NUCLAER PHYSICS

IGCSE RESOURCES21

Short Answer Questions:

1. **What is the purpose of using radioactive tracers in medical diagnostics?**

To diagnose conditions like cancer and locate tumors by tracking the emissions from the tracer. Radioactive tracers are chemical compounds that emit radiation, allowing doctors to visualize the internal organs and detect abnormalities such as tumors using a gamma camera.

2. **How does gamma radiation help in the treatment of cancer?**

Gamma radiation kills cancer cells by targeting tumors while minimizing damage to healthy tissue. Gamma rays can penetrate the body and are directed at cancerous tumors to destroy them, but care is taken to protect surrounding healthy tissue from radiation damage

3. **What are isotopes of carbon, and how do they differ from each other?**

Carbon has three isotopes: Carbon-12, Carbon-13, and Carbon-14. They differ in the number of neutrons: Carbon-12 has 6 neutrons, Carbon-13 has 7, and Carbon-14 has 8. Isotopes are variants of the same element that have the same number of protons but different numbers of neutrons. This difference affects their stability, with Carbon-14 being unstable and radioactive, while Carbon-12 and Carbon-13 are stable.

4. **What is nuclear fission and how is it related to isotopes?**

Nuclear fission is the splitting of a large unstable nucleus into smaller nuclei, releasing energy. It commonly involves isotopes like Uranium-235 and Plutonium-239. Nuclear fission occurs when an unstable isotope absorbs a neutron and splits, which is a process used in nuclear power stations and bombs. Isotopes such as Uranium-235 are key to this process due to their instability.

5. **What are the parent nuclei involved in nuclear fusion to form helium?**

The parent nuclei are deuterium (hydrogen-2) and tritium (hydrogen-3). In nuclear fusion, deuterium and tritium nuclei combine to form helium-4 and release energy and a neutron. These isotopes of hydrogen are essential for the fusion process.

6. **What is the significance of Einstein's equation $E=mc^2$ in nuclear fusion?**

It explains how mass is converted into energy during fusion. Einstein's equation illustrates that the mass of the products (helium-4 and a neutron) is slightly less than the mass of the parent nuclei (deuterium and tritium), and this 'lost' mass is converted into energy, which is released during the fusion process.

7. **What are some safety precautions to take when handling radioactive materials?**

Store radioactive sources in lead-lined boxes and keep them at a distance when not in use. Storing radioactive materials in lead-lined boxes helps to shield against radiation, while keeping them at a distance reduces the risk of exposure.

8. **What are the three main types of nuclear radiation?**

Alpha particles, beta particles, and gamma rays. Alpha particles are positively charged and consist of two protons and two neutrons. Beta particles are high-speed electrons with a negative charge. Gamma rays are electromagnetic waves with no charge.

9. **What happens to the uranium-235 nucleus during nuclear fission?**

It splits into two lighter nuclei, specifically Krypton-92 and Barium-141, along with the release of three neutrons and energy. During nuclear fission, the unstable uranium-235 nucleus undergoes a reaction that results in its splitting into lighter nuclei (Krypton-92 and Barium-141), releasing neutrons and energy. This process is fundamental to understanding how nuclear reactors work.

10. **Why is it important to limit the time spent handling radioactive sources?**

Limiting handling time reduces the risk of radiation exposure to yourself and others. The longer you are in proximity to radioactive materials, the greater the risk of exposure, hence minimizing handling time is a crucial safety precaution.

11. **What is the primary source of background radiation in the environment?**

Radon gas from the ground.Radon gas is released from the natural decay of uranium found in rocks and soil, making it the primary contributor to background radiation.

12. **What are the three main types of nuclear radiation emitted from unstable nuclei?**

Alpha particles, beta particles, and gamma rays. These three types of nuclear radiation are produced during the radioactive decay process of unstable atomic nuclei.

13. **What happens to the atomic and mass numbers during alpha decay?**

The atomic number decreases by 2 and the mass number decreases by 4. In alpha decay, a heavy unstable nucleus emits an alpha particle, which consists of 2 protons and 2 neutrons. This results in a new nucleus with 2 fewer protons (atomic number) and 4 fewer nucleons (mass number).

14. **How do alpha, beta, and gamma radiation differ in terms of penetrating power?**

Alpha radiation has low penetrating power, beta radiation has moderate penetrating power, and gamma radiation has high penetrating power. Alpha particles can be stopped by paper or skin, beta particles can penetrate a few millimeters of aluminum, while gamma rays can travel through several kilometers of air and require dense materials like lead or concrete to reduce their intensity.

