MEGA LECTURE

AQA (GCSE Notes)

Chapter 4: Atomic Structure

Q1. What is the approximate radius of an atom in metres?
Answer: The approximate radius of an atom is **1×10^{-10} metres**.
Solution: Atoms are very small, and their size is measured in standard form for convenience. The radius of a typical atom is around 1×10^{-10} m, which equals 0.0000000001 metres. This tiny size explains why atoms cannot be seen with the naked eye and require special equipment like electron microscopes for observation.

Q2. What particles make up the nucleus of an atom?
Answer: The nucleus of an atom is made up of **protons and neutrons**.
Solution: The nucleus is the central part of the atom and contains two types of particles: protons, which carry a positive charge, and neutrons, which have no charge. These particles account for nearly all the mass of the atom. Electrons are not found in the nucleus.

Q3. Where are electrons found in an atom?
Answer: Electrons are found in **energy levels around the nucleus**.
Solution: Electrons are negatively charged particles that move around the nucleus in fixed regions called energy levels or shells. These levels are at different distances from the nucleus and hold specific numbers of electrons. The arrangement of electrons in these levels determines the atom's chemical behaviour.

Q4. What is the charge on a proton?
Answer: A proton has a **positive charge of +1**.
Solution: Protons are subatomic particles found in the nucleus of an atom. Each proton carries a positive electric charge of +1. This positive charge balances the negative charge of electrons in a neutral atom, making the overall charge zero.

Q5. What is the charge on a neutron?
Answer: A neutron has **no charge (it is neutral)**.
Solution: Neutrons are found in the nucleus along with protons. Unlike protons, neutrons do not carry any electric charge. Their role is to add mass to the atom and help stabilise the nucleus by reducing repulsion between protons.

Q6. What is the charge on an electron?
Answer: An electron has a **negative charge of -1**.
Solution: Electrons are tiny particles that orbit the nucleus in energy levels. Each electron carries a negative charge of -1, which is equal in size but opposite in sign to the charge on a proton. In a neutral atom, the number of electrons equals the number of protons.

Q7. Why does an atom have no overall electrical charge?
Answer: An atom has no overall charge because **it contains equal numbers of protons and electrons**.
Solution: Protons are positively charged, and electrons are negatively charged. In a neutral atom, the number of protons equals the number of electrons. Their charges cancel each other out, resulting in no overall electrical charge.

Q8. How does the mass of an atom compare to the mass of its nucleus?
Answer: Almost all the mass of an atom is in its nucleus.
Solution: The nucleus contains protons and neutrons, both of which have significant mass. Electrons have a negligible mass in comparison. Therefore, the total mass of the atom is almost equal to the combined mass of the protons and neutrons in the nucleus.

Q9. How much smaller is the nucleus compared to the whole atom?
Answer: The nucleus is **less than 1/10,000 the size of the atom**.
Solution: Although the nucleus contains nearly all the mass of the atom, it occupies a tiny fraction of its volume. Its radius is less than 1/10,000 that of the whole atom, making it extremely dense.

Q10. What happens to an electron when an atom absorbs electromagnetic radiation?
Answer: The electron **gains energy and moves to a higher energy level**.
Solution: When an atom absorbs energy, its electrons absorb the energy and jump to a higher energy level, further from the nucleus. This process is called excitation and depends on the amount of energy absorbed.

Q11. What happens to an electron when it emits electromagnetic radiation?
Answer: The electron **loses energy and moves to a lower energy level**.
Solution: When an excited electron returns to its original or lower energy level, it releases the extra energy as electromagnetic radiation. This emission results in light or other forms of radiation depending on the energy change.

Q12. What is meant by energy levels in an atom?
Answer: Energy levels are **fixed distances from the nucleus where electrons are found**.
Solution: Electrons in atoms occupy certain allowed orbits known as energy levels or shells. Each level corresponds to a specific amount of energy. Electrons can move between these levels by absorbing or emitting energy.

Q13. What is the atomic number of an element?
Answer: The atomic number is **the number of protons in an atom**.
Solution: The atomic number uniquely identifies an element. All atoms of a given element have the same number of protons in their nucleus. For example, carbon always has 6 protons, so its atomic number is 6.

Q14. What does the atomic number tell us about an atom?
Answer: It tells us **how many protons and, in a neutral atom, how many electrons it has**.
Solution: The atomic number defines the identity of an element. It equals the number of protons in the nucleus. In a neutral atom, the number of electrons equals the number of protons, so the atomic number also tells us the electron count.

