of tumors in the human body.

In Radiotherapy:

Co-60 is used to treat cancer inside the body. P-32 and Sr-90 are used to treat skin cancer.

v. How is the goiter in thyroid gland detected? ***(A.B)***

OR

A patient has a goiter. How will be it detected? **(Ex-SQ.10)(RWP 2017, MTN 2016)**

Ans: **DETECTION OF GOITER**

Iodine-131 is used for diagnosis of goiter in thyroid gland.

vi. Define nuclear fission reaction. ***(K.B)***

Ans: **NUCLEAR FISSION**

Definition:

"A reaction that involves the splitting of heavy nucleus into two or more lighter nuclei with a release of huge amount of energy is called a nuclear fission reaction."

Example:

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3{}^{1}_{0}n + energy$$

During this reaction, released neutrons continue to bombard other uranium -235 atoms.

vii. When U-235 breaks up, it produces a large amount of energy. How is this energy used? ***(A.B)***

Ans: **USE OF ENERGY**

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3{}^{1}_{0}n + energy$$

In this reaction a large amount of energy is released which may be used to convert water into steam in boilers. The steam then drives the turbines to generate electricity.

viii. How many neutrons are produced in the fission reaction of U-235? ***(K.B)***

Ans: **NUMBER OF NEUTRON**

In the fission reaction of U-235, three neutrons are produced.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3{}^{1}_{0}n + energy$$

ix. U-235 fission produces two atoms of which elements? ***(K.B)***

Ans: **FISSION PRODUCE ELEMENTS**

U-235 fission produces one atom of barium-139 and one atom of krypton-94.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3{}^{1}_{0}n + energy$$

ANSWER KEYS

2.1 THEORIES AND EXPERIMENTS RELATED TO STRUCTURE OF ATOM

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

2.1.1 RUTHERFORD'S ATOMIC MODEL

1	D	2	B	3	A	4	B	5	A	6	C

2.1.2 BOHR'S ATOMIC THEORY

1	B	2	C	3	A	4	A	5	D

2.2 ELECTRONIC CONFIGURATION

1	C	2	C	3	D	4	B	5	D	6	B	7	B	8	B

2.3 ISOTOPES

1	B	2	A	3	B	4	A	5	B	6	D	7	B

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. Which one of the following results in the discovery of proton? **(GRW 2017 G-I, RWP 2016 G-I)*(U.B+K.B)***

(A) Cathode rays (B) Canal rays (C) X-rays (D) Alpha rays.

2. Which one of the following is the most penetrating? **(SWL 2017 G-I, BWP 2016 G-II)*(U.B+K.B)***

(A) Protons (B) Electrons (C) Neutrons (D) Alpha particles

3. The concept of orbit was used by: **(RWP 2017 G-I, FSD 2016 G-I)*(K.B)***

(A) J. J. Thomson (B) Rutherford (C) Bohr (D) Planck

4. Which one of the following shell consists of three subshells? **(FSD 2016 G-II, LHR 2017 G-II, MTN 2016 G-I)*(K.B)***

(A) O shell (B) N shell (C) L shell (D) M shell

5. Which radioisotope is used for the diagnosis of tumor in the body? **(FSD 2017 G-I, RWP 2016 G-II)*(A.B)***

(A) Cobalt-60 (B) Iodine-131 (C) Strontium-90 (D) Phosphorus-32

6. When U-235 breaks up, it produces: **(GRW 2016 G-I, BWP 2016 G-I, DGK 2016 G-I)*(K.B)***

(A) Electrons (B) Neutrons (C) Protons (D) Nothing

7. The p subshell has: **(LHR 2016 G-I)*(K.B)***

(A) One orbital (B) Two orbitals (C) Three orbitals (D) Four orbitals

8. Deuterium is used to make: **(DGK 2017 G-II, BWP 2017 G-II, SGD 2016 G-I)*(A.B)***

(A) Light water (B) Heavy water (C) Soft water (D) Hard water

9. The isotope C-12 is present in abundance of: **(BWP 2017 G-I)*(K.B)***

(A) 96.9 % (B) 97.6 % (C) 99.7 % (D) None of these

10. Who discovered the proton? **(SGD 2017 G-1)*(K.B)***

(A) Goldstein (B) J. J. Thomson (C) Neil's Bohr (D) Rutherford

ANSWER KEY

1	**b**	**3**	**c**	**5**	**b**	**7**	**c**	**9**	**d**
2	**c**	**4**	**d**	**6**	**b**	**8**	**b**	**10**	**a**

EXERCISE SHORT QUESTION

1. What is the nature of charge on cathode rays? **(MTN 2017, GRW 2017 G-II)*(U.B+K.B)***

Ans: **NATURE OF CHARGE ON CATHODE RAYS**

- Their deflection towards positive plate in an electric field showed that cathode rays are negatively charged particles.
- J.J. Thomson discovered the e/m (charge/mass) ratio on cathode rays and found it equal to electron.