15. **How does beta decay affect the atomic and mass numbers of a nucleus?**

The atomic number increases by 1 while the mass number remains unchanged. In beta decay, a neutron in the nucleus is converted into a proton, which increases the atomic number by 1. However, since a neutron is transformed into a proton, the total number of nucleons (mass number) remains the same.

16. **What is the half-life of iodine-131?**

8 days. The half-life of iodine-131 is the time it takes for half of the radioactive atoms in a sample to decay, which is 8 days.

17. **Why is it important to limit the time spent handling radioactive sources**?

Limiting handling time reduces the risk of radiation exposure to yourself and others. The longer you are in proximity to radioactive materials, the greater the risk of exposure, hence minimizing handling time is a crucial safety precaution.

18. **How do you calculate the initial activity of a radioactive sample considering background radiation?**

Initial activity = Measured activity - Background radiation. The initial activity of the radioactive sample is calculated by subtracting the estimated background radiation (approximately 10 counts per second) from the measured activity (approximately 50 counts per second), resulting in an initial activity of 40 counts per second.

19. **What did Rutherford's gold foil experiment reveal about the structure of the atom?**

The atom is mostly empty space with a small, dense, positively charged nucleus. Rutherford's experiment showed that most alpha particles passed through the gold foil, indicating that atoms are largely empty space. The few that were deflected or bounced back suggested the presence of a small, dense nucleus containing most of the atom's mass.

20. **How did Rutherford's findings challenge the Plum Pudding model of the atom?**

Rutherford's findings indicated that the atom has a dense nucleus, contradicting the idea of a uniform distribution of positive charge in the Plum Pudding model. The Plum Pudding model suggested that positive charge was spread out evenly throughout the atom. However, Rutherford's experiment showed that some alpha particles were deflected back, indicating a concentrated positive charge in a small nucleus, which required a new atomic model.

21. **How does ionizing radiation affect the immune system?**

It lowers the number of white blood cells, making a person more susceptible to infections. Ionizing radiation can damage or destroy white blood cells, which are crucial for fighting infections. A reduced white blood cell count compromises the immune system, increasing vulnerability to illnesses.

22. **What are some safety precautions to take when handling radioactive materials?**

Use lead-lined boxes for storage, wear gloves, use tongs, minimize handling time, and wear protective clothing. To mitigate the risks of radiation exposure, it's important to store radioactive materials safely, handle them with care, and limit the time spent in proximity to them. These practices help protect both the handler and the environment.

23. **What are isotopes?**

Isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons. Isotopes share the same chemical properties because they have the same number of protons, but they differ in mass due to the different number of neutrons.

24. **What was the main finding of Rutherford's experiment in 1909?**

Rutherford proposed a model of the atom with a dense, positively charged nucleus at the center. Rutherford's experiment revealed that atoms have a small, dense nucleus containing positive charge, which was a significant advancement in atomic theory.

25. **What does the atomic number represent in nuclear notation?**

The atomic number (Z) represents the number of protons in the nucleus of an atom. The atomic number is crucial for identifying the element and determining its position in the periodic table.

26. **What did Rutherford discover about protons in 1919?**

He identified protons as positively charged particles ejected from nitrogen gas when bombarded with alpha particles. This discovery was crucial as it confirmed the existence of protons as a key component of the atomic nucleus.

27. **What is the relative mass of a proton compared to an electron?**

About 1,800 times greater. The mass of a proton is approximately 1,800 times that of an electron, highlighting the significant difference in mass between these particles.

28. **How does mass affect the deflection of charged particles in a magnetic field?.**

Mass has a stronger influence on deflection than charge; lighter particles are deflected more. In a magnetic field, the deflection of charged particles depends on both their charge and mass. Lighter particles, like beta particles, are deflected more than heavier particles, like alpha particles, due to their lower mass, even if the charge is higher.

29. **What particles make up the nucleus of an atom?**

Protons and neutrons. The nucleus of an atom is composed of positively charged protons and uncharged neutrons, collectively known as nucleons.

30. **What is the role of Fleming's left hand rule in determining the direction of force on charged particles in a magnetic field?**

Fleming's left hand rule helps determine the direction of force acting on a charged particle in a magnetic field. Fleming's left hand rule states that if you align your left hand with the index finger pointing in the direction of the magnetic field and the middle finger in the direction of the current, the thumb will point in the direction of the force acting on the charged particle.