UNIT 18

ATOMIC AND NUCLEAR PHYSICS

18.1 ATOM AND ATOMIC NUCLEUS
18.2 NATURAL RADIOACTIVITY
18.3 BACKGROUND RADIATIONS

LONG QUESTIONS

Q.1 What is meant by natural radioactivity? Explain how it is discovered and how radiations are identified? *(K.B+A.B+U.B)* **(GRW 2013, DGK 2017)**

Ans: **NATURAL RADIOACTIVITY**

Definition:

"The spontaneous emission of radiation by unstable nuclei is called natural radioactivity. And the elements which emit such radiations are called radioactive elements**"**.

Discovery of Becquerel:

In 1896, Becquerel accidentally discovered that uranium salt crystals emit an invisible radiation that can darken a photographic plate. He also observed that the radiation had the ability to ionize a gas. Subsequent experiments by other scientists showed that other substances also emitted radiations.

Contribution of Marie Curie:

The most significant investigations of this type were conducted by Marie Curie and her husband Pierre. They discovered two new elements which emitted radiations. These were named polonium and radium. This process of emission of radiations by some elements was called natural radioactivity by Marie Curie.

Subsequent experiments performed by Henri Becquerel suggested that radioactivity was the result of the decay or disintegration of unstable nuclei.

International symbol that indicates an area where radioactive material is being handled or produced.

Forms of Radiations:

There are three types of radiations usually emitted by a radioactive substance. These are:

- Alpha (α) particle
- Beta (β) particles
- Gamma (γ) rays

Identification of Radiations:

If the radioactive source is placed inside the magnetic field. The radiation emitted from the source splits into three components: α and β-radiations bend in opposite direction in the magnetic field while Gamma γ-radiation does not change its direction.

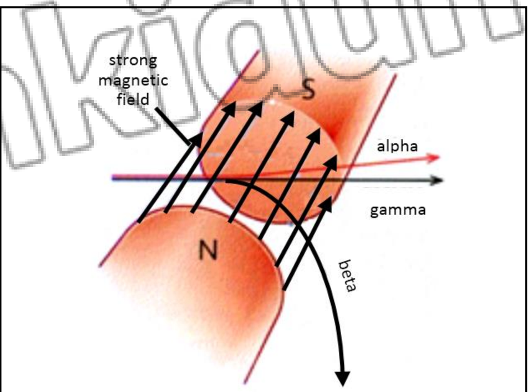


Figure: **Schematic Diagram of Types of Radiations**

18.1, 18.2, 18.3 SHORT QUESTIONS

Q.1 What do you know about atom? *(K.B)* **(For your information Pg. # 175)**

Ans: **ATOM**

The word atom is derived from the Greek word "atomos", meaning "Indivisible". At one time, atoms were thought to be the smallest particles of matter but currently we define atom as composite systems and contain even smaller particles: protons, neutrons and electrons.

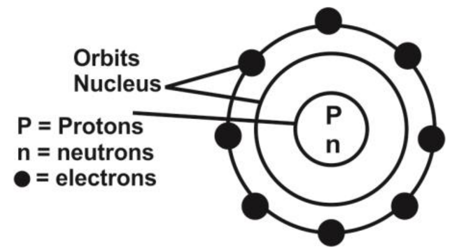


Figure: **Structure of Atom**

Q.2 What do know about discovery of an atom? *(K.B)*

Ans: **DISCOVERY OF AN ATOM**

Scientists were always interested to know the smallest particle of matter. Greek Philosopher Democritus in 585 BC postulated that matter is built from small particles called atoms. The atom means indivisible in Greek language.

Q.3 What do you know about the placement of atomic particles in an atom? *(K.B)*

Ans: **NUCLEUS**

Rutherford in 1911, discovered that atom had a central part called the nucleus.

He also discovered that the positive charge in an atom was concentrated in a small region called nucleus. The nucleus contains protons and neutrons which are collectively called nucleons. Atom also contains electrons which revolve in nearly circular orbits about the positively charged nucleus.

Q.4 What are nucleons? *(K.B)*

Ans: **NUCLEONS**

Definition:

"The nucleus contains protons and neutrons which are collectively called nucleons".

Example:

Nuclide of carbon atom has 6 protons and 6 neutrons.

The number of nucleons is 6 + 6 = 12

Q.5 What is atomic number? *(K.B)*

Ans: **ATOMIC NUMBER**

Definition:

"The atomic number Z is equal to the number of protons in the nucleus".

Example:

Nuclide of carbon atom has 6 protons.

Atomic number of carbon $Z = 6$

Representation:

It is represented by Z.

Q.6 What is neutron number? *(K.B)*

Ans: **NEUTRON NUMBER**

Definition:

"The neutron number N is equal to the number of neutrons in the nucleus".

Example:

Nuclide of Carbon atom has 6 neutrons.
Neutron number of Carbon $N = 6$

Representation:

It is represented by N.

Q.7 What is atomic mass number? *(K.B)*

Ans: **ATOMIC MASS NUMBER**

Definition:

"The atomic mass number is equal to the number of nucleons (protons + neutrons) in the nucleus".

Formula:

$A = Z + N$.

Example:

Nuclide of carbon atom has 6 protons and 6 neutrons.
Atomic number of carbon $Z = 6$
Neutron number of carbon $N = 6$
Atomic Mass number of carbon $A = Z + N$
Atomic Mass number of carbon $A = 6 + 6$
Atomic Mass number of carbon $A = 12$

Representation:

It is represented by A.

Q.8 How an atom is represented? *(K.B)*

Ans: **REPRESENTATION**

Generally an atom is represented by the symbol ${}_{Z}^{A}X$.

Example:

Nuclide of hydrogen atom having only one proton is ${}_{1}^{1}H$.

Q.9 Compare the mass of different atomic particles with atom. *(K.B)*

Ans: **COMPARISON**

The mass of neutron is nearly equal to that of proton. But proton is about 1836 times heavier than an electron. So the mass of an atom is nearly equal to the sum of masses of protons and neutrons.

Q.10 What is the difference between atomic number and atomic mass number? Give a symbolical representation of a nuclide. *(K.B)* **(Review Question 18.1)**

Ans: **DIFFERENTIATION**

The differences between atomic number and atomic mass number is:

Atomic number	Atomic Mass number
Definition	
• The atomic number is equal to the number of protons in the nucleus.	• The atomic mass number is equal to the number of nucleons (protons + neutrons) in the nucleus.
Representation	
• It is denoted by Z.	• It is denoted by A.
Formula	
• $Z = A - N$	• $A = Z + N$

Q.11 Define isotopes with an example. ***(K.B)*** **(MTN 2017, RWP 2017, FSD 2017)**

Ans: **ISOTOPES**

Definition:

"Isotopes are atoms of an element which have same number of protons but different number of neutrons in their nuclei**"**.

Example:

There are three isotopes of hydrogen.

Protium ($^{1}_{1}H$):

Protium contains one proton in the nucleus and one electron that revolves around the nucleus.

Deuterium ($^{2}_{1}H$):

Deuterium contains one proton, one neutron and one electron.

Tritium ($^{3}_{1}H$):

Tritium contains one proton, two neutrons and one electron.

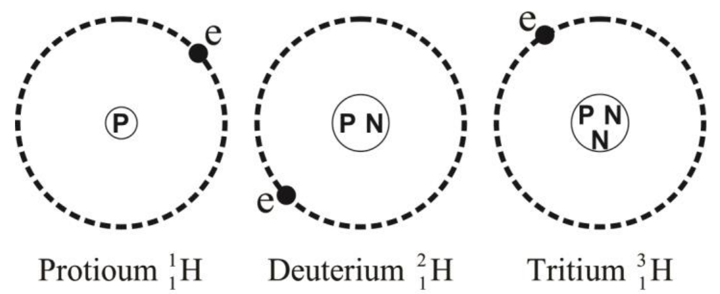


Figure: Isotopes of Hydrogen

Q.12 Define natural radioactivity? ***(K.B)*** **(RWP 2016, SHW 2016, 2017)**

Ans: ***Given on Page # 378***

Q.13 What is the contribution of Marie Curie and Pierre? ***(K.B)***

Ans: ***Given on Page # 378***

Q.14 How many types of radiations are emitted by radioactive substance? Name them. ***(K.B)***

Ans: ***Given on Page # 378***

Q.15 Why positively charged proton in nucleus doesn't fly a part in response of huge electrical force of repulsion between them? ***(K.B)*** **(Do you know Pg. #176)**

Ans: **STRONG NUCLEAR FORCE**

The positively charged protons in a nucleus have huge electrical forces of repulsion between them. There is an attractive force between the nucleons called the strong force which holds them together. This force acts over only a very short distance. Without this strong nuclear force, there would be no atoms beyond hydrogen.

Q.16 What is meant by background radiations? ***(K.B)*** **(SGD 2017, MTN 2017, FSD 2016)**

OR What is meant by background radiations? Enlist some sources of background radiations. **(Review Question 18.9)**

Ans: **BACKGROUND RADIATIONS**

Definition:

"Radiations present in atmosphere due to different radioactive substances are called background radiations**"**.

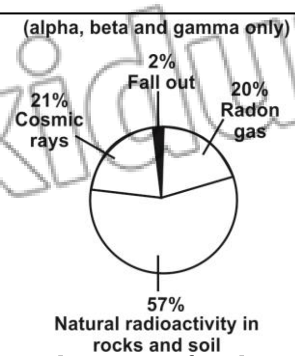


Figure: **The Sources of Background Radiations for Environment**

Everywhere in rocks, soil, water, and air of our planet are traces of radioactive elements. This natural radiation is called the background radiation. It is as much part of our environment as sunshine and rain.

Q.17 What are cosmic radiation? *(K.B)* **(SHW 2016, RWP 2017)**

Ans: **COSMIC RADIATION**

The Earth, and all living things on it also receive radiation from outer space. This radiation is called cosmic radiation which primarily consists of:

- Protons
- Ions
- Alpha particles and larger nuclei.