2. Write down the properties of cathode rays. **(LHR 2014)*(U.B+K.B)***

OR

Give five characteristics of cathode rays.

(DGK 2017, GRW 2017 G-I, LHR 2016 G-I, RWP 2017 G-I,II, SGD 2016, 2017 BWP 2016, MTN 2016)

Ans: *Answer given on Pg # 60*

3. The atomic symbol of a phosphorus ion is given as $\left({}^{31}_{15}P^{3-}\right)$: *(U.B+A.B)*

(A) How many protons, electrons and neutrons are there in the ion? *(U.B)*
(B) What is name of the ion? *(U.B)*
(C) Draw the electronic configuration of the ion. *(A.B)*
(D) Name the noble gas which has the same electronic configuration as the phosphorus ion has. *(U.B)*

Ans: **NUMBER OF ELECTRONS, PROTONS AND NEUTRONS**

(A) In $\left({}^{31}_{15}P^{3-}\right)$ ion:

(i) Number of protons = 15
(ii) Number of electron = 15+3=18 (P^{3-} has three more electrons than neutral P-atom)
(iii) Number of neutrons = 31-15=16
(B) The name of ion is phosphide ion.
(C) Electronic configuration of ${}^{31}_{15}P^{-3}$ = $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$ (P^{3-} has three more electrons than neutral P-atom)
(D) Argon has same electronic configuration as the phosphorous ion has.

4. Differentiate between shell and subshell with examples of each.
(LHR 2016 G-II, FSD 2017 G-II, BWP 2017 G-II) *(U.B)*

Ans: **DIFFERENTIATION**

The differences between shell and subshell are as follows:

Shell	Sub-shell
Definition	
• The circular path of an electron around the nucleus is called shell or principal energy level is called *a shell.*	• Each shell consists of smaller paths called subshells.
Subdivision	
• The shells are subdivided into subshells.	• The subshells are further composed of atomic orbitals.
Representation	
• These are represented by K, L, M, N etc.	• s, p, d and f are considered as the subshells of a shell. These are represented by s, p, d, f.

5. An element has an atomic number 17. How many electrons are present in K, L and M shells of the atom? *(U.B)*

Ans: **NUMBER OF ELECTRON IN SHELLS**

Atomic number of element = Number of electrons = 17
The number of electron present in K, L and M shells of an atom will be 2, 8 and 7 respectively.

6. Write down the electronic configuration of Al^{3+}. How many electrons are' present in its outer most shell? *(U.B+A.B)*

Ans: **ELECTRONIC CONFIGURATION OF Al^{3+}**

Atomic number of Al = 13
Number of electrons in Al = 13
Number of electrons in Al^{3+} = 13-3 = 10 electrons.
Thus electronic configuration of Al^{3+} ion:

In Shells:

K L

2 8

In Subshells:

$1s^2, 2s^2, 2p^6$

NUMBER OF ELECTRONS IN OUTER MORE SHELL

Number of electrons present in outer most shell of Al^{3+} = 10 electrons

7. Magnesium has electronic configuration 2, 8, 2, ***(U.B)***

(A) How many electrons are in the outermost shell?

(B) In which subshell of the outermost shell electrons are present?

(C) Why magnesium tend to lose electrons?

Ans:

(a) Electronic configuration of Mg =

K L M

2 8 2

Mg = $1s^2, 2s^2, 2p^6, 3s^2$

It has two electrons in the outermost shell.

(b) The outermost electrons are present in "s" subshell of the 3rd shell (M).

(c) Magnesium is electropositive in character. It has the ability to lose its two electrons from its outermost shell.

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

8. What will be the nature of charge on an atom when it loses an electron or when it gains an electron? ***(U.B)***

Ans:

NATURE OF CHARGE

When atom loses 1 electron:

When an atom loses an electron, it acquires positive charge due to more number of protons in the nucleus e.g.

$$Na \longrightarrow Na^{1+} + 1e^-$$

$$(2,8,1) \quad (2,8)$$

When atom gains 1 electron:

When an atom gains an electron, it possesses negative charge due to more electrons than protons in the atom e.g.

$$Cl + 1e^- \longrightarrow Cl^{1-}$$

$$(2,8,7) \quad (2,8,8)$$

9. For what purpose is U-235 used?

(GRW 2017 G-I, SGD 2017 G-II, FSD 2017 G-II, DGK 2017 G-II) ***(A.B)***

Ans:

USE OF U-235

Radioactive isotope U-235 is used to generate electricity.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + {}^{1}_{0}3n + \text{energy}$$

The heat produced during this reaction converts water into steam. Steam turns turbines to produce electricity.

