Q. 1 What are isotopes? What do they have in common and what are their differences?

Ans. **Isotopes**: Nuclei of elements having same atomic number but different mass number are called isotopes. They have same number of protons but numbers of neutrons are different. They have same chemical properties but different physical properties e.g., hydrogen has three isotopes like ${}_1H^1$, ${}_1H^2$ and ${}_1H^3$.

Q. 2 Why are heavy nuclei unstable?

Ans. Heavy nuclei are unstable because their binding energy per nucleon is less. Also due to weak nuclear forces as the neutrons are not tightly bound.

Q. 3 If a nucleus has a half-life of 1 year, does this mean that it will be completely decayed after 2 years? Explain.

Ans. **Half life:** Time required to decay an element into half of its original quantity is called half life.

The half-life is linked with the aggregate quantity (total number of nuclei). Its definition does not deal with a single nucleus. A single nucleus may or may not decay.

Secondly:

If instead of nucleus, we deal with quantity then it will not decay completely after 2 years. Un-decayed quantity after 1 year = ½ N_o

Un-decayed quantity after 2 years = ¼ N_o

Therefore three-fourth quantity will decay after 2 years.

Q. 4 What fraction of radioactive sample decays after two half-lives have elapsed?

Ans. Number of un-decayed atoms after first half life time $T_{1/2}$ = 50 %

Number of un-decayed atoms after first half life = ½ N_o

Number of un-decayed atoms after second half life = ¼ N_o

Therefore three-fourth quantity will decay after 2 years.

Q. 5 The radioactive element 88Ra226 has a half life of 1.6 x 10^3 years. Since the Earth is about 5 billion years old, how can you explain why we still find this element in nature?

Ans. After so many half-lives, although the activity falls, the fraction though becomes very small but never reaches zero. For complete decay infinite time is required. So some quantity of ${}^{88}Ra_{226}$ will be found after 5 billion years.

Q. 6 Describe a brief account of interaction of various types of radiations with matter.

Ans. α , β and γ radiations interact with matter. They penetrate in the matter with different ranges. They produce ionization after interaction from it, we can measure their energy. After striking they produce fluorescence with some substances. Their interactions with matter produce photoelectric effect, Compton effect and pair production.

Q. 7 Explain how α and β particles may ionize an atom without directly hitting the electrons? What is difference in action of the two particles for producing ionization?

Ans. Due to electrostatic force, after passing through matter, α and β particles produce ionization in matter. α particle being positively charged attracts an electron and β particle being negatively charged repels an electron from the atom. α particle produce intense ionization along its straight path. The ionizing ability of β particle is about 100 times less than α particles. The path of β particle is not straight but straggling or scattering.

Q. 8 A particle which produces more ionization is less penetrating. Why?

Ans. It loses much of its energy due to more ionization, and its range in the medium is small so less penetrating.

Q. 9 What information is revealed by the length and shape of the tracks of an incident particle in Wilson cloud chamber?

Ans. α- particle leaves thick, straight and continuous tracks due to intense ionization produced by them. β-particles form thin and discontinuous tracks extending in erratic manner showing frequent deflections. γ-rays leave no definite tracks along their paths.

Q.10 Why must Geiger Muller tube for detecting α -particles have a very thin end window? Why does a Geiger Muller tube for detecting γ-rays not need a window at all?

Ans. According to the range and penetrating power of α- particles, G.M. tube have very thin end window. The range of α-particle is small due to greater mass so if we take thick window sheet then it will be absorbed by the sheet. Due to high penetrating power, γ-rays do not need any window. They can penetrate even through a thick sheet, so it does not matter whether window sheet is there or not.

Q. 11 Describe the principle of operation of a solid state detector of ionizing radiation in terms of generation and detection of charge carriers.

Ans. A solid-state detector is a specially designed p-n junction. It operates under a reverse bias in which electron hole pairs are produced by the incident radiation to cause a current pulse to flow through the external circuit. Then the electrical pulse is amplified and recorded.

Q. 12 What do you mean by the term critical mass?

Ans. **Critical mass**: The minimum mass of a material that can sustain a nuclear chain reaction. It is the quantity of mass which is enough to absorb most of neutrons produced in fission chain reaction and to produce large amount of energy.