Q.18 What a secondary radiations? *(K.B)*

Ans: **SECONDARY RADIATIONS**

The cosmic radiation Interacts with atoms in the atmosphere to create a shower of secondary radiation. These include:

- X –Rays
- Muons
- Protons
- Alpha particles
- Electrons
- Neutrons

18.1, 18.2, 18.3 MULTIPLE CHOICE QUESTIONS

1. Matter is built from small particles called: *(K.B)*
(A) Atoms (B) Ions
(C) Radicals (D) Molecules

2. Central part of atom is: *(K.B)*
(A) Nucleus (B) Proton
(C) Electron (D) Neutron

3. Which statement is correct about isotopes? *(K.B)*
(A) Atoms of an element have same number of protons.
(B) Atoms of an element have different number of neutrons in their nuclei
(C) Protium, deuterium and tritium are isotopes of hydrogen
(D) All of above

4. The mass of the proton and neutron is nearly equal to: *(K.B)*
(A) 1.67×10^{-27} kg (B) 1.67×10^{-31} kg
(C) 1.67×10^{-19} kg (D) 1.67×10^{-21} kg

5. A nucleon is _________ times heavier than electron. ***(K.B)***
(A) 1827 (B) 1836
(C) 1841 (D) 1832

6. The total number of nucleons in a nucleus is: ***(K.B)***
(A) Atomic number (B) Atomic mass number
(C) Isotope number (D) None of these

7. The total number of protons in a nucleus or total number of electrons in the orbits is: ***(K.B)***
(A) Atomic number (B) Atomic mass number
(C) Isotope number (D) None of these

8. The atomic number is represented by: ***(K.B)***
(A) A (B) Z
(C) N (D) None of them

9. The number of neutrons in a nucleus is represented by: ***(K.B)***
(A) A (B) Z
(C) N (D) None of them

10. The number of protons and neutrons in a nucleus or atomic mass is represented by: ***(K.B)***
(A) A (B) Z
(C) N (D) None of them

11. Atoms of the element which have same number of protons but different number of neutrons are: ***(K.B)***
(A) Isotopes (B) Nuclide
(C) Both a & b (D) None

12. Rutherford discovered that the positive charge in an atom was concentrated in a small region called: ***(K.B)***
(A) Atom (B) Nucleus
(C) Molecule (D) Shell

13. ___________ are collectively called nucleons. ***(K.B)***
(A) Protons in nucleus (B) Electrons in shell
(C) Protons and neutrons in nucleus (D) Neutrons in nucleus

14. In which simplest atom, nucleus has only one proton? ***(K.B)***
(A) Helium (B) Carbon
(C) Nitrogen (D) Hydrogen

15. Generally an atom is represented by the symbol: ***(K.B)***
(A) $^{A}_{B}X$ (B) $^{A}_{Z}X$
(C) $^{Z}_{A}X$ (D) $^{A}_{0}X$

16. In nuclide $^{13}_{6}X$ the number of protons are: ***(K.B)***
(A) 3 (B) 10
(C) 8 (D) 6

17. Isotopes of an element have the same: ***(K.B)***
(A) Chemical properties (B) Atomic number
(C) Atomic mass number (D) Colures

18. Tritium contains one proton, while protium and deuterium contains: *(K.B)*

(A) Two protons (B) Three protons
(C) One proton (D) No proton

19. Size of electron is: *(K.B)* **(For your information Pg. # 176)**

(A) < 10^{-18}m (B) 10^{-15}m
(C) 10^{-14}m (D) 10^{-10}m

20. Size of atom is: *(K.B)* **(For your information Pg. # 176)**

(A) < 10^{-18}m (B) 10^{-15}m
(C) 10^{-14}m (D) 10^{-10}m

21. Size of nucleus is: *(K.B)* **(For your information Pg. # 176)**

(A) < 10^{-18}m (B) 10^{-15}m
(C) 10^{-14}m (D) 10^{-10}m

22. Who accidentally discovered that uranium salt crystals emit an invisible radiation that can darken a photographic plate? *(K.B)*

(A) Becquerel (B) Marie Curie
(C) Pierre (D) Rutherford

23. How many types of radiation are emitted by radioactive substance? *(K.B)*

(A) 1 (B) 2
(C) 3 (D) 5

24. Which radiation does not change its direction? *(K.B)*

(A) α-radiation (B) β-radiation
(C) γ-radiation (D) None of them

25. The Earth and all living things receive radiation from outer space: *(K.B)*

(A) X- rays (B) Cosmic rays
(C) Radon gas (D) None of these

26. Radiation present in atmosphere due to different radioactive substances: *(K.B)*

(A) Background radiation (B) α - radiation
(C) β- radiation (D) γ - radiation

EXAMPLE 18.1

Find the number of protons and neutrons in the nuclide defined by $^{13}_{6}X$ (BWP 2016) *(U.B+A.B)*

Solution:

Given data:

$$\text{Atomic number} = Z = 6$$
$$\text{Atomic mass} = A = 13$$

To Find:

Number of proton = ?
Number of neutron = ?

Calculation:

$$\text{Atomic number} = \text{Number of proton}$$
$$\text{Atomic Mass} = \text{No. of Proton} + \text{No. of Neutron}$$
$$13 = 6 + \text{Number of neutron}$$
$$\text{Number of neutron} = 13 - 6 \Rightarrow 7$$

Result:

Hence, number of neutrons are 7 and number of protons are 6.

18.4 NUCLEAR TRANSMUTATIONS

LONG QUESTIONS

Q.1 Define nuclear transmutation? Explain the radioactive decay of nuclide. *(K.B+U.B+A.B)*

OR Discuss alpha (α) – decay. Give its general equation and example. **(SHW 2016, SGD 2017)**

OR Discuss beta (β) – decay. Give its general equation and example. **(RWP 2017)**

OR What are the three basic radioactive decay processes and how do they differ from each other? **(Review Question 18.4)**

Ans: **NUCLEAR TRANSMUTATIONS**

Definition:

"The spontaneous process in which a parent unstable nuclide changes into a more stable daughter nuclide with the emission of radiations is called nuclear transmutation**"**.

Introduction:

During natural radioactivity an unstable nucleus of radioactive element disintegrates to become more stable.

Representation:

Radioactive decay by means of a nuclear equation in which an unstable parent nuclide *X* changes into a daughter nuclide *Y* with the emission of an alpha particle, beta particle or gamma particle are given as under.

Alpha (α) –decay:

$${}^{A}_{Z}X_{N} \longrightarrow {}^{A-4}_{Z-2}Y_{N-2} + {}^{4}_{2}He_{2} + \text{Energy}$$

parent nuclide — daughter nuclide — $\alpha-$particle

Example:

$${}^{226}_{88}Ra_{138} \longrightarrow {}^{222}_{86}Rn_{136} + {}^{4}_{2}He_{2} + \text{Energy}$$

radium — radon — $\alpha-$particle

It means in alpha decay, the proton number or atomic number *Z* of the parent nuclide reduces by 2 and its mass number or nucleon number A decreases by 4.

Beta (β) –decay:

$${}^{A}_{Z}Z_{N} \longrightarrow {}^{A}_{Z+1}Y_{N-1} + {}^{0}_{-1}e_{+1} + \text{Energy}$$

parent nuclide — daughter nuclide — $\beta-$particle

Example:

$${}^{14}_{6}C_{8} \longrightarrow {}^{14}_{7}N_{7} + {}^{0}_{-1}e_{+1} + \text{Energy}$$

carbon — nitrogen — $\beta-$particle

In beta (β)-decay, the parent nuclide has its proton number *Z* increased by 1 but its mass number or nucleon number *A* remains unchanged.

Gamma (γ) –decay:

$${}^{A}_{Z}X^{\star} \longrightarrow {}^{A}_{Z}X + \gamma$$

parent nuclide — daughter nuclide — gamma rays

Example:

$${}^{60}_{27}Co^{\star} \longrightarrow {}^{60}_{27}Co + {}^{0}_{0}\gamma + \text{Energy}$$

cobalt — cobalt — $\gamma-$rays

Gamma rays are usually emitted alongwith either an alpha or a beta particle.

18.4 SHORT QUESTIONS

Q.1 Define nuclear transmutation? *(K.B)* **(MTN 2017, BWP 2016, FSD 2016)**

Ans: ***Given on Page # 385***

Q.2 How a helium atom is formed? *(K.B)* **(Physics Insight Pg. # 178)**

Ans: **FORMATION OF HELUUM ATOM**

When alpha and beta particle are slowed down by collisions, they becomes harmless. In fact, they combine to form neutral helium atoms.

Q.3 Define ionization? *(K.B)* **(MTN 2016)**

Ans: **IONIZATION**

Definition:

"The phenomenon by which radiations split matter into positive and negative ions is called Ionization**".**

All three kinds of radiations i.e. alpha, beta and gamma can ionize the matter.

Alpha Particles:

Alpha particles have the greatest power of ionization as compared to beta particles and gamma rays. It is due to large positive charge and large mass of alpha particles.

Beta Particles:

Beta particles ionize a gas much less than alpha particles do.

Gamma Rays:

The Ionization power of gamma rays is even less than that of beta particles. Ionization of three radiations in gas.

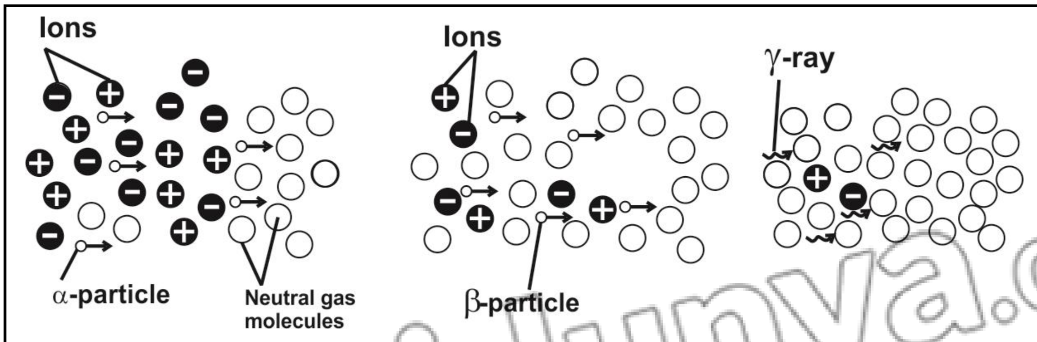


Figure: Ionizing Effect of Radiations

Q.4 What is meant by penetrating ability? *(K.B)* **(FSD 2016, BWP 2017, DGK 2017, RWP 2016)**

Ans: **PENETRATING ABILITY**

The strength of radiations to penetrate a certain material is called penetrating power.

Alpha (α) Particles:

The alpha particles have the shortest range because of its strong interacting or ionizing power.

Beta (β) Particles:

The beta particles have more penetration power than alpha particles and they have less ionizing power than alpha particles.

Gamma (γ) Rays:

The gamma rays can penetrate a considerable thickness of concrete. It is due to their large speed and neutral nature.

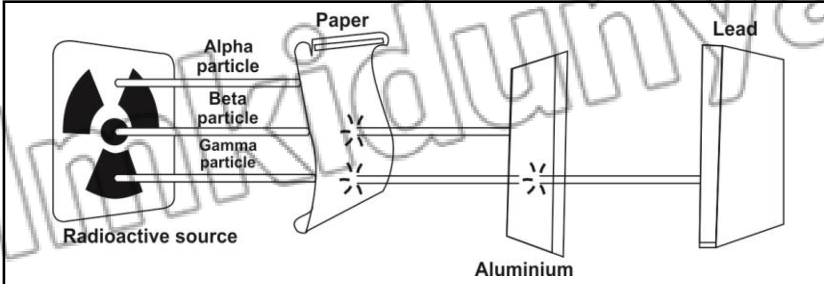


Figure: Penetrating Power of Radiations

Q.5 Why alpha decay occurs in element having atomic number greater than 82? *(C.B)*

Ans: Alpha decay generally occurs in element having greater number of proton and neutron means which has high atomic mass and atomic number. The proton and neutron repel themselves by electromagnetic force and they live together in nucleus due to strong force. Both these forces balance each other and responsible for stability of element but when atomic mass of element increase it means that its electromagnetic forces becomes stronger and strong force become weak. Due to this effect alpha decay happens and the atomic mass of element decrease.