10. A patient has a goiter. How will it be detected? **(RWP 2017, MTN 2016, GRW 2017 G-II)** ***(A.B)***

Ans: Isotopes of **Iodine-131** are used for diagnosis of **goiter** in thyroid gland.

11. Give three properties of positive rays. **(DGK 2016 G-II, 2017)*(U.B+K.B)***

Ans: **Travelling in Straight Line:**

These rays travel in a straight line in a direction opposite to cathode rays.

Deflection in Electric Field:

Their deflection in electric and magnetic field proved that these were positively charged.

Dependence:

The nature of canal rays depends upon the nature of gas, present in the discharge tube.

12. What are the defects of Rutherford's atomic model?

(RWP 2017, SWL 2016, FSD 2016, 17, GRW 2017 G-II, LHR 2017 G-I)*(K.B+U.B)*

Ans: **DEFECTS OF RUTHERFORD'S MODEL**

Although Rutherford's experiment proved that the plum pudding model of an atom was not correct, yet it had following defects:

Stability of Atom:

According to classical theory of radiations, electrons being the charged particles should release or emit energy continuously and they should ultimately fall into the nucleus.

Nature of Spectrum:

If the electrons emit energy continuously, they should form a **continuous spectrum** but in fact, **line spectrum** was observed.

13. As long as electron remains in an orbit, it does not emit or absorb energy. When does it emit or absorb energy? ***(U.B)***

Ans: **EMISSION OR ABSORPTION OF ENERGY**

Electrons do not emit or absorb energy till they remain in their orbits. Electron emits energy when it jumps from high energy level to the lower energy level. An electron absorbs energy when it jumps from a lower energy orbit to a higher energy orbit. The change in energy is given by the following Planck's equation:

$$\Delta E = E_2 - E = h\nu \qquad \text{(Energy absorbed)}$$

Where,

E_1 = Energy of lower energy orbit

E_2 = Energy of higher energy orbit

"h" is Planck's" constant. Its value is 6.63×10^{-34} Js and v is frequency of light.

Similarly,

$$\Delta = E_2 - E_1 = -h\nu \qquad \text{(Energy emitted)}$$

EXERCISE LONG QUESTIONS

1. How are cathode rays produced? What are its five major characteristics?

Ans: *Answer given on pg # 60* (Topic 2.1)

2. How was it proved that electrons are fundamental particles of an atom?

Ans: *Answer given on pg # 60* (Topic 2.1)

3 Draw a labeled diagram to show the presence of protons in the discharge tube and explain how canal rays were produced.

Ans: *Answer given on pg # 61* (Topic 2.1)

4. How Rutherford discovered that atom has a nucleus located at the centre of the atom?

Ans: *Answer given on pg # 65* (Topic 2.1.1)

5. One of the postulates of Bohr's atomic model is that angular momentum of a moving electron is quantized. Explain its meaning and calculate the angular momentum of third orbit (i.e. n=3)

Ans:

ANGULAR MOMENTUM

Meaning:

Electron can revolve only in orbits of a fixed angular moment mvr.

Calculation of Angular Momentum of 3rd orbit:

Formula:

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

Where 'n' is the quantum number or orbit number having values 1, 2, 3 and so on.

Angular momentum of third orbit = $\frac{nh}{2\pi}$

$$= \frac{3\times 6.63\times 10^{-34}}{2\times 3.14}$$

$$= 3.1\times 10^{-3}\,kgm^2s^{-1}$$

6. How did Bohr prove that an atom must exist?

Ans: *Answer given on pg # 67* (Topic 2.1.2)

7. What do you mean by electronic configuration? What are basic requirements while writing electronic configuration of an element (atom)?

Ans: *Answer given on pg # 72* (Topic 2.2)

8. Describe the electronic configuration of Na^+, Mg^{2+} and $Al^3{}_+$ ions. Do they have the same number of electrons in the outermost shell?

Ans:

ELECTRONIC CONFIGURATION

(i) Na^+:

Number of electrons in Na atom = 11

Number of electrons in Na^+ ion = 11–1 = 10

Electronic configuration in shells = K L
2 8

Electronic configuration in subshells = $1s^2, 2s^2, 2p^6$

(vi) Mg^{2+}:

Number of electrons in Mg atom = 11

Number of electrons in Mg^{2+} ion = 12 – 2 = 10

Electronic configuration in shell = K L
2 8

Electronic configuration in subshells = $1s^2, 2s^2, 2p^6$

(vii) Al^{3+}:

Number of electrons in Al atom = 13

Number of electrons in Al^{3+} ion = 13 – 3 = 10

Electronic configuration in shell = K L
2 8

Electronic configuration in subshells = $1s^2, 2s^2, 2p^6$

SAME NUMBER OF ELECTRONS IN VALENCE SHELL

It is proved that Na^+, Mg^{2+} and Al^{3+} ions all have 8 electrons in their outermost shells.

