CHAPTER NO. 21 (NUCLEAR PHYSICS)

Question 21.1:- What are isotopes? What do they have in common and what are their differences?

Answer:- Isotopes are the nuclei of same element, which have same charge number Z but have different mass number A.

Common:- The isotopes have the same number of protons.

Difference:- The isotopes have different number of neutrons and nucleons.

Question 21.2:- Why are heavy nuclei unstable?

Answer:- The heavy nuclei are unstable due to excess or either neutrons or protons. The forces that make up the nuclide are not balanced in heavy nuclide. Weak nuclear force is dominant than strong nuclear force which results in radioactivity.

Question 21.3:- If a nucleus has a half-life of 1 year, does this mean that it will be completely decayed after 2 years? Explain.

Answer:- No, a radioactive sample will take infinite time to decay completely because decay rate reduces to half after every half-life has elapsed.

The remaining fraction after n half-lives will be $R = \frac{1}{2^n}$.

Half-life = $T_{1/2}$ = 1 year,

Given time = t = 2 years

n = No. of half-lives = $t/T_{1/2} = 2$

$R = \frac{1}{2^2} = 25\ \%$

25 % of radionuclide is still left undecayed after two years.

Question 20.4:- What fraction of a radioactive sample decays after two half-lives have elapsed?

Answer:- The decayed fraction after n half-lives will be $D = 1 - \frac{1}{2^n}$.

n = No. of half-lives = 2

$R = 1 - \frac{1}{2^2} = 1 - \frac{1}{4} = 3/4$

75 % of radionuclide has decayed after two half-lives have elapsed.

Question 20.5:- The radioactive element $_{86}Ra^{226}$ has a half-life of 1.6×10^3 years. Since the Earth is about 5 billion years old, how can you explain why we still can find this element in nature?

Answer:- The half-life of $_{86}Ra^{226}$ is 1.6 x 10^3 years but its total life is equal to infinity. This is common property of all radioactive elements. That's why we can still find $_{86}Ra^{226}$ on earth while earth's life is 5 billion years.

Question 21.6:- Describe a brief account of interaction of various types of radiations with matter.

Answer:- Electromagnetic radiation interact with matter in three different ways mainly depending upon their energies. These three processes are described as under:-

Photoelectric effect:- At low energies (less than about 0.5 MeV), the dominant process that removes photons from a beam is the photoelectric effect. It takes place in metals.

Compton effect:- At intermediate energies, the dominant process is Compton scattering. It takes place in semimetals.

Pair production:- At higher energies (more than 1.02 MeV), the dominant process is pair production. It takes place in the vicinity of a heavy nucleus.

Question 21.7:- Explain how α and β-particles may ionize an atom without directly hitting the electrons? What is the difference in the action of two particles for producing ionization?

Answer:- An α-particle is nucleus of helium, it requires electrons for its neutralization. When an energetic α-particle passes through matter, ionizes thousands of atoms by attracting their electrons.

β-particle is a high speed electron that ionizes the atoms by ejecting their electrons by the Coulomb force of repulsion.

Question 21.8:- A particle which produces more ionization is less penetrating. Why?

Answer:- A particle with greater ionizing power will lose its energy in a short distance inside a medium by producing intense ionization. Hence, its range in that medium is very small.

Question 21.9:- What information is revealed by the length and shape of the tracks of an incident particle in Wilson cloud chamber?

Answer:- In Wilson cloud chamber, the length and shape of the tracks gives the information about energy, mass and charge of particles.

The tracks of α-particles are straight, continuous and thicker because these particles have greater mass as well as greater ionizing power.

The tracks of β-particles are thinner, short and discontinuous tracks because these particles has less mass and less value of ionizing power as compared to α-particles.

γ-rays have no definite tracks because of high penetrating power and less ionizing power.

Question 21.10:- Why must a Geiger Muller tube for detecting α-particle have a very thin end window? Why does a Geiger Muller tube for detecting γ-rays not need a window at all?

Answer:- The GM tube has a very thin end window for detecting α-particles because this window provides easy way for these low penetrating particles, to enter into the tube.

