Chapter = 18

# NUCLEAR PHYSICS

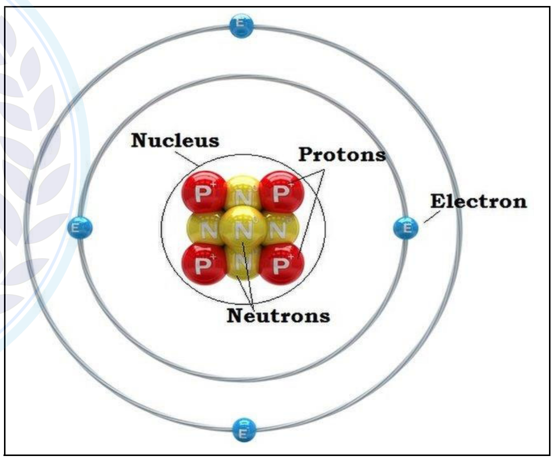
## NUCLEAR PHYSICS



**Definition**:- The branch of physics dealing with the nature and properties of the atomic nuclei is known as nuclear physics. OR
It is the branch of physics which deals with the properties and behavior of nuclei and the particles within nuclei.

## ATOM

**Definition:-** The smallest particle of matter which may or may not exist in free state but can part in a chemical reaction is known as atom.
**Structure of atom**:- Structure of atom means internal study of an atom.
**Diameter of Nucleus**:- The size of atom is about "$10^{-14}$ m" .
**Diameter of Atom**:- The diameter of atom is "$10^{-10}$ m".
**Shape of atom**:- It is spherical in shape.
**Parts of atom:-** Atom consists of two parts which are given below.
**(1)** Outer part.
**(2)** Central part.




**Outer part:-**
**(i)**It is a lighter part of an atom.
**(ii)**It consists of circular orbits in which electrons revolves around the nucleus.
**(iii)** Electrons carry negative charge.
**(2)Central part :-**
**(i)**This part is also called "nucleus".
**(ii)**It is the massive and denser part of an atom.
**(iii)**It consists of protons and neutrons.

**Note**: -

**(i)**The central core of the atom which contains all the atom's positive charge and mass of its mass is known as nucleus.
**(ii)**Electron is negatively charged particle i.e has charge = e = - 1.67 x $10^{-19}$ C.
**(iii)**Proton is a positively charged particle and has a charge equal to that of an electron. Charge on proton = e = + 1.67 x $10^{-19}$ C.
**(iv)**Neutrons is a neutral particle i.e has no charge.
**(v)** Protons and Neutrons are collectively known as "**NUCLEONS**".
**(vi)**Proton carries positive charge.
**(vii)** Neutrons are neutral.
**(viii)**The net charge on nucleus is positive.
**(ix)**The net charge on the whole atom is zero due to equal number of protons and electrons.
**(x)**Mass of electron = $m_e$= 9.109 x $10^{-31}$ kg.
**(xi)**Proton is 1836 times heavier than electron. Mass of electron = $m_p$= 1.672 x $10^{-27}$ kg.
**(xii)**Neutron mass is almost same to that of proton.Mass of electron= $m_p$= 1.6750 x $10^{-27}$ kg.

## ATOMIC NUMBER

**Definition:-** The number of protons in the nucleus of an atom is known as atomic number.

**Other Name:-** It is also called **Charge number.**

**Symbol:-** It is represented by "**Z**".

**Mathematical Form:-** **Z = A-N**

**Examples:-**

**(i)** Atomic number of Hydrogen is "1".
**(ii)** Atomic number of Oxygen is "8".
**(iii)** Atomic number of Sodium is "11".
**(iv)** Atomic number of Helium is "2"etc.

## MASS NUMBER

**Definition:-** The total number of nucleons in the nucleus of an atom is known as mass number. OR
The total number of Protons and neutrons present in the nucleus of an atom is known as a mass number.
**Other Name:-** It is also called atomic mass OR nucleon number.
**Symbol:-** It is represented by "**A**".
**Mathematical Form:-** **A = N + Z**
**Examples:-**
**(i)**Mass number of Hydrogen is "1".
**(ii)**Mass number of Helium is "4".
**(iii)**Mass number of Oxygen is "16".
**(iv)**Mass number of Sodium is "23" etc.

## NEUTRON NUMBER

**Definition:-** The number of neutrons inside a given nucleus is known as neutron number.
**Symbol:-** It is denoted by **"N".**
**NUCLIDE:-**
**Definition:-** The symbolic representation of an element with atomic number and mass number is known as nuclide.
**Symbolically Representation:-** $_{Z}X^{A}$
**Examples:-** $_{1}H^{1}$, $_{1}H^{2}$, $_{1}H^{3}$etc are nuclides.
**NUCLEONS:-**
**Definition:-** The particles found inside nuclei are known as nucleons.
**Examples:-** Protons and neutrons etc.

# ISOTOPES

**History:-** The concept of isotopes of an elements was first of all introduced by an English radio-chemist F.Soddy in 1902.

**Derivation:-** The word isotopes is the combination of two **"Greek"** words i-e.

**(i) Iso** - means "**same**".

**(ii)Topes** means "**position**".

**Meaning:-** The word isotopes means "**Same position**".

**Definition:-** Atoms of the same elements containing the same number of **Protons** but different number of **neutrons** in their nuclei are known as isotopes. OR
The atoms of an element having the same **atomic number** but different **mass numbers** are known as isotopes.

**Explanation:-** All the isotopes have same **chemical properties** due to same atomic number but different **physical properties** due to different mass number.

**Examples:-**

**(i) Hydrogen has three isotopes which are given in the table .**

**ISOTOPES OF HYDROGEN**

| Name | symbol | Electrons | Protons | Neutrons | Atomic number | Mass number |
|---|---|---|---|---|---|---|
| **Protium** | $_1H^1$ | 1 | 1 | 0 | 1 | 1 |
| **Deuterium** | $_1H^2$ | 1 | 1 | 1 | 1 | 2 |
| **Tritium** | $_1H^3$ | 1 | 1 | 2 | 1 | 3 |

**(ii) Uranium has mainly two isotopes which are given in table (R).**

**ISOTOPES OF URANIUM**

| Nam | symbol | Electrons | Protons | Neutrons | Atomic number | Mass number |
|---|---|---|---|---|---|---|
| **Uranium-235** | $_{92}U^{235}$ | 92 | 92 | 143 | 92 | 235 |
| **Uranium-238** | $_{92}U^{238}$ | 92 | 92 | 146 | 92 | 238 |

# RADIOACTIVITY

**History:-** Radioactivity was first of all discovered by a **French** scientist **Henri Becquerel** in **1896**.



**Definition:-** The phenomenon of disintegrations of unstable atomic nuclei with the emission of alpha particles or beta particles or gamma rays is known as radioactivity. OR The spontaneous emission of radiation by unstable nuclei is known as radioactivity.

**Radioactive Element:-** The elements which possess this property are known as radioactive elements.


**Purpose:-** This process occurs in un-stable nuclei to attain stability.

**Examples:-** (i)Uranium.(ii)Radium.(iii)Thorium.(iv)Carbon -14 etc.

**Symbol of radioactive element:-**

**Condition:-** For natural radioactivity $Z > 82$.

**Dependence: -** Radioactivity of a substance depends upon its nature.

**Independence:-** Radioactivity of a substance does not depends upon

- Temperature
- Pressure etc.