Q.6 Why only Helium-4 nucleus emit during alpha decay but not the isotopes of hydrogen or other element? *(C.B)*

Ans: In alpha decay helium-4 nucleus has two neutron and two proton so its binding energy is maximum because it has magic number 2 Proton and 2 Neutron. But isotopes of hydrogen and other element do not have high binding energy that is why when element having high atomic number and atomic mass decay it emit alpha particle (helium-4).

Q.7 Write any two properties of alpha particles. *(K.B)* **(SGD 2016)**

Ans: **PROPERTIES OF ALPHA PARTICLES**

The properties of alpha particles are as follows:

- Positively charged particles (helium nuclei), ejected at high speed with a range of only a few centimeters in air.
- They can be stopped by an ordinary sheet of thin aluminum foil.

Q.8 Write any two properties of beta particles. *(K.B)* **(MTN 2016)**

Ans: **PROPERTIES OF BETA PARTICLES**

The properties of beta particles are as follows:

- Streams of high – energy electrons, ejected at various speed as high as close to the speed of light.
- Beta particles may be able to penetrate several millimeters of aluminum.

Q.9 What is beta decay? *(C.B)*

Ans: Beta decay in nuclear transmission is decay in which a neutron change into proton, an electron, and an uncharged particle, almost massless relative of the electron called an antineutrino and a proton change into neutron and positron and a neutrino. There are two types of beta decay, **positive beta decay and negative beta decay. *(C.B +A.B)***

Q.10 Define positive beta decay?

Ans: The beta decay in which a proton change into neutron and formed a positron and a neutrino particle. Due to positive beta decay the atomic number of element decrease by one but atomic mass remains same because neutron increase by one. .

$$^{A}_{Z}X_{N} \rightarrow {}^{A}_{Z-1}X_{N+1} + e^{+} + \nu_e(\text{neutrino})$$

$$p \rightarrow n + e^{+} + \nu_e$$

Q.11 Define negative beta decay? *(C.B)*

Ans: The decay in which a neutron change into proton and formed a electron and an antineutrino particle. Due to negative beta decay the atomic number of element increase by one but atomic mass remains same because neutron decease by one.

$$^{A}_{Z}X_{N} \rightarrow {}^{A}_{Z+1}X_{N-1} + e^{-} + \bar{\nu}_{e}\text{(Antineutrino)}$$

$$n \rightarrow p + e^{-} + \bar{\nu}_{e}$$

Q.12 Write any two properties of gamma rays. *(K.B)* **(BWP 2016, DGK 2016, FSD 2016)**

Ans: **PROPERTIES OF GAMMA RAYS**

The properties of gamma rays are as follows:

- Electromagnetic radiations of very short wavelength.
- High – energy gamma rays can penetrate at least 30 cm of lead or 2 km of air.

Q.13 Write the ranges of radiations in air. *(K.B)*

Ans: **RANGE OF RADIATIONS**

Alpha (α) Particles:

Alpha particle has a range of only a few centimeters in air.

Beta (β) Particles:

Beta particles have range of several meters in air.

Gamma (γ) Rays:

Gamma rays have a range of several hundred meters in air.

Q.14 What is the commonly used unit of radioactivity? *(K.B)* **(For your information Pg. # 178)**

Ans: **UNIT OF RADIOACTIVITY**

The SI unit of radioactivity is the Becquerel, Bq. In SI bass units, 1 Bq = 1 disintegration per second (dps). This is a very small unit.

Example:

1.0 g of radium has an activity of 3.73×10^{10} Bq. Therefore, the kilo Becquerel (kBq) and the mega Becquerel (MBq) are commonly used. The activity of 1.0 g of radium is 3.73×10^{4} MBq.

Q.15 Write a note on nature of radiations. *(K.B)*

Ans. **NATURE OF RADIATIONS**

Alpha (α) Particles:

Alpha particle is a helium nucleus comprising of two protons and two neutrons with a charge of 2e.

An unstable nucleus with large protons and neutrons may decay by emitting alpha radiations.

Beta (β) Particles:

Beta radiation is a stream of high-energy electrons. An unstable nuclei with excess of neutrons may eject beta radiations.

Gamma (γ) Rays:

Gamma radiations are high energy light protons. They are electromagnetic radiations of very high frequency (short wavelength) emitted by the unstable excited nuclie.

Q.16 Draw table to show the properties of radiations briefly. *(K.B)*

Ans: **PROPERTIES OF RADIATIONS**

The following table show the properties of radiations.

Three Types of Radiations		
Alpha Particle	**Beta Particle**	**Gamma Ray**
	Charge	
Charge +2	Charge –1	No Charge
	Penetrating power	
Least penetration	Moderate penetration	Highest penetration
	Nuclear Transmutation	
Transmutes nucleus: $A \rightarrow A-4$ $Z \rightarrow Z-2$ $N \rightarrow N-2$	Transmutes nucleus: $A \rightarrow A$ $Z \rightarrow Z+1$ $N \rightarrow N-1$	Transmutes nucleus: $A \rightarrow A$ $Z \rightarrow Z$ $N \rightarrow N$

Q.17 Why the beam of radiation only directed to cancerous cells? ***(A.B)***

(Radiation treatment Pg.# 181)

Ans: RADIATION TREAMENT

Gamma radiations destroy both cancerous cells and healthy cells. Therefore, the beam of radiation must be directed only at cancerous cells.

Example:

During brain radiotherapy, patient is carefully positioned in the helmet to ensure that the gamma rays converge at the desired point in the brain. A lead apron protects the body from exposure to radiation.

18.4 MULTIPLE CHOICE QUESTIONS

1. **Transmutation is:** ***(K.B)***
   (A) Unstable nuclei changes into more stable nuclei
   (B) Spontaneous process
   (C) Both A and B
   (D) Non spontaneous process
2. **Complete the equation** $^{226}_{85}\text{Ra} \rightarrow ^{222}_{86}\text{Rn} + ?$ **+ energy:** ***(U.B)***
   (A) $^{0}_{-1}e$ (B) $^{14}_{17}\text{N}$
   (C) $^{4}_{2}\text{H}_{e}$ (D) $^{A}_{z}\text{Y}$
3. $^{14}_{6}\text{C} \rightarrow ? + ^{0}_{-1}\text{e} +$ **Energy:** ***(U.B)***
   (A) $^{0}_{-1}\text{e}$ (B) $^{4}_{2}\text{He}$
   (C) $^{14}_{6}\text{e}$ (D) $^{14}_{7}\text{N}$
4. $^{60}_{27}\text{Co} \rightarrow ^{60}_{27}\text{CO} + ^{0}_{0}\gamma$ **+ Energy this equation shows emission of:** ***(U.B)***
   (A) β-particles (B) Alpha particles
   (C) Gamma particles (D) None of these
5. **SI unit for radioactivity is:** ***(K.B)***
   (A) Becquerel (B) Candela
   (C) Mole (D) Ampere

6. 1 Bq = ? *(K.B)*

(A) 1 disintegration per second (dps) (B) ms^{-1}

(C) ms^{-2} (D) All of them

7. Charge on alpha particles is: *(K.B)*

(A) 2e (B) 3e

(C) 4e (D) 5e

8. Stream of high energy electrons: *(K.B)*

(A) β-particles (B) α-particles

(C) γ-particles (D) Σ-particles

9. Gamma rays are also called: *(K.B)*

(A) Photons (B) Electrons

(C) Protons (D) Positrons

10. Which have the greatest power of ionization as compared to others? *(K.B)*

(A) β-particles (B) α-particles

(C) γ-particles (D) x-rays

11. Penetrating power of γ rays as compared to α rays and β rays is: *(K.B)*

(A) Greater (B) Smaller

(C) Equal (D) All of these

12. The phenomenon by which radiations split matter into positive and negative ions is called: *(K.B)*

(A) Ionization (B) Penetration

(C) Sublimation (D) Deflection

13. Which particle has shortest penetrating range? *(K.B)*

(A) α- particle (B) β-particle

(C) γ- particle (D) None of these

18.5 HALF LIFE AND ITS MEASUREMENT

LONG QUESTIONS

Q.1 What do you understand by the half-life of a radioactive elements? Explain with one example. *(K.B+U.B+A.B)*

(LHR 2013, DGK 2016, BWP 2016, MTN 2016, SGD 2016)(Review Question 18.7)

Ans: **HALF-LIFE AND ITS MEASUREMENT**

Definition:

"The **time** during which half of the **unstable radioactive nuclei disintegrate** is called the half-life of the sample of radioactive element**"**.

Every radioactive element has its own characteristic half-life.

Explanation:

Process of radioactivity is random and the rate of radioactive decay is proportional to the number of unstable nuclei present. In the process, a constant fraction of large number of unstable radioactive nuclei decays in a certain time. So the life time of the unstable nuclei is unlimited and is difficult to measure. We can get the idea about decay rate by the term half-life.

Example:

Radium–226 has a half-life of **1620 years**, which means that half of a radium-226 sample will be converted to other elements by the end of 1620 years. In the next 1620 years, half of the remaining radium will decay, leaving only one-fourth the original amount of radium, and so on.

Figure: **Radioactivity of Radium**

Calculation of Half-Life:

If the half-life of the radioactive element is $T_{1/2}$, then at the end of this time the number of atoms in the sample will become half i.e., 1/2. After a time $2T_{1/2}$, i.e., after second half-life period, the number of remaining atoms will become $\frac{1}{2}.\frac{1}{2} = \frac{1}{2}^2 = \frac{1}{4}$, after a time **3** $T_{1/2}$, the number of remaining atoms left will be $\frac{1}{2}.\frac{1}{2}.\frac{1}{2} = \frac{1}{2}^3 = \frac{1}{8}$, and at the end of '$tT_{1/2}$' number of atoms that remain will be $\frac{1}{2}^t$.

Calculation of Amount of Sample:

If N_0 is the original number of atoms in the sample of radioactive element, then after '**t**' half-lives number of atoms left in the sample can be determined by using the relation,

$$\text{Remaining atoms} = \text{Original atoms } \frac{1}{2}^t$$

Or

$$N = N_0 \times \frac{1}{2}^t$$

Dependence:

The process of radioactivity does not depend upon the chemical combinations or reactions. It is also not affected by any change in physical conditions like temperature, pressure, electric or magnetic fields.