9. Give the applications of isotopes in the field of radiotherapy and medicines.

Ans: *Answer given on pg # 78* (Topic 2.3)

10. What is an isotope? Describe the isotopes of hydrogen with diagrams.

Ans: *Answer given on pg # 76* (Topic 2.3)

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 **How it is proved that the nucleus dense and hard?** ***(U.B)***

Ans: The complete rebounce of a few particles show that the nucleus is very dense and hard.

Q.2 **How Rutherford came to know that size of the nucleus is very small as compared to the size of the atom?** ***(U.B)***

Ans: Since a few particles were deflected it shows that the size of the nucleus is very small as compared to the volume of an atom.

Q.3 **What are the nucleons?** ***(U.B+K.B)***

Ans: Except electrons, all other fundamental particles that lie within a nucleus are known as nucleons.

Q.3 **What is meant by angular momentum?** ***(K.B)***

Ans: **ANGULAR MOMENTUM**

"The momentum of an object moving in a circle is called angular momentum".

Electron can revolve only in orbits of a fixed angular moment mvr, given as:

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

Where 'n' is the quantum number or orbit number having values 1, 2, 3 and so on.

Q.4 **Why neutrons are highly penetrating?** ***(U.B)***

Ans: **NEUTRONS ARE HIGHLY PENETRATING**

Reason:

Because they carry no charge hence they don't react with matter.

Q.5 **Write down the electronic configuration of phosphorous.** ***(U.B+A.B)***

Ans: **Phosphorous ($_{15}$P):**

$$\text{In shells} = \begin{matrix} K & L & M \\ 2 & 8 & 5 \end{matrix}$$

$$\text{In subshells} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^3$$

Q.6 **Identify the element having valence shell electronic configuration $4s^1$** ***(U.B+A.B)***

Ans: **IDENTIFICATION OF ELEMENT**

Electron are filled in shells and sub-shells of an atom according to increasing energy. So element having valence sub-shell electronic configuration $4s^1$ has its **inner sub-shell electronic configuration** as follow:

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$

So according to above electronic configuration atom of this element has **19** electrons. As, in neutral atom

Number of electron = Number of proton

so the element is **Potassium (K)**

TERMS TO KNOW

Terms	Definitions
Dalton's Atomic Theory	According to it all matter is made up of very small indivisible particles called atoms. All matter is composed of atoms. An atom is indivisible, hard, dense sphere. Atoms of the same element are alike. They combine in different ways to form compound.
Plum Pudding Theory	Thomson put forth his "plum pudding theory". He postulated that **atoms were solid structure of positively charge with tiny negative particles stuck inside. It is like plum in the pudding.**
Electronic Configuration	***"****The* ***distribution of electrons around the nucleus in various shells and subshells*** *according to their* ***increasing energy*** *is called electronic configuration".*
Shell	Shells are the **main energy levels** that electrons can occupy.
Sub-Shell	Each shell consists of smaller paths called subshells.
Isotopes	"*The* ***atoms of an element*** *that have* ***same atomic number*** *but* ***different mass number*** *are called isotopes".*
Carbon Dating	"*Age determination of old carbon containing objects (****fossils****) by* ***measuring the radioactivity of C-14 in them*** *is called* ***radio-carbon dating*** *or simply* ***carbon dating****. This is an important method of age determination of old objects"*
Nuclear Fission Reaction	*"A reaction that involves the splitting of heavy nucleus into two or more lighter nuclei with a release of huge amount of energy is called a nuclear fission reaction."*

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. (6×1=6)

1. The p-subshell has:

(A) One orbital (B) Two orbitals (C) Three orbitals (D) Four orbitals

2. Which shell consist of four sub-shells.

(A) K-shell (B) L-shell (C) M-shell (D) N-shell

3 For the treatment of skin cancer isotopes use:

(A) P-32 (B) Sr-90 (C) Both A and B (D) Co-60

4. Who discovered electron?

(A) J.J Thomson (B) Goldstein (C) Chadwick (D) Rutherford

5. The ratio of mass of proton to mass of electron is:

(A) 1:1840 (B) 1840:1 (C) 1:1480 (D) 1480:1

6. d-subshell can accommodate electrons:

(A) 2 (B) 6 (C) 10 (D) 14

Q.2 Give short answers to the following questions. (5×2=10)

(i) How does electron differ from neutron?

(ii) What is meant by angular momentum?

(iii) Write down electronic configuration of Cl^- and Al^{3+}.

(iv) Why does an electron first fill 2p orbital and than 3s orbital?

(v) Give defects of Rutherford Atomic Model.

Q.3 Answer the following questions in detail. (5+4=9)

(i) How Bohr proved that an atom must exist? (5)

(ii) How are Cathode rays produced? What are their four major characteristics? (4)

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.