**Radioactive radiations**: - The radiations emitted by radioactive elements.

**Example: -** Uranium $_{92}U^{238}$ atom disintegrates spontaneously and forms a new element thorium $_{92}Th^{238}$ by emitting an alpha particle and energy in the form of gamma radiations.

$$_{92}U^{238} \longrightarrow {}_{92}Th^{238} + {}_{2}He^{4} + \text{Energy}$$

**Unit: -** The SI unit of radioactivity is **Becquerel** (Symbol **Bq** ).

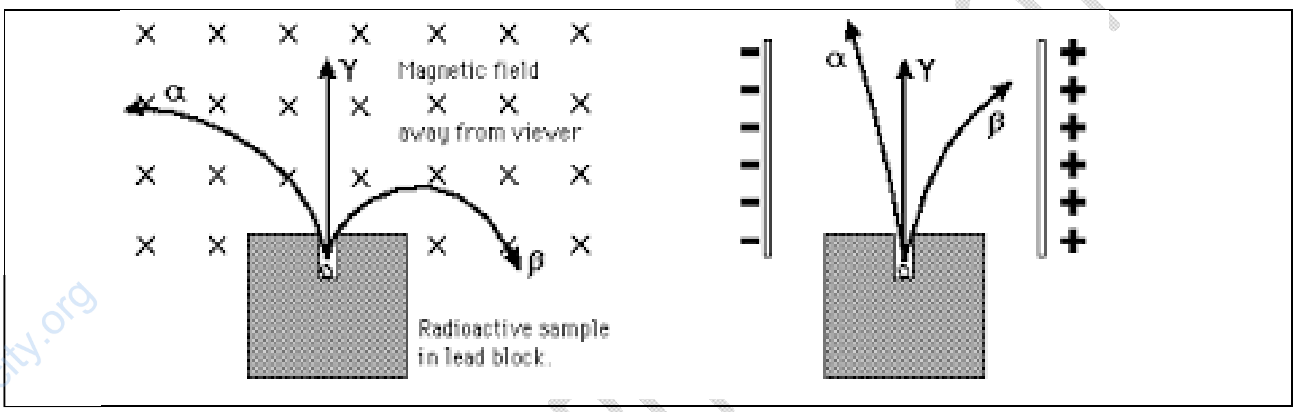
**Becquerel**:- One Becquerel is defined as " the activity of a quantity of radioactive material in which one nucleus decays per second".

**Note:-** (i)Nuclei which emit radiations are termed as un-stable.(ii) Nuclei which do not emit radiations are termed as stable.(iii)Radioactivity occurs without apparent external cause.(iv) It cannot be speed up or speed down by physical or chemical means.(v)It no definite pattern, rule or method and occurs randomly.(vi)Individual disintegrations occur randomly.

**Nature of radioactive radiations:-** In order to study the nature of radioactive radiations we can explain by a simple experiment.

**Apparatus**:-

- Lead block having small hole.
- Vacuum chamber.
- Photographic plate.
- Strong magnetic field.
- Radioactive element. As shown in figure




**Working**: - The radioactive source is placed inside the magnetic field. Under the action of magnetic field the radiation emitted from the source splits into three types i-e alpha and beta radiations bends in opposite direction in the magnetic field while gamma radiation does not change its direction as shown in figure.

**Note: - Form the above experiment is cleared that**
**(i) Radio-active radiations are three types in nature.**
**(ii) Alpha rays and Beta rays are charged in nature.**
**(iii)Gamma rays are neutral in nature.**

## NATURE OF EMISSION

It is found that all the three kind of radiation have different nature.

### ALPHA ($\alpha$)EMISSION

**(i)**They have +2 charge.

**(ii)**Their speed range between $1.4 \times 10^7$ to $1.8 \times 10^7$ m/s ($ms^{-1}$) .

**(iii)**They have high ionization power.



**(iv)**They have low penetrating power.

**(v)**They can affect the photographic plates.

**(vi)**They can produce fluorescence in Zinc Sulphide.

**(vii)**At atmospheric pressure they travel a small distance in air i-e about 4 cm to 5 cm.

**(viii)** They can be deflected by electric and magnetic fields.

## BETA ($\beta$) EMISSION

**(i)** They carry **-1** charge.

**(ii)**They **move nearly** with the speed of light.

**(iii)** They have **moderate** ionization power.

**(iv)**They have **moderate** penetrating power.

**(v)** They can affect the photographic plates.

**(vi)**They can produce fluorescence in **Zinc Sulphide**.

**(vii)** They can easily pass through **30 cm thick sheet of iron.**

**(viii)** They can be deflected by electric and magnetic fields.

**(ix)** The mass and charge of $\beta - rays$ is equal to the mass and charge of an electron.

**(x)** They are fast moving electrons which are emitted by the nucleus.

## 3. GAMMA ($\gamma$)EMISSION

**(i)**They are neutral in nature.

**(ii)** They move nearly with the speed of light.

**(iii)** They have very small ionization power as compared to $\alpha$ $and$ $\beta$ rays.

**(iv)** They have higher penetrating power than $\alpha$ $and$ $\beta$ rays.

**(v)** Their effect photographic plates is much higher than that of $\alpha$ $and$ $\beta$ rays.

**(vi)** They can produce fluorescence in Barium Planinocynide.

**(vii)** They can easily pass through 30 cm thick sheet of iron.

**(viii)** They are not affected by electric and magnetic fields.

**(ix)** They are electromagnetic waves (radiations) which are emitted by the nucleus.

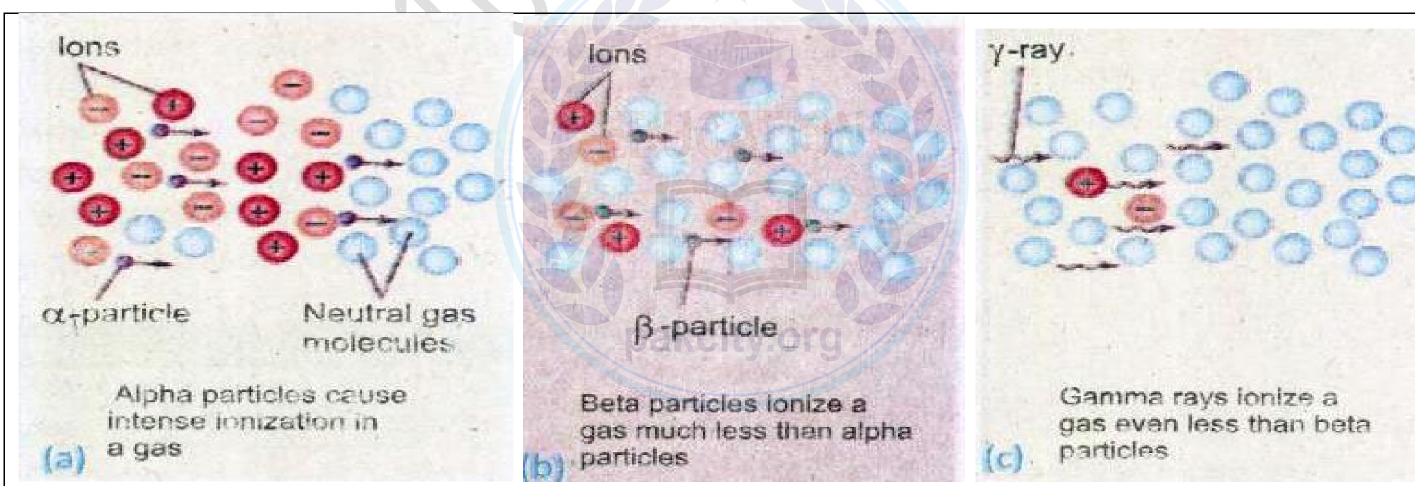
**TABLE 18.1 ALPHA, BETA, AND GAMMA RADIATION**

| Particle | Symbols | Composition | Charge | Effect on parent nucleus |
|---|---|---|---|---|
| alpha | $\alpha$ | 2 protons and 2 neutrons | +2 | Mass loss: new element produced |
| beta | $\beta$ | electron | -1 | No change in mass: new element produced |
| gamma | $\gamma$ | high energy electromagnetic radiations | 0 | energy loss |

## RELATIVE IONIZING ABILITIES

**Definition:-** The phenomena by which radiation can split matter into positive and negative ions is known as ionization.

**Explanation:-** All three types of radiation ( alpha "$\alpha$" , beta "$\beta$" and gamma "$\gamma$") have quite different ionizing abilities in air. Alpha ($\alpha$) particles ionizes air much strongly due to its large mass and charge than beta and gamma radiations. Gamma radiation has the least ionizing ability as compared to alpha and beta radiations.




(a) Alpha particles cause intense ionization in a gas

(b) Beta particles ionize a gas much less than alpha particles

(c) Gamma rays ionize a gas even less than beta particles

**NOTE:-** The strength of ionization depends upon the mass and charge of particle. Greater the Mass and charge greater will be its ionization power and vice versa.