For detecting γ-rays, there is no need of such a window because γ-rays are highly penetrating.

Question 21.11:- Describe the principle of operation of a solid state detector of ionizing radiation in terms of generation and detection of charge carriers.

Answer:- Its principle is based upon the production of electron-hole pair by getting energy from incident radiations. These generated carriers cause current pulse in the external circuit, which is detected and counted by a scaler. The energy required to generate an electron-hole pair is very small so it is useful for detection and counting of low energy radiations.

Question 21.12:- What do we mean by term critical mass?

Answer:- The mass of $_{92}U^{235}$ in which one neutron, out of all neutrons produced in one fission reaction, produces further fission is called critical mass. The volume of this mass of uranium is called critical volume.

Question 21.13:- Discuss the advantages and disadvantages of nuclear power compared to the use of fossil fuel generated power.

Answer:-

ADVANTAGES	**DISADVANTAGES POWER**
NUCLEAR POWER	
It is cheaper source of electricity. Its output is constant for a given period of time. It does not produce smoke	Nuclear fuel emits dangerous radiations. Nuclear waste is harmful and must be dumped deep into unpopulated areas. Its fuel is not easily available.

pollution. It creates a large amount of power output.	
FOSSIL FUEL GENERATED POWER	
Fossil fuel is not dangerous. Its waster products are not harmful. Its fuel is easily available.	It is not cheaper source of energy. Its output is not constant. It produces smoke pollution. It generates limited amount of energy.

Question 21.14:- What factors make a fusion reaction difficult to achieve?

Answer:- The fusion reaction requires temperature up to million degree centigrade and high energy to overcome a large electrostatic force of repulsion between two fusing nuclei. These requirements are very difficult to achieve.

Question 21.15:- Discuss the advantage and disadvantages of fusion power from the point of safety, pollution and resources.

Answer:- <u>Advantages</u> 1) As the fusion reaction is free from radioactive fossil products, so it is not dangerous.

2) It gives more energy per nucleon as compared with nuclear fission reaction.

3) The reactants of fusion reaction i.e. low mass nuclei are easily available.

<u>Disadvantages</u> 1) The fusion reaction requires temperature up to million degree centigrade and high energy. These requirements are very difficult to achieve.

2) The fusion reaction cannot be controlled like fission reaction.

Question 21.16:- What do you understand by "background radiations"? State the two sources of this radiation.

Answer:- The radiation present in the atmosphere without any potential source of radioactivity are called background radiations.

The two major sources of background radiations are:-

1) Cosmic rays.

2) Radioactive materials under crest of earth.

Question 21.17:- If someone accidently swallows an α-source and a β-source, which would be more dangerous to him? Explain why?

Answer:- If someone swallowed α-source, then it will be more damaging to blood cells due to its high ionizing power as compare to β-source.

Question 21.18:- Which radiation does would deposit more energy to your body (a) 10 mGy to your hands or (b) 1 mGy does to your entire body.

Answer:- Absorbed Dose = D = $\frac{E}{m}$

Energy absorbed = E = Absorbed Dose x Mass = D x m

Since mass of hand is much less than mass of body, 1mGy dose to entire body will deposit more energy than 10 mGy dose to hand.

Question 21.19:- What is radioactive tracer? Describe one application each in medicine, agriculture and industry.

Answer:- A radioactive tracer is a chemical compound in which one or more atoms have been replaced by a radionuclide so due to its radioactive decay it can be used to explore the mechanism of chemical reaction by tracing its path.

The use of phosphorous or nitrogen as a tracer has helped to adopt a better mode of fertilizer supply to plants.

Radioactive iodine can be used to check that a person's thyroid gland is working properly or not. A similar method can be used to study the circulation of blood using sodium-24.

Radiotracer can be used to trace any leakage in sewerage.

Question 21.20:- How can radioactivity help in treatment of cancer?

Answer:- High energy radiation can penetrate deep into the body. The malignant cancerous and pre-cancerous cells have the ability to absorb more amount of energy than healthy cells. Thus, radioactivity can be used for selective destruction of tissues, such as cancer tumor.