18.5 SHORT QUESTIONS

Q.1 Define half-life. With an example. *(K.B)* **(FSD 2016, SGD 2017)**

Ans: *Given on Page # 392*

Q.2 What is the unit of nuclear radiation? *(K.B)* **(For your information Pg. # 180)**

Ans: **UNIT OF NATURAL RADIATION**

Nuclear radiations is measured in units of roentgen equivalent man (rem), a unit of equivalent dose.

Q.3 What is the safe limit of X-rays for a patient? *(K.B)* **(For your information Pg. # 180)**

Ans: **SAFE LIMIT OF X – RAYS**

Patient should be exposed to X – rays with the limit of 0.1 to 1.0 rem.

Q.4 What is the safe limit of radiations per year? *(K.B)* **(For your information Pg. # 180)**

Ans: **SAFE LIMIT OF RADIATIONS PER YEAR**

The safe limit of radiations exposure is 5.0 rem per year.

Q.5 How long will take for complete decay of pure element? *(K.B)*

(Physics Insight Pg. # 180)(MTN 2017)

Ans: **COMPLETE DECAY OF PURE ELEMENT**

A half – life is the time a radioactive element takes for half of a given number of nuclei to decay. During a second half – life, half of the remaining nuclei decay, so in two half – lives, three quarters of the original material has decayed, not all of it.

Q.6 Enlist half-lives of some isotopes? (K.B)
OR Write half – life of Hydrogen, Lead, Uranium, Carbon. **(BWP 2017)**
Ans: Half-lives of some isotopes are:

Element	Isotope	Half-Life	Radiation Produced
Hydrogen	${}_{0}^{1}H$	12.3 years	β
Carbon	${}_{6}^{14}C$	5730 years	β
Cobalt	${}_{6}^{14}C$	30 years	β,γ
Iodine	${}_{53}^{131}I$	8.07 days	β,γ
Lead	${}_{82}^{212}Pb$	10.6 hours	β
Polonium	${}_{84}^{194}Po$	0.7 seconds	α
Polonium	${}_{84}^{210}Po$	138 days	α,γ
Uranium	${}_{92}^{235}U$	7.1×10^{8} years	α,γ
Uranium	${}_{92}^{238}U$	4.51×10^{9} years	α,γ
Plutonium	${}_{94}^{236}Pu$	2.85 years	α
Plutonium	${}_{94}^{242}Pu$	3.79×10^{5} years	α,γ

18.5 MULTIPLE CHOICE QUESTIONS

1. **Radium-226 has a half-life of: *(K.B)***
   (A) 1820 years (B) 1920 years
   (C) 1620 years (D) 1600 years
2. **The rate of radioactive decay is proportional to the number of: *(U.B)***
   (A) Stable nuclei present (B) Unstable nuclei present
   (C) Electrons present (D) Protons present
3. **High energy gamma rays can penetrate at least _________ of air. *(K.B)***
   (Characteristic of radiation Pg. #180)
   (A) 1 km (B) 2 km
   (C) 3 km (D) 4 km
4. **Nuclear radiation is measured in: *(K.B)*** **(For your information Pg. #180)**
   (A) rem (B) dps
   (C) As (D) Pa

EXAMPLE 18.2

The activity of a sample of a radioactive bismuth decreases to one – eight of its original activity in 15 days. Calculate the half – life of the sample. *(U.B+A.B)*

<u>Solution</u>:

Let $T_{1/2}$ is the half – life and A_0 is the original activity of the sample. After time $T_{1/2}$ activity will be $A_0/2$. After $2T_{1/2}$ activity will become ½. $A_0/2 = A_0/4$. While after time $3T_{1/2}$, i.e., after three half – lives, the activity will drop to $A_0/8$. It means activity drops to one – eighth of original activity in a time of $3T_{1/2}$.

Therefore, $3T_{1/2} = 15$. This means half – life $T_{1/2}$ of the sample will be 5 days. .

EXAMPLE 18.3

A radioactive element has a half – life of 40 minutes. The initial count rate was 1000 per minute. How long will it take for the count rate to drop to (a) 250 per minutes (b) 125 per minutes (c) Plot a graph of the radioactive decay of the element. ***(U.B+A.B)***

Solution:

Given data:

Half-life radioactive elements = 40 minutes

Initial count rate per minute = 1000

To Find:

(a) Drop count rate 250 per minute = ?

(b) Drop count rate 125 per minute = ?

(c) Graph of radioactive decay = ?

Calculation:

The initial count rate is 1000, therefore,

$$1000 \xrightarrow{40\text{ min.}} 500 \xrightarrow{40\text{ min.}} 250 \xrightarrow{40\text{ min.}} 125$$

(a) As clear from above, it takes 2 half – lives for the count rate to decrease from 1000 to 250 per min, hence

Time taken = 2 × 40 min. = 80 min.

(b) It takes 3 half – lives for the count rate to decrease from 1000 to 125 per min, hence

Time taken = 3 × 40 min. = 120 min = 2 h

(c) Graph is shown as under:

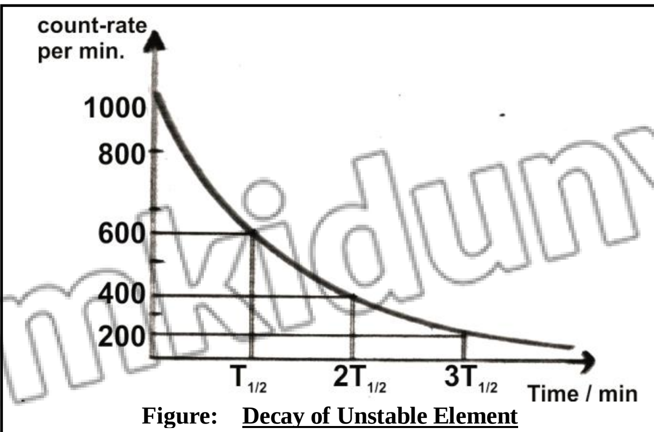


Figure: Decay of Unstable Element

Result:

Hence, it will take 80 minute for count rate to drop 250 per minutes and it will take 2 h for count rate it drop 125 per minutes.

18.6 RADIOISOTOPES AND THEIR USES

LONG QUESTIONS

Q.1 Describe stable and unstable nuclide with examples of radioisotopes.*(K.B+U.B+A.B)*

Ans: **STABLE AND UNSTABLE NUCLIDE**

Definition:

"The stable and non-radioactive elements can also be changed into radioactive elements by bombarding them with protons, neutrons or alpha particles. Such artificially produced radioactive elements are called radioactive isotopes or radioisotopes**"**.

Example:

Examples of radioisotopes production are:

Bombardment of Neutron:

- $^{1}_{0}n + {}^{23}_{11}Na \longrightarrow {}^{24}_{11}Na +$ Gamma (γ) rays

  neutron, stable sodium nuclide, a sodium radioisotope

Bombardment of Alpha Particle:

- $^{4}_{2}He + {}^{27}_{13}AI \longrightarrow {}^{30}_{15}P + {}^{1}_{0}n$

  alpha particle, stable aluminum nuclide, a phosphorous radioisotope

Radioisotopes:

Nuclei which do not emit radiations naturally are called stable nuclei. In general most of the nuclei with atomic number **1** to **82** are stable nuclei. While the elements whose atomic number is greater than **82** are naturally unstable. They emit different types of radiations all the time, and hence continuously change from one type of element to another.

Q.2 Describe the uses of radioisotopes with its applications in different fields? *(A.B)*

(LHR 2015, FSD 2016, SHW 2016)

Ans: **USES OF RADIOISOTOPES**

Radioisotopes are frequently used in medicine, industry and agriculture for variety of useful purposes.

Applications:

Following are few applications of radioisotopes in different fields.

1. **Tracers:**

Uses in Medical Field:

- Radioactive tracers are chemical compounds containing some quantity of radioisotope.
- They can be used to explore the metabolism of chemical reactions inside the human body, animal or plant.
- Radioisotopes are used as tracers in medicine, industry and agriculture.
- For example, radio iodine-131 readily accumulates in the thyroid gland and can be used for the monitoring of thyroid functioning.
- For the diagnosis of brain tumor phosphorous-32 is used.
- The malignant part of the body absorbs more quantity of Isotopes, and this helps in tracing the affected part of the body.

Uses in Industry:

- In industry tracers can be used to locate the wear and tear of the moving parts of the machinery.
- They can be used for the location of leaks in underground pipes.
- By introducing a suitable radioactive tracer into the pipe, the leak can be conveniently traced from higher activity in the region of crack in the pipe.

Uses in Agriculture:

- In agriculture radio phosphorous-32 is used as a tracer to find out how well the plants are absorbing the phosphate fertilizer which is crucial to their growth.
- To check the action of a fertilizer, researchers combine a small amount of radioactive material with the fertilizer and then apply the combination to a few plants. The amount of radioactive fertilizer taken up by the plants can be easily measured with radiation detectors.

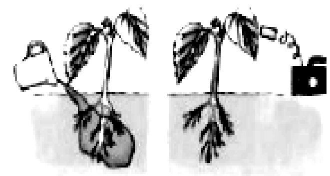


Figure: Study of Action of Fertilizers

2. **Medical Treatment:**

- Radioisotopes are also used in nuclear medicines for curing various diseases.
- Radioactive **cobalt-60** is used for curing cancerous tumors and cells. The radiations kill the cells of the malignant tumor in the patient.

3. **Carbon Dating:** **(DGK 2016, BWP 2016, SHW 2016)**

Radioactive carbon-14 is present in small amount in the atmosphere. Live plants use carbon dioxide and therefore become slightly radioactive.

When a tree dies, the radio carbon-14 present inside the plant starts decaying. Since the half-life of carbon-14 is 5730 years, the age of a dead tree can be calculated by comparing the activity of carbon-14 in the live and dead tree.

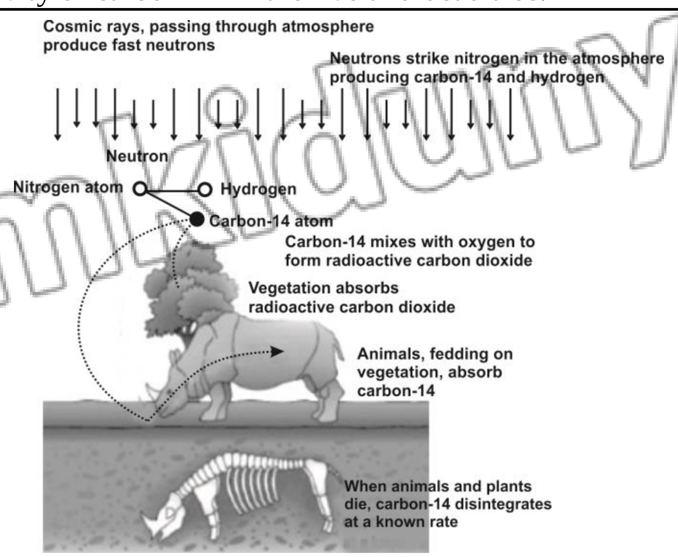


Figure: Carbon Cycle

The activity of the live tree remains almost constant as the carbon-14 is being replenished while the carbon-14 in the dead tree is no more replenished. Therefore, by measuring the activity in the ancient relic, scientists can estimate its age.