## RELATIVE PENETRATION ABILITIES



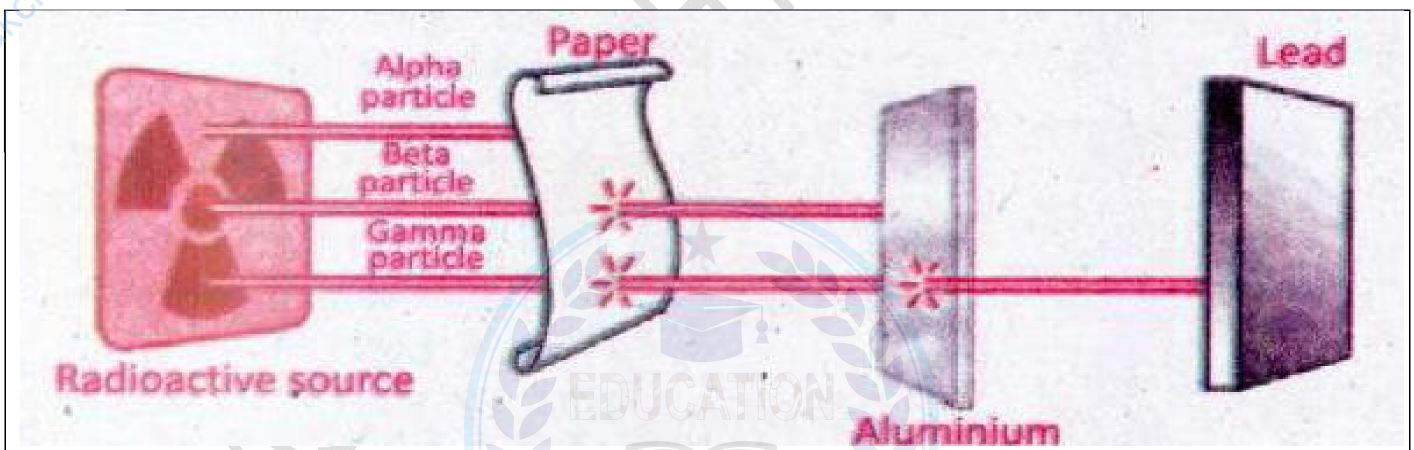
**Definition:-** The strength of radiations to penetrate a certain material is known as penetrating power.

**Explanation:-** Penetrating ability is how deeply a radiation can go into a material. All the three types of radiation (alpha "$\alpha$" , beta "$\beta$" and gamma "$\gamma$") have quite different ionizing abilities as well.

**(i)** Alpha particle has the shortest range because of its strong interaction or ionization power.

**(ii)** Beta has strongly interacts with matter due to its charge and has a short range as compared to gamma radiation.

**(iii)** Gamma rays can penetrate considerable thickness of concrete. It is due to their high speed and neutral nature as shown in figure.




## NUCLEAR TRANSMUTATIONS

**Definition:-** The process through which an unstable nucleus transforms into a more stable nuclide is known as nuclear transmutation.

**Other Name:-** It is also called **"Nuclear Decay".**

**Explanation:-** In nuclear transmutations the original elements is called parent and newly formed element is termed as daughter.

# TYPES OF NUCLEAR TRANSMUTATIONS OR NUCLEAR

There are three types of nuclear decay which are given below.

(1) Alpha Decay.

(2) Beta Decay.

(3) Gamma Decay.



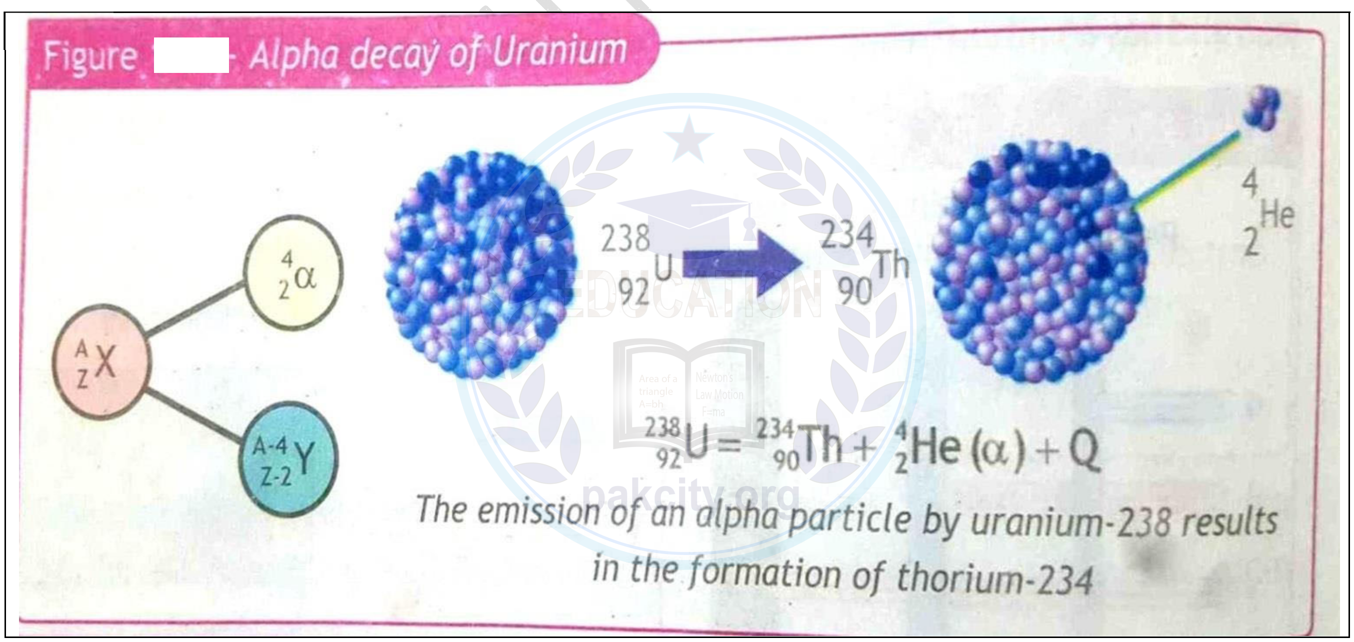
## (1) ALPHA DECAY

**Definition:-** It is a type of radioactive decay in which an atomic nucleus emits an alpha particle (Helium nuclei).

**Explanation:-** In alpha decay, the original " Parent " nuclide is converted to a " daughter" by the emission of an alpha particle. When a radioactive element emits an alpha particle its mass number (A) will be reduced by four and a charge reduced by two.

**Mathematically:-** ${}^{A}_{Z}X = {}^{A-4}_{Z-2}Y + \alpha + Q$

**Example: -** ${}^{238}_{92}U = {}^{234}_{92}Th + {}^{4}_{2}He + Q$




*The emission of an alpha particle by uranium-238 results in the formation of thorium-234*

## (2) BETA DECAY

**Definition:-** It is a type of radioactive decay in which an atomic nucleus emits a beta particle (electron).



**Explanation:-** In beta decay, the original " Parent " nuclide is converted to a " daughter" by the emission of beta particle. When a radioactive element emits a beta particle its number of nucleons will be remains the same but charge number is reduced by one unit.

**Mathematically:-** $${}^{A}_{Z}X = {}_{Z+1}^{A}Y + {}^{0}_{-1}\beta + Q$$

**Examples:-** $${}^{14}_{6}C = {}^{14}_{7}N + {}^{0}_{-1}\beta + Q$$

$${}^{234}_{90}Th = {}^{234}_{91}Pa + {}^{0}_{-1}\beta + Q$$

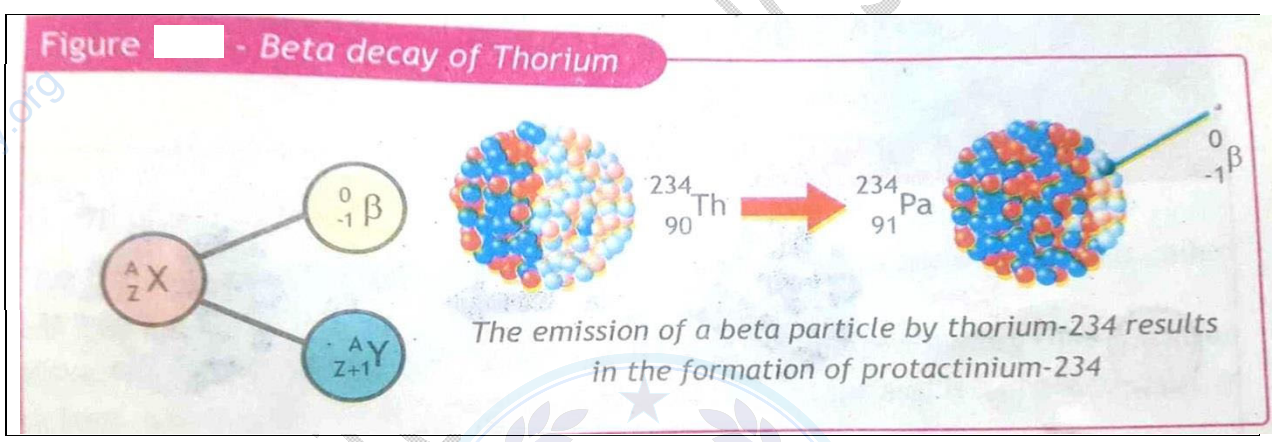



Figure - Beta decay of Thorium

The emission of a beta particle by thorium-234 results in the formation of protactinium-234