Q. 13 Discuss the advantages and disadvantages of nuclear power compared to the use of fossil fuel generated power.

Ans. One kilogram of uranium, when completely utilized in fission reaction, has about the same fuel value as 3×10^6 kg of coal. Nuclear power is an important substitute for world's energy supplies. In fossil fuel generated power plant steam comes from a boiler fired with coal. In nuclear power plant, the steam is generated by heat released from the fission process. Radiation hazards and atmosphere pollution are disadvantages of nuclear power.

Q. 14 What factors make a fusion reaction difficult to achieve?

Ans. High temperature and energy is needed to overcome high repulsive force between nucleons to form a heavy nucleus. To overcome this electrostatic force of repulsion we need fast moving nuclei, which can be produced from an accelerator. Also we can get high energy from fission reaction for fusion reaction.

Q. 15 Discuss the advantages and disadvantages of fusion power from the point of safety, pollution and resources.

Ans. We have limited resources of energy but have ever increasing demand of energy. Controlled fusion power plants are probably the promising sources of energy for the future. We have abundant supply of hydrogen and fusion is relatively safer and cleaner process compared with the fission reactions.

Safety:

Advantage: Less radiation hazards, e.g., only neutron radiation effect.

Disadvantage: Difficult to bring under control

Pollution:

Advantage: Less external radiation and contamination. No need for wasteful disposal.

Disadvantage: Needful high energy is taken from fission which is also difficult to control.

Resources:

Advantage: We have abundant supply of hydrogen.

Disadvantage: But high-energy particles or laser are needed.

Q. 16 What do you understand by "background radiation"? State two sources of this radiation.

Ans. **Background radiation**: The low intensity radiation resulting from the bombardment of the earth by cosmic rays and from the presence of naturally occurring radio-nuclides in rocks, soil, air and building materials are called background radiation.

Sources:

1- Cosmic rays apparently coming from upper atmosphere.

2- Naturally occurring radioactive materials in the earth's crust.

Q. 17 If you swallowed an α -source and a β –source, which would be the more dangerous to you? Explain why?

Ans. Swallowing α-source is more dangerous than β-source. α-particles pass through matter and produce more ionization and cause much damage. β-particles produce less ionization and pass through body as they have high penetrating power.

Q. 18 Which radiation dose would deposit more energy to your body (a) 10 mGy to your hand, or (b) 1 mGy dose to your entire body.

Ans. With 1 m Gy dose to entire body, more energy will deposit in the body as its clear from following relation:

$D = E / m$ or $E = D \times m$

For a) E_{hand} = 10 m Gy x m_{hand}
For b) Ebody = 1 mGy x m_{body}
Since $m_b$ody > 10 m_{hand}
So in second case (b) more energy will be absorbed.

Q. 19 What is a radioactive tracer? Describe one application each in medicine, agriculture and industry.

Ans. **Radioactive tracer**: Radio-isotopes used to trace the path or position of an element through a biological, chemical, or mechanical system is called radioactive tracer.

Medicine:

Diagnosis: By taking radioactive iodine with food, position of iodine can be followed by G.M. counter. So detector tells the position of the food in the digestive system.

Agriculture:

Productivity of food grains: Labeled fertilizer of radio phosphorous (P32) is placed at several depths and distances from plant. The relationship between the root growth and taking of phosphorous from the soil determine percentage productivity of food grains.

Industrial:

Labeling the elements: Labeled radioactive carbon (C14) mixed in certain compound provide a simple test of leaks in pipes and the flow of rates of liquid without effecting the actual flow.

Q. 20 How can radioactivity help in the treatment of cancer?

Ans. Cobalt-60 is often used in the treatment of cancer. Those cells that multiply rapidly absorb more radiation and are more easily destroyed. γ-rays are used for internal imaging of the brain to determine precisely the size and location of a tumour or other parts of body. Iodine-131 is used to cure cancer of thyroid gland. P32 is used for skin cancer. Safety precautions are necessary for the hospital persons and the patient.