Estimation of Age of Geological Specimens:

Other radioisotopes are also used to estimate the age of geological specimens.

- Some rocks contain the unstable potassium isotope *K*-40. This decays to the stable argon nuclide *Ar*-40 with half-life of 2.4×10^8 years.
- The age of rock sample can be estimated by comparing the concentrations of *K*-40 and *Ar*-40.

18.6 SHORT QUESTIONS

Q.1 What are radioisotopes? *(K.B)*

Ans: ***Given on Page # 394***

What are stable nuclides? *(K.B)*

Ans: ***Given on Page # 394***

Q.2 What are unstable nuclides? *(K.B)*

Ans: ***Given on Page # 394***

Q.3 Differentiate between stable and unstable nuclides? *(K.B)* **(SGD 2017)**

Ans: **DIFFERENTIATION**

The differences between stable and unstable nuclides are as follows:

Stable Nuclei	Unstable Nuclei
Definition	
• Nuclei which do not emit radiations naturally are called stable nuclei.	• Nuclei which emit radiations naturally are called unstable nuclei.
Atomic numbers of stable and unstable nuclei	
• Most of the nuclei whose atomic number is from 1 to 82 are stable nuclei.	• The elements, whose atomic number is greater than 82, are naturally unstable.
Variation	
• They do not change from one type of element to another.	• They continuously change from one type of element to another.

Q.4 What is a radioactive tracer? *(K.B)*

Ans: ***Given on Page # 394***

Q.5 How can radioactivity help in the treatment of cancer? *(A.B)*

Ans: ***Given on Page #*** 394

Q.6 How a radioisotope can be used to determine the effectiveness of fertilizer? *(A.B)*

Ans: ***Given on Page #395***

Q.7 Write uses of radioisotopes. *(A.B)*

Ans: ***Given on Page # 395***

Q.8 Write uses of tracers. *(A.B)*

Ans: ***Given on Page # 394***

MULTIPLE CHOICE QUESTIONS

1. Stable nuclei have atomic number between: *(K.B)*

(A) 1 – 82 (B) 2 – 89
(C) 2 – 88 (D) 2 – 85

2. Elements are naturally unstable having atomic number greater than: *(K.B)*

(A) 84 (B) 89
(C) 82 (D) 88

3. $^{4}_{2}\mathrm{He} + ^{27}_{13}\mathrm{Al} \longrightarrow ? + ^{1}_{0}\mathrm{n}$ ***(K.B)***

(A) $^{24}_{11}Na$ (B) $^{30}_{15}P$
(C) $^{23}_{11}Na$ (D) $^{24}_{13}Na$

4. Which chemical compounds containing some quantity of radioisotope? *(K.B)*

(A) Radioactive tracer (B) Hard compounds
(C) High energy compounds (D) Soft compounds

5. Which compound readily accumulates in the thyroid gland and can be used for monitoring of thyroid functioning? *(A.B)*

(A) I – 131 (B) I – 130
(C) I – 132 (D) I – 129

6. Which compound is used for diagnosis of brain tumor? *(A.B)*

(A) Phosphorus -32 (B) Iodine -131
(C) Hydrogen-3 (D) Neon -152

7. Radioactive isotope is used for curing cancerous tumors and cells: *(A.B)*

(A) P -32 (B) I-131
(C) C-14 (D) Co-60

8. When a tree dies radioactive isotope present in plant starts decaying? *(A.B)*

(A) C -14 (B) P - 32
(C) I - 131 (D) Co - 60

9. The half –life of C-14 is: *(K.B)* **(LHR 2015)**

(A) 5720 years (B) 5730 years
(C) 5700 years (D) 5202 years

10. The half-life of stable *Ar*-40 is: *(K.B)*

(A) 2.4×10^{8} years (B) 2.9×10^{4} years
(C) 2.5×10^{9} years (D) 2.4×10^{11} years

11. Half-life of plutonium $\left(^{236}_{96}\mathrm{Pu}\right)$ is 2.85 years and $^{242}_{94}\mathrm{Pu}$ is: *(K.B)* **(LHR 2014)**

(A) 3.79×10^{5} years (B) 7.1×10^{8} years
(C) 2.85 years (D) 7.1×10^{10} years

12. Half-life of $^{60}_{27}Co$ is: *(K.B)*

(A) 20 years (B) 40 years
(C) 50 years (D) 30 years

EXAMPLE 18.4

The C-14:C-12 ratio in a fossil bone is found to be 1/4th that of the ratio in the bone of a living animal. The half-life of C-14 is 5730 years. What is the approximate age of the fossil? ***(U.B+A.B)***

Solution:

Given data:

C = 14: C – 12 ratio in fossil bone = 1/4th
Half-life of C-14 = 5730 years

To Find:

Approximate age of fossil = ?

Calculation:

Ratio has been reduced by factor of 4. Therefore, two half-life have passed.
Approximate age of fossil = 2 × 5730 = 11460 years

Result:

Hence, approximate age of fossil is 11460 years.

18.7 FISSION REACTION
18.8 NUCLEAR FUSION

LONG QUESTIONS

Q.1 Define and explain the phenomenon of nuclear fission? ***(K.B+U.B+A.B)***
(SGD 2016, DGK 2016)

Ans: **FISSION REACTION**

Definition:

"Nuclear fission takes place when a heavy nucleus, such as **U-235**, splits, or fissions, into two smaller nuclei by absorbing a **slow moving (low-energy) neutron".**

Schematic Diagram:

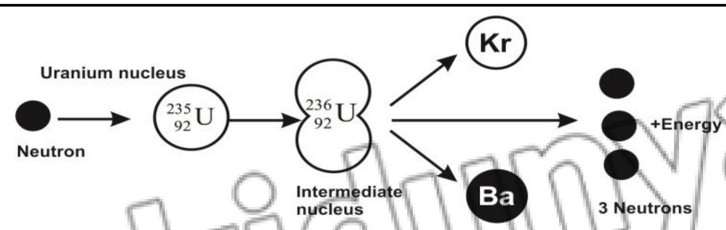


Figure: Nuclear Fission Reaction

General Equation:

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{236}_{92}U^* \longrightarrow X + Y + neutron$$

where **U*–236** is an Intermediate state that lasts only for a fraction of second before splitting into nuclei **X** and **Y**, called fission fragments.

Discovery:

Nuclear fission was first observed in **1939** by **Otto Hahn and Fritz Strassman.** The uranium nucleus was split into two nearly equal fragments after absorbing a slow moving (low-energy) neutron. The process also resulted in the production of typically two or three neutrons per fission event. On the average, **2.47** neutrons are released per event as represented by the expression.

$$ {}_{0}^{1}n + {}_{92}^{235}U \rightarrow {}_{56}^{141}Ba + {}_{36}^{92}Kr + 3{}_{0}^{1}n $$

In nuclear fission, the total mass of the products is less than the original mass of the heavy nucleus. Measurements showed that about **200 MeV** of energy is released in each fission event. This is a large amount of energy relative to the amount released in chemical processes.

Example:

If we burn 1 tonne of coal, then about 3.6×10^{10} J of energy is released. But, during the fission of 1 kg of Uranium –235 about 6.7×10^{11} J of energy is released.

Fission Chain Reaction:

We have seen that neutrons are emitted when U-235 undergoes fission. These neutrons can in turn trigger other nuclei to undergo fission with the possibility of a chain reaction Calculations show that if the chain reaction is not controlled, it will proceed too rapidly and possibly results in the sudden release of an enormous amount of energy (an explosion).

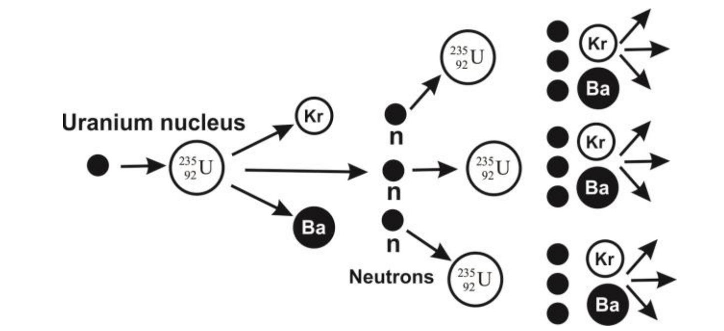


Figure: Fission Chain Reaction

Controlled Fission Chain Reaction:

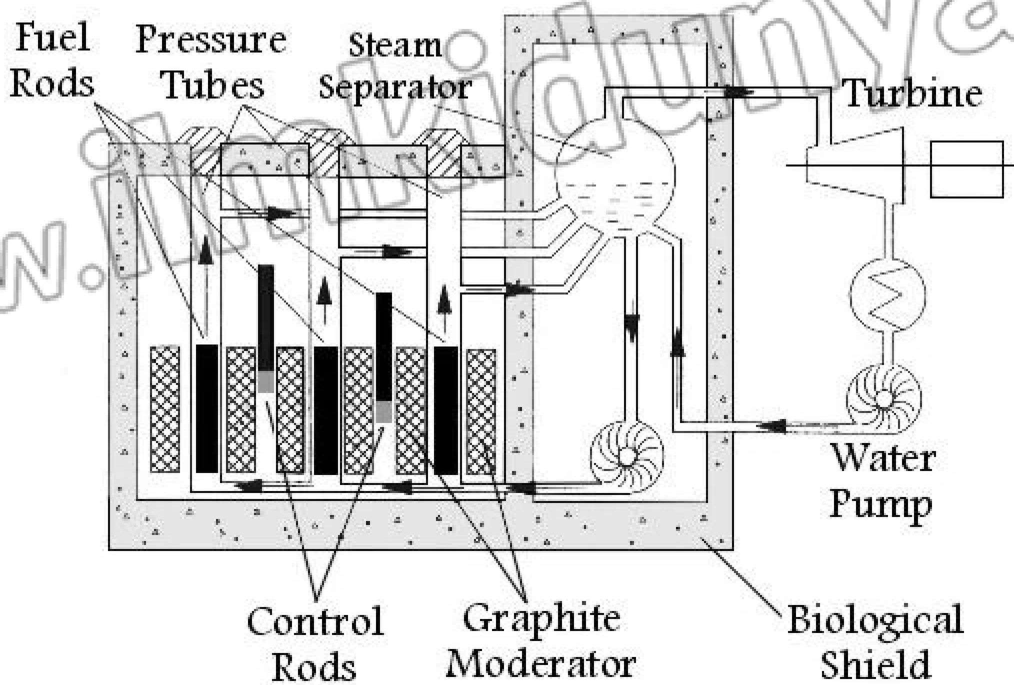
This fission chain reaction is controlled in nuclear reactors. A nuclear reactor provides energy for useful purposes. In this sort of self-sustained reaction extra neutrons liberated in fission reactions are absorbed using some material to slow down the chain reaction.