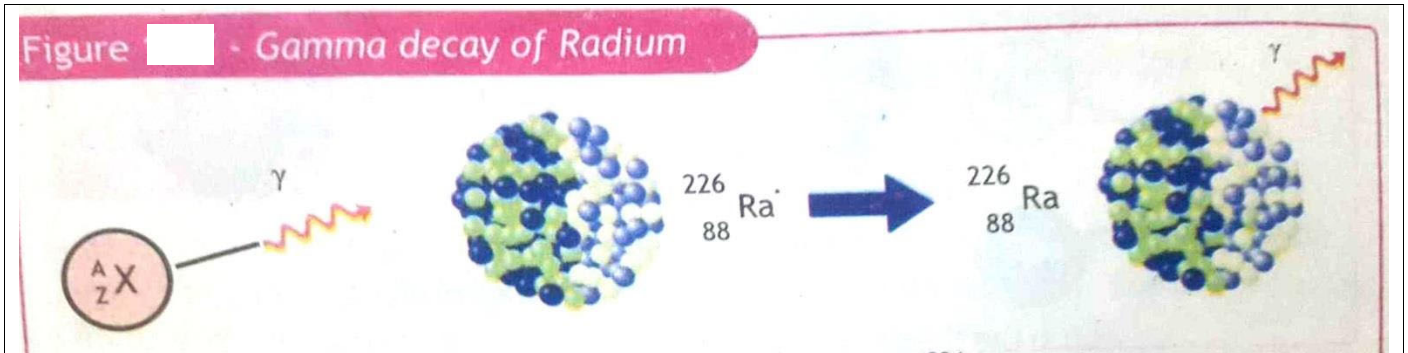
## (3) GAMMA DECAY

**Definition:-** It is a type of radioactive decay in which an atomic nucleus emits a gamma rays (electromagnetic rays of rays of high frequency and short wave length).

**Explanation:-** In most cases the alpha ($\alpha$) or beta ($\beta$) emission from the nucleus leave it in excited state such nuclei archive further stability by emitting gamma rays.

**Mathematically:-** $${}^{A}_{Z}X^{*} = {}^{A}_{Z}X + \gamma$$

**Examples: -** $${}^{60}_{27}Co^{*} = {}^{60}_{27}Co + \gamma$$




$^{226}_{88}Ra^* = ^{226}_{88}Ra + \gamma$

The emission of a gamma ray by radium-226 results radium-226 with gamma

## ACTIVITY AND ITS UNIT

**Definition: -** The rate of disintegration in a radioactive substance is known as activity.

**Unit:-** Its common unit is curie which is abbreviated "Ci".

**Curie:-** The rate of activity of a radioactive substance is said to be one curie (1 Ci) if it undergoes 3.70 x $10^{10}$ decays per second.

$$1\ Ci = 3.70 \times 10^{10}\ Bq = 3.70 \times 10^{10}\ decays / sec$$

## HALF- LIFE OF RADIOACTIVE

**Definition:-** The time interval in which half of the atoms in any given sample decay into daughter elements is known as half-life of the radioactive element. OR

The time it takes for half of the radioactive nuclei in a sample to decay is known as half- life.

The time interval in which half of the radioactive atoms in any given sample decay into daughter elements is known as half- life of the radioactive elements.

**Other Name:-** It is also called "**Half value time".**

**Symbol:-** It is denoted by "$T_{1/2}$".

**Explanation:-**

- It is a nuclear process.

- It is a spontaneous process.
- It is an irreversible process.
- It is an intrinsic property.



**Factors:-**

**Dependence:-** Nature of elements.

**Independence:-** It is not effected by any physical or chemical change.

**Examples:-**

**(i)** Hal life of radioactive sodium is only **15 hours.**

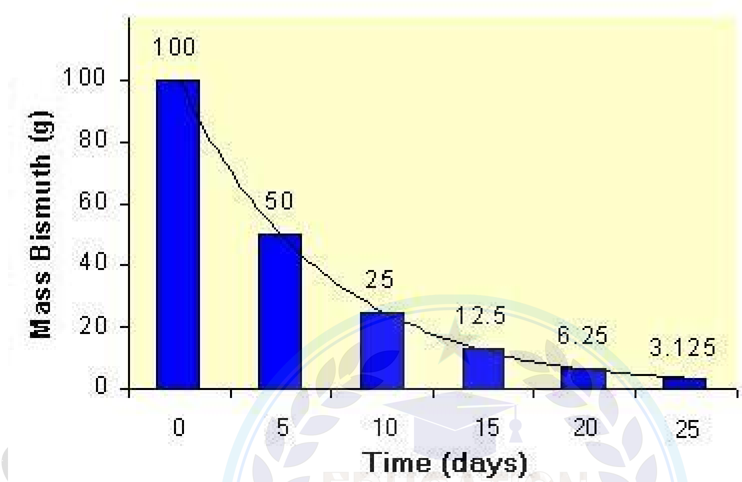
**(ii)** Hal life of Polonium is 212 is $3\times10^{-7}$ sec.

**(iii)** Hal life of Radian is **1600 years.**

**(iv)** Hal life of krypton is **3.16 minutes.**

**(v)** Hal life of Lead-210 is **22.3 years etc.**

**Graphical Representation of half life:-**




Let "N" represents the amount of the original sample remaining any given time interval " $\Delta t$" and "$N_0$" represent the original amount in the sample , given in the same units as "N". Then

**After 1 half- life :-** $N = \frac{1}{2} N_0$

**After 2 half- life :-** $N = \frac{1}{2} (\frac{1}{2} N_0) = (\frac{1}{2})^2 N_0$

**After 3 half- life :-** $N = \frac{1}{2} \times \frac{1}{2} (\frac{1}{2} N_0) = (\frac{1}{2})^3 N_0$

Generally

$N = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$ ………………… $N_0 = (\frac{1}{2})^n N_0$……………… (R)

In equation (R) "n" represents the number of half-lives.

$$n = \frac{Time\ interval}{Half-life} = \frac{\Delta t}{T_{1/2}} \quad \text{…………………………… (s)}$$

**Note:- Different materials have different half-lives which ranges from $10^{10}$ years to a friction of second.**

## RADIO-ISOTOPES

**Definition:-**The isotopes of radioactive elements are known as radio-isotopes.

**Types of radio-isotopes**:- There are two types of radio-isotopes which are given below.

(i) Natural radio-isotopes

(ii) Artificial radio-isotopes

**Natural radio-isotopes** :-

**Definition**:- The isotopes of natural radioactive elements are known as natural radio-isotopes.

**Explanation**:-

- They occur in nature naturally.
- The atomic number of these elements is greater than 82.

**Examples**:-

- Uranium
- Radium
- Polonium etc.

# ARTIFICAL RADIO ISOTOPES

**Definition**:- The isotopes of artificial radio-isotopes are known as artificial radio-isotopes.



**Explanation**:-

- They can be produced by bombarding subatomic particles into elements.
- The atomic number of these elements is from 1 to 82.

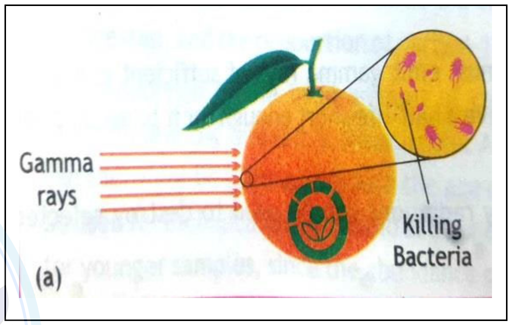
**Examples**:-

- Sodium ($_{11}Na^{24}$ )
- Carbon ($_{12}C^{14}$)
- Phosphorus ($_{15}P^{32}$) etc.