Q15. What is the mass number of an atom?
Answer: The mass number is **the total number of protons and neutrons in the nucleus**.
Solution: To find the mass number, you add the number of protons and the number of neutrons in an atom. This number gives the total mass of the nucleus since electrons contribute very little mass.

Q16. What does the mass number represent?
Answer: It represents **the total number of protons and neutrons in an atom**.
Solution: Since electrons have negligible mass, the mass number is almost equal to the atomic mass. It reflects the combined mass of protons and neutrons in the nucleus.

Q17. How can you calculate the number of neutrons in an atom?
Answer: Number of neutrons = **Mass number − Atomic number**
Solution:
Step 1: Identify the mass number (protons + neutrons)
Step 2: Identify the atomic number (number of protons)
Step 3: Subtract the atomic number from the mass number
Formula: Neutrons = Mass number − Atomic number

Q18. What are isotopes?
Answer: Isotopes are **atoms of the same element with the same number of protons but different numbers of neutrons**.
Solution: All isotopes of an element have the same atomic number, so they are the same element, but different mass numbers because the number of neutrons varies. For example, carbon-12 and carbon-14 are isotopes of carbon.

Q19. How do isotopes of the same element differ?
Answer: They differ in **the number of neutrons and their mass number**.
Solution: Although isotopes have the same number of protons and electrons, the number of neutrons is different. This changes their mass number and can affect their physical properties or stability, such as radioactive decay.

Q20. Why do isotopes have different mass numbers?
Answer: Because they have **different numbers of neutrons** in their nuclei.
Solution: The mass number is the sum of protons and neutrons. Since isotopes have the same number of protons but different numbers of neutrons, their mass numbers differ.

Q21. Do isotopes of the same element have the same number of protons?
Answer: Yes, isotopes **always have the same number of protons**.
Solution: The number of protons defines the element. If the proton count changes, the atom becomes a different element. Isotopes only vary in their neutron count, not their proton count.

Q22. Why do isotopes have different numbers of neutrons?
Answer: To maintain **nuclear stability** in different atomic conditions.
Solution: Atoms may require different neutron numbers to remain stable. Some combinations of protons and neutrons are more stable than others, so nature allows for variation in neutron count within the same element.

Q23. What happens to an atom when it loses an electron?
Answer: It becomes a **positively charged ion (cation)**.
Solution: Electrons are negatively charged. When an atom loses one or more electrons, it has more protons than electrons, resulting in a net positive charge. This new particle is called a positive ion or cation.

Q24. Why does losing electrons make an atom a positive ion?
Answer: Because **the number of positive charges becomes greater than the negative charges**.
Solution: Normally, atoms have equal numbers of protons and electrons. When electrons are lost, the balance is disrupted, and the atom has more protons, giving it an overall positive charge.

Q25. How is an ion different from a neutral atom?
Answer: An ion has **a net electrical charge**, while a neutral atom has **no overall charge**.
Solution: A neutral atom has equal numbers of protons and electrons. When it gains or loses electrons, it becomes an ion. If it loses electrons, it becomes positively charged. If it gains electrons, it becomes negatively charged.

Q26. Can an atom become negatively charged? How?
Answer: Yes, an atom becomes negatively charged by gaining one or more electrons.
Solution: An atom is electrically neutral when the number of protons equals the number of electrons. If it gains extra electrons, it will have more negative charges than positive ones. This imbalance causes the atom to become a negative ion, also called an anion. For example, an oxygen atom can gain two electrons and become O^{2-}.

Q27. What is the standard form of 0.0000000001?
Answer: The standard form of 0.0000000001 is 1×10^{-10}.
Solution: Step 1: Identify the first non-zero digit, which is 1. Step 2: Count the number of places from the decimal point to that digit — it's 10 places. Step 3: Rewrite the number in the form of $a \times 10^{-n}$. Final answer: 1×10^{-10}.

Q28. Why is standard form used in atomic measurements?
Answer: Standard form is used because atomic measurements are very small and standard form

makes them easier to write, read and compare.

Solution: Atomic values such as the radius of an atom or mass of subatomic particles are so small that they include many zeros. Writing these numbers in full is difficult and leads to errors. For example, 0.0000000001 m is easier to write as 1×10^{-10} m. Standard form also helps in scientific calculations and communication.

Q29. Write the radius of an atom in standard form.

Answer: The radius of an atom in standard form is 1×10^{-10} metres.