Fission in a nuclear reactor:

In a nuclear reactor in a nuclear power station, a controlled chain reaction takes place and thermal energy (heat) is released at a steady rate. The energy is used to make steam for the turbines, as in a conventional power station. In many rectors, the nuclear fuel is uranium dioxide, the natural uranium being enriched with extra uranium-235. The fuel is in sealed cans (or tubes).

Maintaining the reaction:

To maintain the chain reaction in a reactor, the neutrons have to be slowed down, otherwise many of them get absorbed by the uranium-235. To slow them a material called a moderator is needed. Graphite is sued in some reactors, water in others. The rate of there reaction cadmium, materials which absorb neutrons.



18.7, 18.8 SHORT QUESTIONS

Q.1 What is nuclear fission? ***(K.B)***

Ans: *Given on Page # 398*

Q.2 Briefly explain how heat is produced in a nuclear reactor? ***(K.B+U.B)***

Ans: **NUCLEAR REACTOR**

The fission of U-235 may be represent as:

$$ {}_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + \text{Energy} $$

Where Q is the amount of energy released and it is nearly equal to 200 Mev. This energy is appeared in the form of heat.

Q.3 What do you know about fission chain reaction? ***(K.B)***

Ans: **FISSION CHAIN REACTION**

Neutrons are emitted when U-235 undergoes fission. These neutrons can in turn trigger other nuclei to undergo fission with the possibility of a chain reaction. Calculations show that if the chain reaction is not controlled, it will proceed too rapidly and possibly results in the sudden release of an enormous amount of energy (an explosion).

Q.4 Define fission fragment. ***(K.B)***

Ans: *Given on page # 398*

Q.5 Define fusion reaction. ***(K.B)***

(LHR 2013, GRW 2014, 2015, SHW2016, DGK 2016, SGD 2016, RWP 2016)

Ans: **FUSION REACTION**

Definition:

"When two light nuclei combine to form a heavier nucleus, the process is called nuclear fusion".

$$^{2}_{1}H+^{3}_{1}H \longrightarrow ^{4}_{2}He+^{1}_{0}n+Energy$$

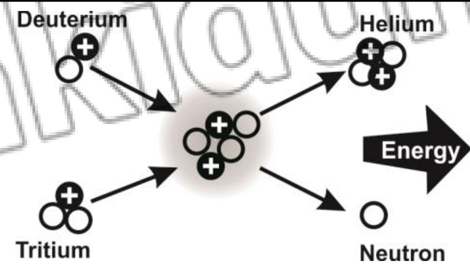


Figure: **Nuclear Fission Reaction**

Q.6 Why the mass of final nucleus is always less than the masses of original nuclei? *(K.B+U.B)*

Ans: **MASS OF NUCLEUS**

The mass of final nucleus is always less than the masses of original nuclei. According to mass energy relation this loss of mass converts into energy.

Example:

If an atom of Deuterium is fused with an atom of tritium, then the helium nucleus of alpha particle is formed.

$$^{2}_{1}H+^{3}_{1}H \longrightarrow ^{4}_{2}He+^{1}_{0}n+Energy$$

Q.7 Differentiation between nuclear fission and nuclear fusion. *(K.B)*

Ans: **DIFFERENTIATION**

The differences between nuclear fission and nuclear fusion are as follows:

Nuclear Fission	Nuclear Fusion
Definition	
• Nuclear fission takes place when a heavy nucleus, such as U-235, splits, or fissions, into two smaller nuclei by absorbing a slow moving (low-energy) neutron.	• When two light nuclei combine to form a heavier nucleus, the process is called nuclear fusion.
Temperature	
• It does not require temperature.	• Extremely high temperature is require for fusion to take place.
Nuclear waste	
• At the end of the reaction nuclear waste is left behind.	• No nuclear waste is left at the end of fusions reaction.

Q.8 How fusion reaction is the source of energy? *(K.B)*

Ans: **FUSION REACTION**

Energy coming from Sun and stars is supposed to be the result of fusion of hydrogen nuclei into Helium nucleus with release of energy. The temperature at the centre of the Sun is nearly 20 million Kelvin which makes the fusion favorable. According to this reaction, four hydrogen nuclei fuse together to form a Helium nucleus along with 25.7 MeV of energy.

18.7, 18.8 MULTIPLE CHOICE QUESTIONS

1. Mass energy equation and theory of relativity was given by: *(K.B)*
(A)Newton (B) Quantum
(C) Einstein (D) Volta

2. Nuclear fission was first observed in 1939 by: *(K.B)*
(A)Otto Hahn and Fritz Strassman (B) Otto Hahn and Curie
(C)Fritz and Curie (D) Otto Hahn and Rutherford

3. In each fission reaction energy released: *(K.B)*
(A) 210meV (B) 299mV
(C) 200 MeV (D) 255meV

4. During fission of 1kg of Uranium -235 energy released is: *(K.B)*
(A) 67×10^{10}J (B) 65×10^{8}J
(C) 60×10^{8}J (D) 66×10^{9}J

5. 1eV = ? **(For your information Pg. #185)**
(A) 1.6×10^{-19} J (B) 1.6×10^{-18} J
(C) 1.6×10^{-17} J (D) 1.6×10^{-16} J

6. How much energy is released by burning 1 tonne of coal? *(K.B)*
(A) 3.6×10^{10}J (B) 3.6×10^{11}J
(C) 4.6×10^{10}J (D) 4.6×10^{11}J

7. When two light nuclei combine to form a heavier nucleus, this process is called: *(K.B)*
(A) Nuclear fission (B) Nuclear fusion
(C) Bombardment (D) Disintegration

8. The temperature of the centre of Sun is: *(K.B)*
(A) 20 million kelven (B) 2 million kelvin
(C) 24 million kelvin (D) 29 million kelvin

9. ________ hydrogen nuclei fuse together to form a helium nucleus. *(K.B)*
(A) 1 (B) 2
(C) 3 (D) 4

18.9 HAZARDS OF RADIATIONS AND SAFETY MEASURES

LONG QUESTIONS

Q.1 Discuss uses and the hazards of radiations? Describe the precaution to minimize radiations dangers (safety measures). *(K.B+A.B)*

Ans: **HAZARDS OF RADIATIONS AND SAFETY MEASURES**

Although, radiations are very useful in medicine, agriculture and industry, they can also cause considerable damage if not used with precautions. Radioactive, nuclear materials are now widely used in nuclear power plants, nuclear-powered submarines, intercontinental ballistic missiles etc. Some of the harmful effects on human beings due to large doses or prolonged small doses of radiations are:

Hazards of Radiation:

1. Radiation burns, mainly due to beta and gamma radiations, which may cause redness and sores on the skin.
2. Sterility (i.e. inability to produce children).

3. Genetic mutations in both human and plants. Some children are born with serious deformities.
4. Leukemia (cancer of the blood cells).
5. Blindness or formation of cataract in the eye.

Nuclear Accident at Chernobyl

During the nuclear accident at Chernobyl, Russia, the explosion of the nuclear reactors melted through a few meters thick concrete housing. This caused a massive destruction of local community and also contaminated vegetation and livestock in the large surrounding area. Millions of dollars were lost as the contaminated vegetable and livestock had to be destroyed.

Safety Precautions:

Radiations cannot detect directly, we should strictly follow safety precautions, even when the radioactive sources are very weak.

1. The sources should only be handled with tongs and forceps.
2. The user should use rubber gloves and hands should be washed carefully after the experiment.
3. All radioactive sources should be stored in thick lead containers.
4. Never point a radioactive source towards a person.
5. Frequent visits to the radiation sensitive areas should be avoided.

18.9 SHORT QUESTIONS

Q.1 Discuss uses and the hazards of radiations. ***(A.B)*** **(GRW 2013, DGK 2016)**

Ans: ***Given on Page # 402***

18.9 MULTIPLE CHOICE QUESTIONS

1. Hazards of radiation for humans are: ***(K.B)***

(A) Leukemia (B) Sterility
(C) Blindness (D) All given

MCQ'S ANSWER KEY (TOPIC WISE)

18.1 ATOM AND ATOMIC NUCLEUS

18.2 NATURAL RADIOACTIVITY

18.3 BACKGROUND RADIATIONS

1	2	3	4	5	6	7	8	9	10	11	12
A	A	A	A	B	B	A	B	C	B	A	B
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
C	D	B	D	B	C	A	D	C	A	C	C
25	**26**										
B	A										

18.4 NUCLEAR TRANSMUTATIONS

1	2	3	4	5	6	7	8	9	10	11	12
A	C	D	C	A	A	A	A	A	B	A	A
13											
A											

18.5 HALF LIFE AND ITS MEASUREMENT

1	2	3	4
C	A	B	A

18.6 RADIOISOTOPES AND THEIR USES

1	2	3	4	5	6	7	8	9	10	11	12
A	C	B	A	A	A	D	A	A	A	C	D

18.7 FISSION REACTION

18.8 NUCLEAR FUSION

1	2	3	4	5	6	7	8	9
C	A	C	A	A	B	B	A	B

18.9 HAZARDS OF RADIATIONS AND SAFETY MEASURES

1
B

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

Choose the correct answer from the following choices:

i. Isotopes are atoms of same element with different: ***(K.B)***
(a) atomic mass (b) atomic number
(c) number of protons (d) number of electronics

ii. One of the isotopes of uranium is $^{238}_{92}U$. The number of neutrons in this isotope is: ***(K.B)***
(a) 92 (b) 146
(c) 238 (d) 330

iii. Which among the following radiations has more penetrating power? ***(K.B)***
(a) a beta particle (b) a gamma ray
(c) an alpha particle (d) all have the same penetrating ability

iv. What happens to the atomic number of an element which emits one alpha particle? ***(K.B)***
(a) increases by1 (b) stays the same
(c) decreases by2 (d) decreases by1

v. The half-life of a certain isotope is 1 day. What is the quantity of the isotope after 2days? ***(K.B)***
(a) one-half (b) one-quarter
(c) one-eighth (d) none of these

vi. When Uranium (92 protons) ejects a beta particle, how many protons will be in the remaining nucleus? ***(K.B)***
(a) 89 protons (b) 90 protons
(c) 91 protons (d) 93 protons

vii. Release of energy by the Sun is due to: ***(K.B)***
(a) nuclear fission (b) nuclear fusion
(c) burning of gases (d) chemical reaction

viii. When a heavy nucleus splits into two lighter nuclei, the process would: *(K.B)*

(a) release nuclear energy (b) absorb nuclear energy
(c) release chemical energy (d) absorb chemical energy

ix. The reason carbon-dating works is that: *(K.B)*

(a) plants and animals are such strong emitters of carbon-14
(b) after a plant or animals dies, it stops taking in fresh carbon-14
(c) there is so much non-radioactive carbon dioxide in the air
(d) when plants or animals die, they absorb fresh carbon-14

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
b	b	b	c	a	d	b	a	b

REVIEW QUESTIONS

18.1. What is difference between atomic number and atomic mass number? Give a symbolical representation of a nuclide. *(K.B+U.B)*

Ans: (See Topic 18.1, Short Question-10)

18.2. What do you mean by the term radioactivity? Why some elements are radioactive but some are not ? *(K.B)*

Ans: **RADIOACTIVITY**

Definition:

"Radioactivity is such a process in which the elements with the charge number greater than 82 naturally keep on radiating**"**.