# USES OF RADIO-ISOTOPES

The following are few applications of radio-isotopes different fields

## FOOD PRESERVATION




Gamma radiations are commonly used to preserve food. Strongly gamma radiations kills would, bacteria or insects in food thus make it safer to eat and have a longer shelf life.

## STERILLISING

Gamma rays are also used to sterilize hospital equipment by irradiation, especially plastic syringes that would be damaged if heated as shown in figure.




Sterilizing Medical equipment

## AGRICULTURE

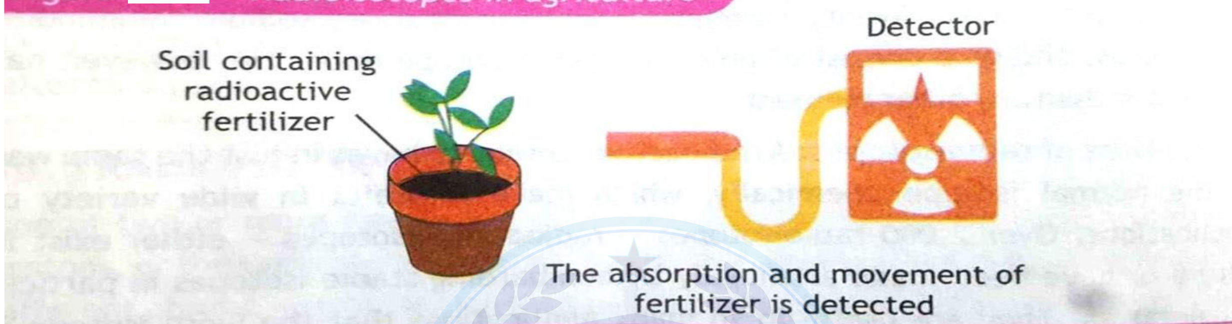
**(i)**They are used to study the chemical and biological process in plants.

**(ii)**They are used to kill bacteria and preserve fruits, vegetables and other foodstuff.

**(iii)** They are used to protect seeds from microorganisms.

**(iv)**Radio isotopes are used to determine the optimum amount of fertilizers and other nutrients intake by plants.

Figure - Radioisotopes in agriculture




## INDUSTRY

**(i)** They are used to detect the leakage in pipes.

(ii) They are used to detect cracks in the joints.

(iii) They are used to control thickness of manufacturing paper, Plastics and metal sheets.

(iv) They are used to determine the degree of wear and tear of engine parts.

## MEDICAL USES

(i) They are used for radiotherapy.

(ii) They are used to sterilize medical instruments.

(iii) They are used to suspect brain tumor.

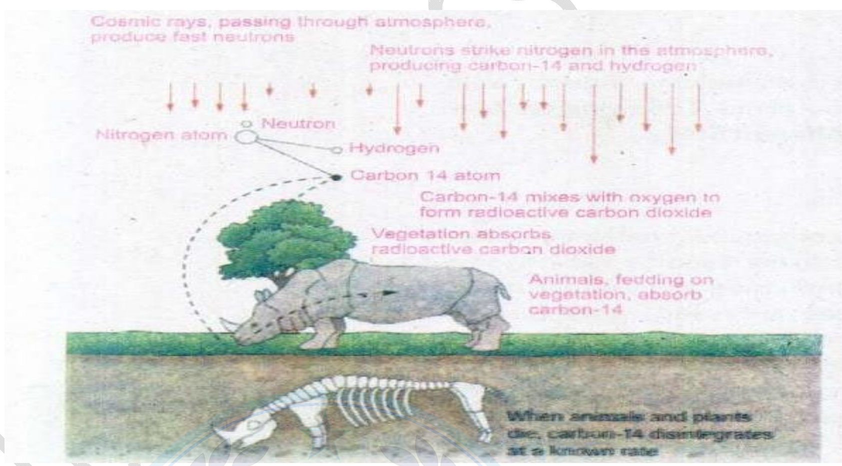
(iv) They are used to examine thyroid glands.



**Geological Dating:-**

Uranium-238 is used for dating rocks. U-238 (Half-life of 4.5 billion year) decays to lead-206. The ratio of U-238 to Pb-206 present in a rock, can be used to determine the age of rock.

**Archaeological Dating:-** Radio-active Carbon-14 is present in small amount in the atmosphere. Living plants use carbon dioxide and therefore slightly becomes radio-active.




When an organisms dies it has a specific ratio of mass of carbon- 14 to carbon -12 incorporated in the cells of its body( The same ratio as in the atmosphere ). At the moment of death no new carbon -14 containing molecules are metabolized , Therefore is at maximum. After death the carbon -14 to carbon-12 ratio begins to decrease because carbon -14 is decaying away at a constant and predicable rate. Remembering that the half- life of carbon -14 is 5700 years , then after 5700 years half as much carbon-14 remains within the organisms.

## EINSTEIN'S MASS ENERGY

**History:-** This law was presented by a German Physicist Einstein's in 1905.
**Purpose:-**To study the relationship between mass and energy.
**Statement:-**The mass and energy are interchangeable.
**Mathematical Form:-** $E = mc^2$ ------------------ (1)

In equation (1) 

- "E" ------------ shows energy
- "m"------------ shows mass
- "c" ------------ shows speed of light

**Examples:-**

- Photo-electric effect
- Compton effect
- Pair production
- Annihilation of matter.



## Nuclear Fission

**Meaning**:-The word fission means "splitting" or "Division".
**History**:-This type of reaction first of all introduced by two" German" Physicists Otto Hahn and Fritz Strassman in 1938.
**Definition**:- The splitting of a heavy nucleus into two parts in which huge amount of energy is released is known as nuclear fission. OR
The splitting of a heavy nucleus into two fragments with the emission of huge amount of energy when bombarded by a slow neutron is known as nuclear fission.
OR
The process of splitting of nuclei into two intermediate size nuclei is known as nuclear fission.
**Explanation**:-
**(i)**It do not required high temperature to initiate.
**(ii)**It is a chain reaction.

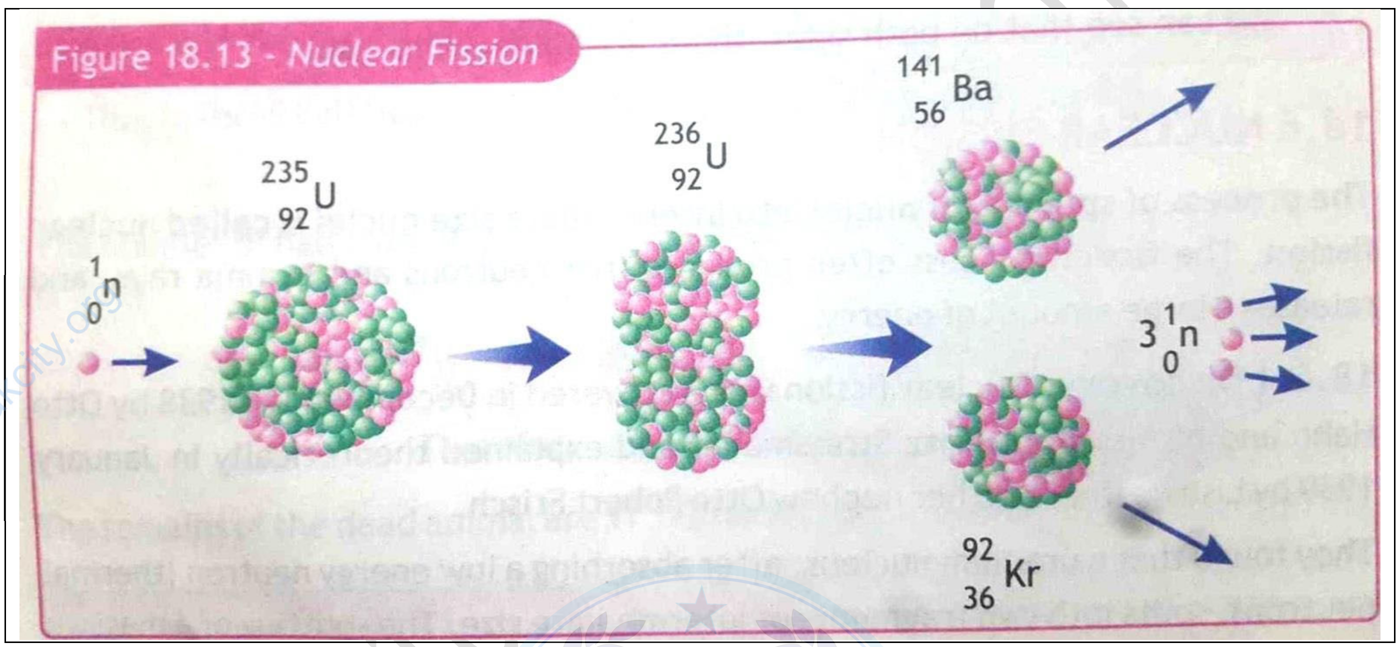
**(iii)**It is carried out by bombarding the heavy nucleus with neutron.
**(iv)**A large amount of energy is released.
**(v)**The products formed as a result of nuclear fission are radioactive and harmful.
**(vi)**It does not normally occur in nature.