Solution: The radius of a typical atom is around 0.0000000001 m. To convert this into standard form: Step 1: Find the first non-zero digit (1). Step 2: Count the decimal places up to 1 (10 places). Step 3: Write it as 1×10^{-10} m.

Q30. If the radius of an atom is 1×10^{-10} m, what would be the approximate radius of its nucleus?

Answer: The approximate radius of a nucleus is 1×10^{-14} m.

Solution: The radius of a nucleus is about 1/10,000 the radius of an atom. Step 1: Atomic radius = 1×10^{-10} m. Step 2: Divide by 10,000 = $(1 \times 10^{-10}) \div (1 \times 10^{4}) = 1 \times 10^{-14}$ m. Final answer: 1×10^{-14} m.

Q31. What is the relative mass of a proton?

Answer: The relative mass of a proton is 1.

Solution: Protons have a mass of approximately 1 atomic mass unit (u). This value is used as a reference when comparing the masses of other subatomic particles. It is not the exact mass in kilograms but a standard relative value.

Q32. What is the relative mass of a neutron?

Answer: The relative mass of a neutron is 1.

Solution: Neutrons have almost the same mass as protons, which is why their relative mass is also taken as 1 atomic mass unit. This makes it easy to calculate the mass number of an atom by just counting protons and neutrons.

Q33. What is the relative mass of an electron?

Answer: The relative mass of an electron is approximately 1/1836.

Solution: Electrons are much lighter than protons and neutrons. Their relative mass is around 1 ÷ 1836 = 0.000544, but for most purposes, it is considered negligible and often taken as 0 in mass number calculations.

Q34. How does the electron arrangement in atoms change with energy absorption?

Answer: Electrons move to higher energy levels when energy is absorbed.

Solution: When an atom absorbs electromagnetic radiation, the electrons gain energy. This causes them to jump to an energy level further away from the nucleus. This is called excitation. The electron can later return to its original level by emitting energy.

Q35. Why do electrons move to lower energy levels?
Answer: Electrons move to lower energy levels when they lose energy.
Solution: Electrons in excited states are unstable and tend to return to their ground state. To do this, they release energy in the form of electromagnetic radiation. This process is called relaxation or emission.

Q36. How do you calculate the number of protons in an atom?
Answer: The number of protons is equal to the atomic number.
Solution: Step 1: Identify the atomic number (Z) from the periodic table or given data. Step 2: Since atomic number = number of protons, the value of Z directly gives the number of protons. For example, if Z = 6, then the atom has 6 protons.

Q37. What is the symbol used to represent atomic number?
Answer: The symbol for atomic number is Z.
Solution: In atomic notation, Z represents the number of protons in the nucleus of an atom. It also tells us the position of the element in the periodic table and determines the element's identity.

Q38. What is the symbol used to represent mass number?
Answer: The symbol for mass number is A.
Solution: Mass number (A) equals the number of protons and neutrons in the atom. It is used in isotope notation where an element is written as:
A
Element
Z

Q39. How can the number of electrons in a neutral atom be found?
Answer: It is equal to the number of protons (atomic number).
Solution: In a neutral atom, the positive charge from protons equals the negative charge from electrons. So, number of electrons = atomic number. For example, oxygen has atomic number 8, so it has 8 electrons in the neutral state.

Q40. Why is the nucleus positively charged?
Answer: Because it contains positively charged protons.
Solution: The nucleus is made up of protons and neutrons. Since protons have a charge of +1 and neutrons have no charge, the overall charge of the nucleus is positive. Electrons, which are negative, orbit around the nucleus and are not part of it.

Q41. What keeps electrons attracted to the nucleus?
Answer: The electrostatic force between negative electrons and positive protons.
Solution: Opposite charges attract. The negative electrons are attracted to the positive nucleus due to the electrostatic force. This keeps the electrons in their orbits around the nucleus despite their motion.

Q42. What happens if the number of protons and electrons in an atom are not equal?
Answer: The atom becomes an ion.
Solution: If there are more electrons than protons, the atom becomes a negative ion (anion). If there are more protons than electrons, it becomes a positive ion (cation). The atom is no longer neutral because the charges are unbalanced.

Q43. What determines the chemical properties of an atom?
Answer: The number and arrangement of electrons, especially in the outer shell.
Solution: Chemical reactions involve electrons, particularly the outermost ones (valence electrons). Elements with similar outer electron arrangements have similar chemical properties, which is why elements in the same group behave alike.