The spontaneous emission of radiation by unstable nuclei is called natural radioactivity.

Reason of radioactivity:

An isotope will be radioactive if its nuclei are unstable. Large atomic nuclei with more than 82 protons and their associated complement of neutrons are inherently unstable uranium and plutonium are examples of such elements. Small atomic nuclei may also be radioactive if the ratio of neutrons to protons exceeds certain limits. Even tiny hydrogen, the smallest of atoms, has a radioactive isotope. If the atom is stable it will not emit radiations.

18.3. How can you make radioactive elements artificially? Describe with a suitable example. *(K.B)*

Ans: **ARTIFICIAL RADIOACTIVITY**

Any stable element, besides the natural radioactive element, can be made radioactive for this purpose very high energy particles (protons, neutrons or alpha particles) are bombarded on the stable element. This bombardment excites the nuclei and the nuclei after becoming unstable become radioactive element. Such radioactive elements are called artificially produced radioactive elements.

Example:

Rutherford was a Scottish scientist, who discovered artificial radioactivity. Through the bombardment of alpha particles against the nuclei of ^{14}N Rutherford produced ^{17}O and protons. Through this observation, Rutherford concluded that atoms of one specific element can be made into atoms of another element through this discovered process of artificial radioactivity

18.4. What are the three basic radioactive decay processes and how do they differ from each other? *(K.B+U.B+A.B)*

Ans: (See Topic 18.4, Long Question-1)

18.5. Write the alpha decay process for $^{234}_{91}Pa$. Identify the parent and daughter nuclei in this decay. *(K.B+U.B)*

Ans: **ALPHA DECAY PROCESS**

$$^{234}_{91}Pa \rightarrow ^{230}_{89}Ac + ^{4}_{2}He + Energy$$

It means in alpha decay, the proton number or atomic number Z of the parent nuclide reduces by 2 and its mass number or nucleon number A decreases by 4.

$^{234}_{91}Pa \Rightarrow$ Parent nuclei

$^{230}_{89}Ac \Rightarrow$ Daughter nuclei

18.6. Explain whether the atomic number increase during nuclear decay. Support your answer with an example. *(K.B)*

Ans: **INCREASE IN ATOMIC NUMBER**

Yes, atomic number can increase during nuclear decay. During the β-decay atomic number of atom can be increased.

Beta (β) –Decay:

$^{A}_{Z}X$	$\rightarrow$	$^{A}_{Z+1}Y$	+	$^{0}_{-1}e$	+ Energy
Parent nuclide		Daughter nuclide		beta (β) -particle	

Example:

$^{13}_{6}C$	$\rightarrow$	$^{14}_{7}N$	+	$^{0}_{-1}e$	+	Energy
Carbon			nitrogen		beta (β) particle	

In beta (β) –decay, the parent nuclide has its protean number Z increased by 1 but its mass number or nucleon number A remains unchanged.

18.7. What do you understand by half-life of a radioactive element? *(K.B+U.B+A.B)*

Ans: (See Topic 18.5, Long Question-1)

18.8. What is meant by background radiations? Enlist some sources of background radiations. *(K.B)*

Ans: (See Topic 18.3, Short Question-16)

18.9. Describe two uses of radioisotopes in medicine industry or research? *(A.B)*

Ans: **USE OF RADIOACTIVE ISOTOPE**

In Medicine:

- Radioactive cobalt-60 is used for curing cancerous tumors and cells. The radiations kill the cells of the malignant tumor in the patient.
- Isotopes of Iodine-131 are used for diagnosis of goiter in thyroid gland.

In Industry or Research:

- The radioisotopes are used in a chemical reaction to follow a radioactive element during the reaction and ultimately to determine the structure. For example, C-14 is used to label CO_2.
- Radioactive isotopes are used to generate electricity by carrying out controlled nuclear fission reaction in nuclear reactors.

Example:

When U-235 is bombarded with slow moving neutrons, the Uranium nucleus breaks up to produce Barium-139 and krypton-94 and three neutrons.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{139}_{56}ba + ^{94}_{36}Kr + 3^{1}_{0} + Energy$$

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.

18.10. What are two common radiation hazards? Briefly describe the precautions that are taken against them. *(K.B)*

Ans: ` **COMMON RADIATION HAZARDS**

The two common radiation hazards are as follows:

- Radiation burns, mainly due to beta and gamma radiations, which may cause redness and sores on the skin.
- Blindness or formation of cataract in the eye.

Precautions:

The precautions of radiation hazards are as follows:

- The sources should only be handled with tongs and forceps.
- The user should use rubber gloves and hands should be washed carefully after the experiment.
- All radioactive sources should be stored in thick lead containers.
- Never point a radioactive source towards a person.
- Frequent visits to the radiation sensitive areas should be avoided.

18.11. Complete this nuclear reaction: $^{235}_{92}U \rightarrow ^{140}_{54}X + ? + 2^{1}_{0}n.$ **Does this reaction involve fission or fusion? Justify your answer. *(K.B)***

Ans: **COMPLETING REACTION**

$$^{235}_{92}U \rightarrow ^{140}_{54}X + ^{94}_{38}Sr = 2^{1}_{0}n + Energy$$

(Xenon) (Strontium) (Neutron)

It is a fission reaction. Because the process of breaking up of nucleus of a heavy atom such as Uranium into two nuclei nearly of the same size with the release of energy is called fission reaction.

18.12. Nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction. Justify this statement with plausible arguments. *(C.B+A.B)*

Ans: **COMPARISON OF FUSION AND FISSION REACTION**

Nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction. In case of fusion reaction, fusion reactors cannot sustain a chain reaction so they never melt down like fission reactors. Fusion reaction produces very less or, if the right atoms are chosen, no radioactive waste. In case of nuclear fission large radioactive waste is produced and disposal of radioactive waste is a complicated problem. For nuclear power, fusion is the better choice.

18.13. A nitrogen nuclide $^{14}_{8}N$ **decays to become an oxygen nuclide by emitting an electron. Show this process with an equation. *(K.B)***

Ans: **EQUATION**

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$$

18.14. Determine which of these radioactive decay processes are possible: *(K.B)*

(a) ${}^{214}_{84}P_o \rightarrow {}^{208}_{82}P_b + {}^{4}_{2}He$ **(b)** ${}^{230}_{90}Th \rightarrow {}^{226}_{88}R_a + {}^{4}_{2}He$

(c) ${}^{233}_{91}P_a \rightarrow {}^{233}_{92}U + {}^{0}_{-1}\beta$ **(d)** ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta$

Ans: **<u>POSSIBILITY OF RADIOACTIVE DECAY PROCESSES</u>**

(a) ${}^{214}_{84}P_o \rightarrow {}^{208}_{82}P_b + {}^{4}_{2}He$ Not possible

(b) ${}^{230}_{90}Th \rightarrow {}^{226}_{88}R_a + {}^{4}_{2}He$ Possible

(c) ${}^{233}_{91}Pa \rightarrow {}^{233}_{92}U + {}^{0}_{-1}\beta$ Possible

(d) ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta$ Possible

CONCEPTUAL QUESTIONS

18.1 Is it possible for an element to have different types of atoms? Explain.

Ans: **<u>POSSIBILITY OF DIFFERENT ATOMS IN AN ELEMENT</u>**

Usually an element has same types of atoms. However, certain elements have different types of atoms. These atoms have same atomic mass numbers, but different atomic number. For example, there are three different types of atoms of hydrogen elements ${}^{1}_{1}H, {}^{2}_{1}H$ and ${}^{3}_{1}H$. These different atoms of same element are known as isotopes.

18.2 Which nuclear reaction would release more energy, the fission reaction of the fusion reaction? Explain

Ans: **<u>COMPARISON OF NUCLEAR ENERGY</u>**

Energy released in fusion reaction is large as compared to that of fission reaction. For example, in the proton-proton fusion reaction about 6.4. MeV energy is released which is much greater than the per nucleon energy released per nucleon for fission reaction which is about 1 MeV.

18.3 Which has more penetrating power, alpha particle or gamma ray photon? Explain.

Ans: **<u>PENETRATING POWER</u>**

<u>Definition</u>:

"The strength of radiation to penetrate a certain material is called penetration power**"**.

<u>Reason</u>:

Alpha particle is a massive particle as compared to a gamma-ray photon. Also photon is neutral out charge on alpha particle is +2e. Hence, alpha particle has greater ionization power and, therefore, has less penetrating power than that of gamma-ray photon.

18.4 What is the difference between natural and artificial radioactivity?

Ans: **<u>DIFFERENTIATION</u>**

The differences between natural and artificial radioactivity are as follows:

Natural Radioactivity	Artificial Radioactivity
Occurrence	
• In natural radioactivity, some elements emit radiations naturally due to their unstable state.	• Some stable elements can also be transformed into radioactive elements. Such process is called artificial radioactivity.
Example	
• ${}^{14}_{6}C$ is natural radioactive isotope of carbon.	• When N-14 is bombarded with neutron, it changes into C – 14 i.e. ${}^{14}_{7}N + {}^{1}_{0}N \longrightarrow {}^{14}_{6}C + {}^{1}_{1}H$

18.5 How long would you likely have to wait to watch any sample of radioactive atoms completely decay?

Ans: **COMPLETE DECAY OF ATOM**

During one half-life, half of the parent nuclei of radioactivity element change into daughter nuclei. However, the total decay time of any radioactive element is indefinite. Thus, we have to wait for infinite amount of time to observe the complete decay.

18.6 Which type of natural radioactivity leaves the number of protons and the number of neutrons in the nucleus unchanged?

Ans: **RADIOACTIVE DECAY CAUSING NO CHANGE**

During gamma-decay process, the number of protons and the number of neutrons remains unchanged e.g.

$$^{60}_{27}\overset{*}{Co} \longrightarrow {}^{60}_{27}Co + {}^{0}_{0}\gamma + \text{Energy}$$

18.7 How much of 1-gram sample of pure radioactive matter would be left after four-half lives?

Ans: **CALCULATION OF HALF LIFE**

Using the formula;

$$\text{Remaining} = \text{Original} \times \frac{1}{2^t}$$

We get

$$\text{Remaining} = 1\text{g} \times \frac{1}{2^4}$$

$$= \frac{1}{16}\text{g}$$

18.8 Tritium, $^{3}_{1}H$ is radioactive isotope of hydrogen. It decays by emitting an electron. What is the daughter nucleus?