**Example**:-
Splitting of uranium by bombarding slow neutron is an example of nuclear fission.

**Reaction:-** $^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{236}_{92}U^{*} \longrightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + ^{1}_{0}n + Q$

Where Q is the nuclear reaction energy.

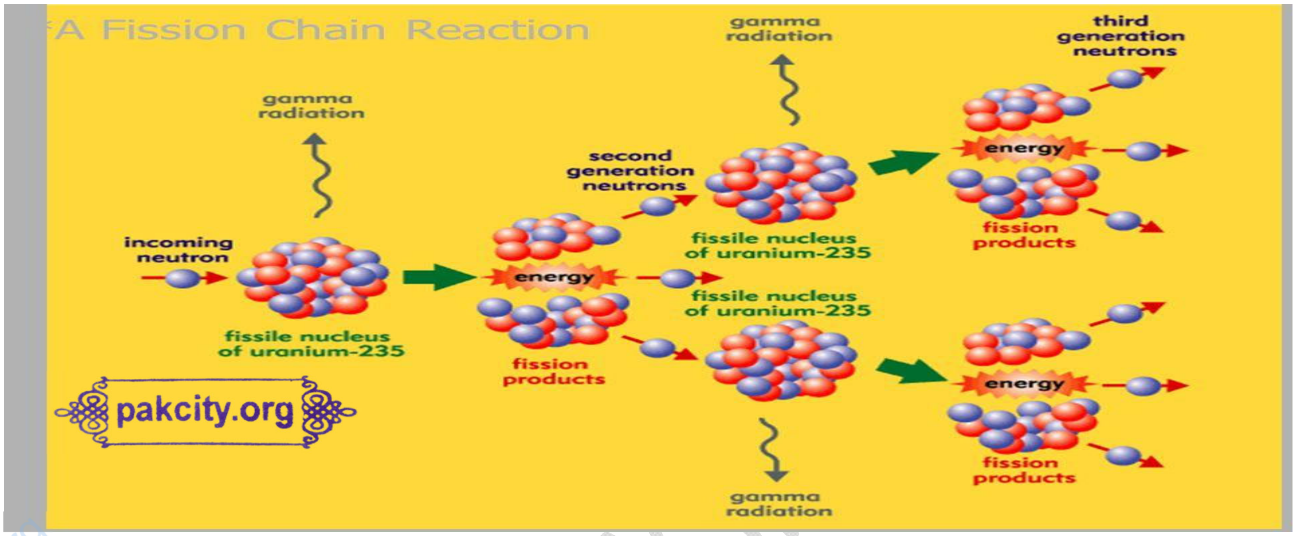



**Note:-** It should be noted that during the fission reaction the sum of the masses of the product nuclei and the neutron is less than the mass of the original nucleus. This difference of the mass results in the release of energy according to the Einstein's mass energy equation.

## FISSION CHAIN REACTION

**Definition**:- The self-sustaining fission reaction started with a single neutron in uranium is known as fission chain reaction.

**Explanation**:- As we know that in a fission process each nucleus emits about two or three neutrons. These neutrons may collide with the other uranium nuclei and cause the fission in them. The nuclei which undergo a fission reaction, will emit neutrons. These neutrons will produce further fission on other nuclei. If this process continues, more and more neutrons are produced. A large amount of energy is released. This is called a nuclear chain reaction.




## FUSION

**History**:- This reaction was first of all introduced by a German Physicist Hans Bethe in 1930's.

**Meaning**:- The word Fusion means Combination OR Together.

**Definition**: - A reaction in which two light nuclei fuses to form a heavy nucleus is known as fusion reaction.

**Explanation:-**

**(i)**It required very high temperature to initiate.

**(ii)**It is a chain reaction.

**(iii)**It is carried by heating light nuclei at very high temperature.

**(iv)**In fusion reactions energy released is several times greater than fission reaction.

**(v)**The product formed as a result of fusion reaction are not radioactive and are not harmful.

**(vi)**It occurs in stars such as the sun.

**Example**: - Proton – proton cycle.

This reaction take place on sun and other stars. It completes into 3-steps which are given below.



**Step 1:-** Proton ( $^1_1H$ ) with proton ( $^1_1H$ ) to form $^2_1H$ :-

$$^1_1H + ^1_1H \longrightarrow ^2_1H + \beta^+$$

**Step 2:-** Deuteron ($^2_1H$ ) with proton ($^1_1H$ ) to form $^3_1He$ :-

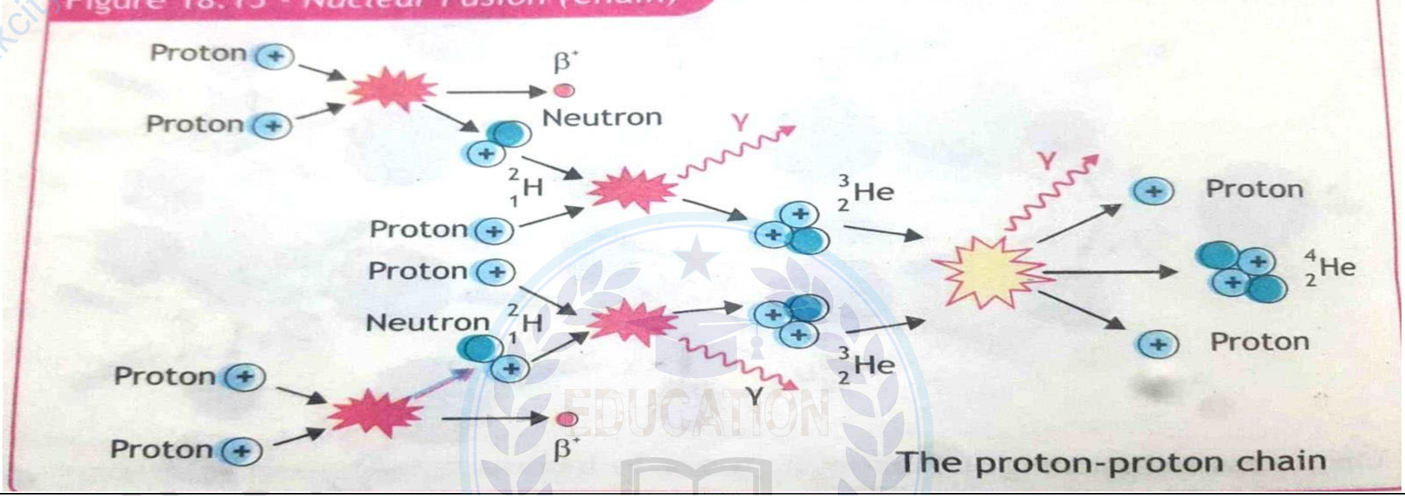
$$^2_1H + ^1_1H \longrightarrow ^3_1He + \gamma - rays.$$

**Step 3:-** Two $^3_1He$ combine to form $^4_2He$ :-

$$^3_1H + ^3_1H \longrightarrow ^4_2He + ^1_1H + ^1_1H + \gamma - rays.$$



Figure 18.15 - Nuclear Fusion (Chain)




The proton-proton chain

## BACKGROUND RADIATION

All living creatures, form the beginning of time, have been are still being exposed to radiation. When a radiation detector is used it will record these radiations called natural background radiation, it comes from three sources.