Ans. **β-DECAY**

The decay process is

$$^{3}_{1}H \longrightarrow {}^{3}_{2}X + {}^{0}_{-1}e$$

Thus, the daughter nuclei $^{3}_{2}X$ is of helium element i.e. $^{3}_{2}He$

18.9 What information about the structure of the nitrogen atom can be obtained from its nuclide $^{14}_{7}N$? in what way atom in $^{14}_{7}N$ is different from the atom in $^{16}_{7}N$?

Ans: **INFORMATION ABOUT NITROGEN ATOM**

Form the nuclide $^{14}_{7}N$, We know that it is one of the isotopes of nitrogen. It has 7 protons, 7 electron and 7 neutrons. As compared to $^{14}_{7}N$, $^{16}_{7}N$ has two extra neutrons in its nucleus as its atomic mass number increases by 2.

NUMERICAL PROBLEMS

18.1 The half-life of $^{16}_{7}N$ is 7.3s. A sample of this nuclide of nitrogen is observed for 29.2s. Calculate the fraction of the original radioactive isotopes remaining after this time. **(LHR 2014)**

Solution:

Given Data:

Half-life of $^{16}_{7}N = T_{1/2} = 7.3$

Total Time = 29.2 s

To Find:

N = ?

Calculations:

We know that

$$\text{No. of Half-life} = t = \frac{\text{Total Time}}{T_{1/2}}$$

$$t = \frac{29.2\,s}{7.3\,s} = 4$$

$$\text{Remaining fraction} = \text{Original} \times \frac{1}{2^t}$$

$$N = N_0 \times \frac{1}{2^4}$$

$$\frac{N}{N_0} = \frac{1}{16}$$

Result:

Hence, the fraction of the original radioactive isotope remaining after 4 half-lives will be 1/16th.

18.2 Cobalt-60 is a radioactive element with half-life of 5.25 years. What fraction of the original sample will be left after 26 years. **(MTN 2017, BWP2017, FSD2017)**

Solution:

Given Data:

Half-life of Co-60 = $T_{1/2}$ = 5.25 years

Total Time = 26 years

To Find:

Remaining fraction = N= ?

Calculations:

We know that

$$\text{No. of Half-life} = t = \frac{\text{Total Time}}{T_{1/2}}$$

$$t = \frac{26\text{ years}}{5.25\text{ years}} = 5$$

$$N = N_0 \times \frac{1}{2^t} \Rightarrow N = N_0 \times \frac{1}{2^5}$$

$$\frac{N}{N_0} = \frac{1}{32}$$

Result:

Hence, the fraction of the original isotope remaining after 5 half-lives will be $\frac{1}{32}$.

18.3 Carbon-14 has a half-life of 5730 years. How long will it take for the quantity of carbon-14 in a sample to drop to one-eighth of the initial quantity? **(LHR 2014, SHW2017, DGK2017, FSD2017)**

Solution:

Given Data:

Half-life of Carbon-14 = $T_{1/2}$ = 5370 Years

Quantity of sample remaining = N=1/8

$N_0 = 1$

To Find:

Total Time = ?

Calculations:

$$N = N_0 \times \frac{1}{2^t} \Rightarrow 1/8 = 1 \times \frac{1}{2^t}$$

$$\frac{1}{2^3} = \frac{1}{2^t} \Rightarrow t = 3$$

Total Time = No. of half-lives × half-life

Total Time = $t \times T_{1/2}$

Or Time = $3 \times T_{1/2}$

Or Time = 3 × 5730 years

Time = 1.72×10^4 years

Result:

Hence, Carbon will drop to 1/8 of its original quantity after 1.72×10^4 years.

18.4 Technetium-99 m is a radioactive element and is used to diagnose brain, thyroid, liver and kidney disease. This element has half-life of 6 hours. If there is 200 mg of this technetium present, how much will be left in 36 hours.

Solution:

Given Data:

Half-life $= T_{1/2} = 6$ hours

Total Time $= 36$ hours

Original quantity $= N_o = 200$ mg

To Find:

Sample remaining = N =?

No. of Half-life = t = ?

We know that

$$\text{No. of Half-life} = t = \frac{\text{Total Time}}{T_{1/2}}$$

$$t = \frac{36\,\text{hours}}{6\,\text{hours}} = 6$$

$$\text{Remaining amount} = \text{Original} \times \frac{1}{2^t}$$

$$= 200\text{ mg} \times \frac{1}{2^6}$$

$$= \frac{200\text{ mg}}{64}$$

Remaining amount = 3.125 mg

Result:

Hence, remaining sample will be 3.125mg.

18.5 Half-life of a radioactive element is 10 minutes. If the initial count rate is 368 counts per minute, find the time for which count rate reaches 23 counts per minutes.

Solution:

Given Data:

Half-life $T_{1/2} = 10$ min.

Initial count rate = 368 counts per min.

Final count rate = 23 count per min.

To Find:

Time taken = ?

Calculations:

Half-life of radioactive element = 10 min

Initial count rate = 368 c/min

After 10 min = 184 c/min

After 20 min = 92 c/min

After 30 min = 46 c/min

After 40 min = 23 c/min

Result:

Hence, count rate will reach to 23 count per min in 40 min.

18.6 In an experiment to measure the half-life of a radioactive element, the following results were obtained:

Count rate	**400**	**200**	**100**	**50**	**25**
Time (in minutes)	**0**	**2**	**4**	**6**	**8**

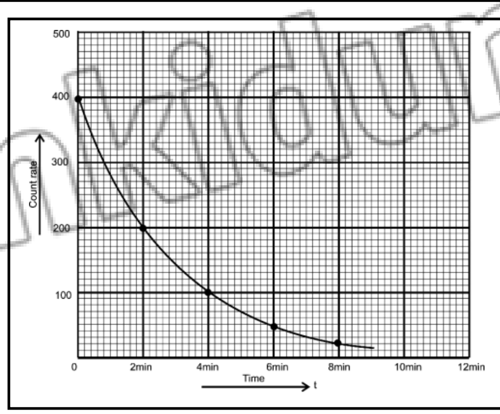
Plot a graph between the count rate and time in minutes. Measure the value for the half-life of the element from the graph.

Solution:

Scale:

One big division = 2 min. (along x-axis)

One big division = 100 counts (along y-axis)



<u>Result</u>:

> **From the graph, it is clear that half-life of the radioactive element is 2 minutes.**

18.7 A sample of certain radioactive element has a half-life of 1500 years. If it has an activity of 32000 counts per hour at the present time, then plot a graph of the activity of this sample over the period in which it will reduce to 1/16 of its present value.

<u>Solution</u>:

Half-life $T_{1/2}$ = 1500 years

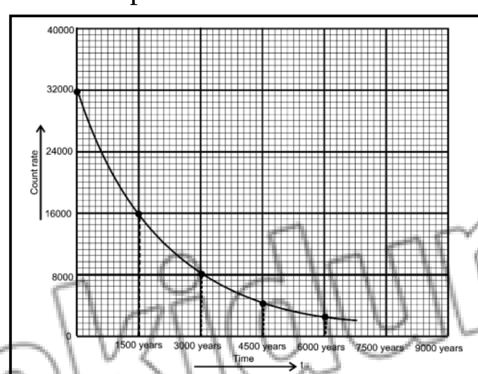
Activity = 32000 counts per hour

$\frac{1}{16}$ th of the activity $= \frac{32000}{16} = 2000$

<u>Scale</u>:

One big division = 1500 years (along x-axis)

One big division = 4000 counts per hour



<u>Result</u>:

> **Hence, the graph shows the period in which it will reduce to $1/6^{th}$ of its present value.**

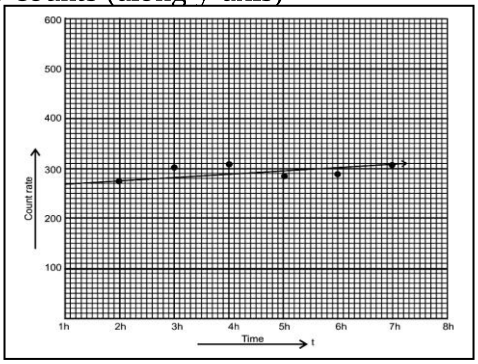
18.8 Half-life of a radioactive element was found to be 4000 years. The count rates per minute for 8 successive hours were found to be 270, 280, 300, 310, 285, 290, 305, 312. What does the variation in count rates show? Plot a graph between the count rates and time in hours. Why the graph is a straight line rather than an exponential?

Solution:

Scale:

One big division = 1 hour (along x-axis)

One big division = 100 counts (along y-axis)



Result:

Variation in count rates shows the random nature of radioactive decay, the graph is almost a horizontal line rather than an exponential curve, which is due to long half-life as compared to period of 8 hours.

18.9 Asches from a campfire deep in a cave show carbon-14 activity of only one-eighth the activity of fresh wood. How long ago was that camfire made?

(GRW 2014, SHW2017, SGD2017, RWP2017)

Solution:

Given Data:

$N_0 = 1$

Activity of C – 14 from ashes = N = $\frac{1}{8}$ th of fresh wood

Half life of C – 14 = $T_{1/2}$ = 5730 years

To Find:

No. of Half-life = ?

Total Time = ?

Calculations:

$N = N_0 \times \frac{1}{2^t} \Rightarrow 1/8 = 1 \times \frac{1}{2^t}$

$\frac{1}{2^3} = \frac{1}{2^t} \Rightarrow t = 3$

No. of half-lives = t = 3

Time = No. of half-lives × $T_{1/2}$

t = 3 × 5730 years

t = 17190 years

Result:

Hence, Asches show that campfire was made 17190 years ago.

SELF TEST

Time: 40 min. **Marks: 25**

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

1. Matter is built from small particles called:
(A) Atoms (B) Ions
(C) Radicals (D) Molecules

2. How many types of radiation are emitted by radioactive substance?
(A) 1 (B) 2
(C) 3 (D) 5

3. Radiation present in atmosphere due to different radioactive substances:
(A) Background radiations (B) α-radiations
(C) β-radiations (D) γ-radiations

4. $^{14}_{6}C \longrightarrow ? + ^{0}_{4}e + \text{Energy}$
(A) $-^{0}_{1}e$ (B) $^{4}_{2}He$
(C) $^{14}_{6}e$ (D) $^{14}_{7}N$

5. High energy gamma rays can penetrate in air, at least of:
(A) 1 Km (B) 2 Km
(C) 3 Km (D) 4 Km

6. Which compound readily accumulates in the thyroid gland and can be used for monitoring of thyroid functioning?
(A) I-131 (B) I-130
(C) I-132 (D) I-129

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

i. What is atomic number?
ii. Define natural radioactivity.
iii. Define ionization.
iv. What are stable nuclides?
v. Write uses of radioisotopes.

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

a) What do you understand by the half-life of a radioactive elements? Explain with the help of an example.
b) Carbon-14 has a half-life of 5730 years. How long will it take for the quantity of carbon-14 in a sample to drop to one-eighth of the quantity?

Note:

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