**(1)COSMIC RADIATION:-** The earth and all living things on it, are constantly bombarded by radiations from space. The dose from cosmic radiation varies in different parts of the world due to differences in elevation and to the effects of the earth's magnetic field

**(2) TERRESTRIAL RADIATION:-** Radioactive material is also found throughout nature. . It is the soil, water and vegetation. Low levels of uranium, thorium and their decay products are found everywhere. The does from terrestrial sources also varies in the different parts of the world.

**(3)INTERNAL RADIATION:-** All people also have radioactive potassium- 40, carbon – 14 , lead – 210 and other isotopes inside their bodies from birth.

## RADIATIONS HAZARDS OR HARMFULL EFFECTS OF RADIATIONS

(i) They can damage the living cells.
(ii) They can cause genetic change in living cells.
(iii) They can cause cancer.
(iv) They can cause incurable burn.
(v)They can affect our sight eyes.

## PROCEDURE TO MINIMISE RADIATIONS DANGERS OR SAFETY MEASURES

i. Since the radiations spread in all directions so we should away from its sources.
ii. During treatment the doctor should use the radiations for the minimum possible time.
iii. The nuclear waste must be buried in the desert far away from the colonies or in the sea.
iv. Radiations symbols must be displayed at all radiation laboratories.
v. The radioactive materials must be placed in a box of lead.
vi. To made concrete thick wall around the reactor to protect ourselves from radiations.
vii. Use film badges and dosimeter to measure the intensity of radiations.
viii. Radiations workers have to wear special protective clothing and gloves.

ix. The persons working in the nuclear laboratory should check themselves medically on regular basis.

x. Food and drinks are strictly prohibited when a person is doing a radioactive experiments.



## NAMES OF INSTRUMENTS USED FOR THE DETECTION OF RADIATIONS

i. **Film** badge
ii. Dosimeter
iii. Wilson cloud chamber
iv. Geiger Muller counter
v. Solid state detector.

What are the source of energy from the sun and stars?

**Answer**:- **Statement**:- The source of energy from the sun and stars are fusion reactions.

**Reason**:- Because fusion reactions take place on the surfaces of Sun and stars.

**Explanation**:- As we known as the energy coming from the Sun and Stars is due the fusion of nucleons. Bathe suggested that a fusion reaction is taking place inside the Sun. According to this reaction when 4 Hydrogen nuclei fuse together to form a Helium nucleus, along with two positrons and three $\alpha - rays$, nearly 25.7 MeV of energy is also released.

**Conclusion**:- So as a result we can say fusion reaction is responsible for the solar and stellar energy.

(4)Which one of the following nuclei will be more stable and why?

(a) $_{92}U^{235}$ (b) $_{16}S^{32}$

Answer:- **Statement**:- The sulpher " $_{16}S^{32}$ " will be more stable than Uranium "$_{92}U^{235}$".

**Reason**:- Because of less number of nucleons.

**Explanation**:- As we know that the stability an element depends upon the number of nucleons. Greater the number of nucleons less will be the stability of an element and vice versa.

Stability of an element $\propto \frac{1}{number\ of\ nucleons}$

**Conclusion:-**So as a result the $_{16}S^{32}$ is more stable than $_{92}U^{235}$ due to less number of nucleons. different from other storage devices

## CONCEPTUAL QUESTIONS



**Q#01:- The atomic number of one particular isotopes is equal to its mass number. Which isotopes is it?**

**Ans**:- **Statement**:- Protium " $_1H^1$ " is one the particular isotope whose atomic number and mass number is same.

**Reason**:- It is because of Protium " $_1H^1$ " has no neutron it the nucleus.

**Explanation**:- As we know that the atoms of an element having the same atomic number but different mass numbers are known as isotopes. E.g Protium ($_1H^1$) , Deuterium ( $_1H^2$ ) and Tritium ($_1H^3$). So only known isotope which have same atomic number and same mass number , it is because the protium ($_1H^1$) nucleus contains only one proton and no neutron.

**Conclusion**:- As conclusion we find that Protium " $_1H^1$" is one the particular isotope whose atomic number and mass number is same.

**Q#02:- Which is more likely to expose , a film kept in a cardboard box $\alpha -$ particles or $\beta$-particles? Explain.**

**Ans:- Statement**:- A film kept in a cardboard box is more likely exposed to $\beta - particles$.

**Reason**:- It is because of $\beta - particles$ has more penetrating power.

**Explanation**:- As we know that the penetrating of a particle depends upon two factors which are given.

**(ii)** Size of the particle.

**(iii)** Energy of the particle.

**(a)**Smaller the size of the particle more will be its penetrating power and vice versa at constant energy.

**(b)**Higher the energy of the particle more will be its penetrating power and vice versa at constant size.

**Conclusion**:- As conclusion we find that a film kept in a cardboard box is more likely exposed to $\beta - particle$.



**Q#03:- Is it possible for a form of heavy hydrogen to decay by emitting an alpha particle? Explain.**

**Ans:- Statement:-** No, it is not possible for a heavy hydrogen atom to emit an alpha particle.

**Reason:-** It is because alpha decay most often occurs in massive nuclei have large number of protons and neutrons.

**Explanation:-** As we know that hydrogen has three isotopes which are Protium ($_1H^1$) , Deuterium ( $_1H^2$ ) and Tritium ($_1H^3$). Deuterium ( $_1H^2$ ) is known as heavy hydrogen which contains only one proton and one neutron. It is a less massive atom and having just one proton and neutron in its nucleus. So it is not possible for heavy hydrogen atom to emit an alpha.

**Conclusion:-** As conclusion we find that it is not possible for a heavy hydrogen atom to emit an alpha particle.

**Q#04:- Different isotopes of a given element have different masses but they have the same chemical properties. Explain why chemical properties are unaffected by a change of isotope.**

**Ans:- Statement**:- Different isotopes of a given element have different masses but they have the same chemical properties. Chemical properties are unaffected by a change of isotope.

**Reason:-** It is because of same electronic confirmation.

**Explanation:-** As we know that the chemical properties of an atom depends upon the electronic configuration. Different isotopes of a given element have similar **chemical properties** because **they** have the number of electrons. The electron arrangement **is** the **same** owing to **same chemical properties**. However they **have different** numbers of neutrons, which affects the **mass** number.

**Conclusion:-** As conclusion we find that Different isotopes of a given element have different masses but they have the same chemical properties. Chemical properties are unaffected by a change of isotope.

**Q#05:- What fraction of a radioactive sample has decayed after two half- lives have elapsed?**

**Ans:- Statement**:- The number of radioactive atoms decayed after two **half- lives is** $\frac{3N_0}{4}$.

**Explanation**:-

Let the original number of atoms = $N_0$

Number of half-lives = n = 2

As we know that N = $(\frac{1}{2})^n N_0$ .................. (1)

By putting the value of "n" in equation (1) we get.

N = $(\frac{1}{2})^2 N_0 = \frac{1}{4} N_0$ ...................................... (2)

Number of decayed atoms = original number of atoms – Un-decayed atoms

$N' = N_0 - N = N_0 - \frac{1}{4} N_0 = \frac{3N_0}{4}$

**Conclusion**:- As conclusion we find that The number of radioactive atoms decayed after two **half- lives is** $\frac{3N_0}{4}$.

**Q#06:-Can carbon -14 dating give the age of fossil dinosaur skeletons? Explain.**

**Ans:- Statement**:- No, carbon-14 dating cannot be used to determine the age of dinosaur skeletons.



**Reason**:- It is because of carbon-14 dating is only effective on samples that are less than 50,000 years old.

**Explanation**:- As we know that carbon-14 dating is a method to find the age of fossils and organic materials. But carbon-14 dating would not work on **dinosaur skeletons bones.** The half-life carbon-14 is only 5,730 years, but the age dinosaurs is from about 252 million to 66 million years. So carbon-14 dating is only effective on samples that are less than 50,000 years old.

**Conclusion**:- As conclusion we find that carbon-14 dating cannot be used to determine the age of dinosaur skeletons.



**Q#07:- Some food is treated with gamma radiation to kill bacteria. Why is there not a concern that people who eat such food might be consuming food containing gamma radiations?**

**Ans:- Statement**:- Some food is treated with gamma radiation to kill bacteria but the food will not become radioactive.

**Reason**:- It is because that the gamma rays does not make food radioactive.

**Explanation**: - As we know that Gamma radiations are commonly used to preserve food. Strongly gamma radiations kills would, bacteria or insects in food thus make it safer to eat and have a longer shelf life.

**Conclusion**:- As conclusion we find that some food is treated with gamma radiation to kill bacteria but the food will not become radioactive.

**Q#08:- Radioactive $\alpha$-emitters are relatively harmless outside the body, but can be dangerous if ingested or inhaled. Explain.**

**Ans:- Statement**:- Radioactive $\alpha$-emitters are relatively harmless outside the body, but can be dangerous if ingested or inhaled.
**Reason**:- It is because of least penetrating power.

**Explanation**:- As we know that alpha particles cannot penetrate the normal body layer of dead cells on the outside of our skin but could damage the cornea of the eye and particularly dangerous. If inhaled, ingested or if they enter a wound .

**Conclusion**:-As conclusion we find that Radioactive $\alpha$-emitters are relatively harmless outside the body, but can be dangerous if ingested or inhaled.

**Q#09:- If nuclear radiation is harmful. How it can be used for treatment of diseases?**

**Ans:- Statement:-** Nuclear radiations are used for the treatment of various diseases.

**Explanation:-**

(i) They are used for radiotherapy.
(ii) They are used to sterilize medical instruments.
(iii) They are used to suspect brain tumor.
(iv) They are used to examine thyroid glands.

**Safety measures: -** To avoid the harmful effects of nuclear radiations should be carefully by expert doctors etc.

# NUMERICAL QUESTIONS



**PB# 01: How many neutrons are contained in a gold nucleus $^{197}_{79}Au$?**

| | |
|---|---|
| **GIVEN DATA:-**<br>Gold nucleus = $^{197}_{79}Au$<br>Atomic mass = A = 197<br>Atomic number= Z= 79<br>**REQUIRED DATA:-**<br>Number of neutrons = N=?<br>**SOLUTION:-** | **FORMULA:-** As we know that<br>A = Z + N OR N = A – Z ................ (i)<br><br>**CALCULATION:-** By putting values in equation (i) we get.<br>N = A – Z = 197 – 79 = 118<br>**RESULT:-**<br>Number of neutrons = N = 118 |

**Pb#02: $^{220}_{86}Rn$ Decays via alpha decay, Identify the daughter nuclide.**

**Solution:-**

**General equation for alpha decay:-** $^{A}_{Z}X = {}^{A-4}_{Z-2}Y + \alpha + Q$ **............... (1)**

$^{A}_{Z}X$ represents the $^{220}_{86}Rn$ **then** Equation (1) becomes.

$$^{220}_{86}Rn = {}^{220-4}_{86-2}Y + \alpha + Q$$

$$^{220}_{86}Rn = {}^{216}_{84}Y + \alpha + Q \text{ .................... (2)}$$

**In the periodic table $^{216}_{84}Y$ represents the Polonium then eq(2) becomes**

$$^{220}_{86}Rn = {}^{216}_{84}Po + \alpha + Q$$

**Result:-** The daughter nuclide after **alpha decay is $^{216}_{84}Po$**.

**Pb# 03:Write the nuclear equations for the beta decay of $^{210}_{82}Pb$ and $^{234}_{90}Th$.**

**Given elements :** $^{210}_{82}Pb$ **and** $^{234}_{90}Th$.



Nuclear reaction for beta decay = ?

**Solution:-**

**(1) Nuclear reaction for $^{210}_{82}Pb$ :- Incase beta decay**

$^{A}_{Z}X = {}_{Z+1}^{A}Y + \overline{\beta} + Q$ ................ (A)

Here $^{A}_{Z}X$ represents the $^{210}_{82}Pb$ **then equation (A) becomes.**

$^{A}_{Z}X = {}_{Z+1}^{A}Y + \overline{\beta} + Q$

$^{210}_{82}Pb = {}^{210}_{83}Y + \overline{\beta} + Q$ .............. (B)

In the periodic table $^{210}_{83}Y$ represents the $^{210}_{83}Y$ (Bismuth) then eq (B) becomes

$^{210}_{82}Pb = {}^{210}_{83}Bi + \overline{\beta} + Q$

**(2) Nuclear reaction for $^{234}_{90}Th$ :- Incase beta decay**

$^{A}_{Z}X = {}_{Z+1}^{A}Y + \overline{\beta} + Q$ ................ (D)

Here $^{A}_{Z}X$ represents the $^{234}_{90}Th$ **then equation (A) becomes.**

$^{234}_{90}Th = {}_{Z+1}^{A}Y + \overline{\beta} + Q$

$^{234}_{90}Th = {}^{234}_{91}Y + \overline{\beta} + Q$ .............. (E)

In the periodic table $^{234}_{91}Y$ represents the $^{234}_{91}Pa$ (Protactinium) then eq (B) becomes

$^{234}_{90}Th = {}^{234}_{91}Pa + \overline{\beta} + Q$ .......... (F)

**Pb# 04:Iodine -131 is an important radioisotope for medical diagnostic and treatment procedures. The half-life of $^{131}I$ is 8.02 days. Out of 100 g of the sample how much will be left after 24 days?**



**GIVEN DATA:-**

Half-life of iodine – 131 = $T_{\frac{1}{2}}$ = 8.02 days.

Total amount of iodine = $N_0$ = 100 g

Time duration = t = 14 days.

Elapsed time = $\Delta t$ = 24 days

**REQUIRED DATA:-**

Left amount of iodine – 131 = N = ?

**SOLUTION:-**

**FORMULA:-** As we know that

$N = (\frac{1}{2})^n N_0$................ (i)

**First we find the value of "n":-**

$n = \frac{\Delta t}{T_{1/2}} = \frac{24}{8.02}$ = 2.99 = 3

**CALCULATION:-** By putting values in eq (i) we get.

$N = (\frac{1}{2})^n N_0 = (\frac{1}{2})^3 \times 100g = \frac{1}{8} \times 100$ g

N = 12.5 gm

**RESULT:-** N = 12.5 gm

**Pb#05:Phosphorus-32 is used in plant sciences for tracking a plant's uptake of fertilizer from the roots to the leaves. The half-life of $^{32}P$ is 15 days. Out of 800 µg of the activity given as fertilizer how much will be left after one month?**

**GIVEN DATA:-**

Half-life of Phosphorus-32 = $T_{\frac{1}{2}}$ = 15 days

Total quantity = $N_0$ = 800 $\mu g$

Elapsed time = $\Delta t$ = 1 month = 30 days

**REQUIRED DATA:-**

Quantity left = N = ?

**SOLUTION:-**

**FORMULA:-** $N = (\frac{1}{2})^n N_0$................ (i)

**CALCULATION:- By** putting values in eq (i) we get.

$N = (\frac{1}{2})^n N_0 = (\frac{1}{2})^2 \times 800\ \mu g$

$N = \frac{1}{4} \times 800\ \mu g = 200\ \mu g$

**RESULT:-** N= 200 $\mu g$

**Problem # 6:- $^{12}C$ to $^{14}C$ ratio in an animal fossil is found to be one fourth of the ratio in the bone of living animal. The half-life of $^{14}C$ is 5730 years, how old is the fossil?**

**GIVEN DATA:-**

**Half-life of carbon-14 = $T_{1/2}$ = 5730 years**

**Quantity left of carbon = N = $\frac{1}{4}N_0$**

**REQUIRED DATA:-**

**Total elapsed = $\Delta t$ = ?**

**SOLUTION:-**

**FORMULA:- n= $\frac{\Delta t}{T_{1/2}}$ OR $\Delta t = n\,T_{1/2}$…… (i)**

We also know that

**N = $(\frac{1}{2})^n N_0$ ………….. (ii)**

Put **N = $\frac{1}{4}N_0$ in eq (ii) we get**

$\frac{1}{4}N_0 = (\frac{1}{2})^n N_0 = \frac{1}{4} = (\frac{1}{2})^n$

$(\frac{1}{2})^2 = (\frac{1}{2})^n$

**2 = n**

**By putting values in eq (i) we get**

$\Delta t = 2 \times 5730$ = 11460 years

**RESULT:-** 11460 years.