Q44. How can two atoms be of the same element but have different masses?
Answer: Because they have different numbers of neutrons.
Solution: These atoms are called isotopes. They have the same number of protons (so they're the same element) but differ in their neutron count, which changes their mass number. For example, carbon-12 and carbon-14 are isotopes of carbon.

Q45. What is meant by the term 'neutral atom'?
Answer: A neutral atom has equal numbers of protons and electrons.
Solution: In this state, the total positive charge from protons is balanced by the total negative charge from electrons. This results in zero overall electrical charge. Most atoms in their stable, natural state are neutral.

Q46. Why are electrons said to have negligible mass?
Answer: Because their mass is extremely small compared to protons and neutrons.
Solution: The relative mass of an electron is about 1/1836 of a proton or neutron. This is so small that, in most calculations like mass number, electron mass is ignored to simplify the maths.

Q47. What is meant by 'standard form' in scientific notation?
Answer: It is a way to write very large or very small numbers as $a \times 10^n$.
Solution: In scientific notation, a number is expressed as a number between 1 and 10 multiplied by 10 raised to an integer power. For example, 0.00001 becomes 1×10^{-5}. It helps make calculations and reading easier.

Q48. Why is most of an atom's mass concentrated in its nucleus?
Answer: Because protons and neutrons are in the nucleus and they are much heavier than electrons.
Solution: Electrons have very little mass. Since the nucleus contains protons and neutrons, which have a relative mass of 1 each, almost the entire mass of the atom is located in the nucleus.

Q49. How are atoms of different elements identified?
Answer: By their atomic number (number of protons).

Solution: Each element has a unique atomic number. For example, hydrogen has 1 proton, so its atomic number is 1. Carbon has 6 protons, so its atomic number is 6. No two elements can have the same atomic number.

Q50. What does it mean when an atom is described using both mass number and atomic number?

Answer: It means we know both the number of protons and the total number of protons plus neutrons.

Solution: Atomic number (Z) tells us the number of protons. Mass number (A) tells us the sum of protons and neutrons. Using both, we can calculate the number of neutrons: Neutrons = $A - Z$. This helps in identifying isotopes and understanding atomic structure.

Q51. What was the earliest model of the atom before electrons were discovered?

Answer: The earliest model of the atom was that it was a tiny, solid, indivisible sphere.

Solution: Before the discovery of electrons, scientists believed atoms were the smallest units of matter and could not be divided further. This idea came from Dalton's atomic theory, which described atoms as solid spheres that made up all substances. There was no knowledge of subatomic particles at that time.

Q52. Why was the atom once thought to be an indivisible solid sphere?

Answer: Because there was no evidence of smaller particles inside the atom.

Solution: In the early 1800s, John Dalton proposed that atoms were indivisible because scientists had no tools or experiments to show otherwise. Atoms were considered the basic building blocks of matter and thought to be the smallest possible units without internal structure.

Q53. What discovery led to the development of the plum pudding model?

Answer: The discovery of the electron led to the plum pudding model.

Solution: In 1897, J.J. Thomson discovered the electron, a negatively charged particle inside the atom. This proved that atoms were not indivisible and had internal structure. To explain this, he proposed the plum pudding model where electrons were embedded in a ball of positive charge.

Q54. Describe the main idea of the plum pudding model of the atom.

Answer: The plum pudding model suggested the atom is a ball of positive charge with electrons scattered inside.

Solution: J.J. Thomson's model showed the atom as a uniform sphere of positive charge (like pudding) with negatively charged electrons (like plums) embedded throughout. It explained the presence of electrons but assumed the positive charge was spread out evenly.

Q55. What role did the electron play in changing early atomic models?

Answer: The discovery of the electron showed atoms had internal structure, leading to new models.

Solution: Before electrons were discovered, atoms were thought to be indivisible. The identification of negatively charged electrons proved that atoms were made up of smaller particles. This finding forced scientists to change the model from a solid sphere to one that included electrons.

Q56. How did the plum pudding model explain the structure of the atom?
Answer: It said atoms were spheres of positive charge with electrons spread throughout.
Solution: The plum pudding model described the atom as a positively charged mass that held negatively charged electrons. This model assumed the positive charge was not concentrated, and electrons were scattered evenly within it to balance the charges.

Q57. What was the main conclusion from the alpha particle scattering experiment?
Answer: Most of the mass and all of the positive charge are in a small central nucleus.
Solution: In Rutherford's experiment, most alpha particles passed straight through the gold foil, but some were deflected sharply. This showed that the atom is mostly empty space and that its mass and positive charge are concentrated in a tiny central nucleus.

Q58. How did the alpha particle scattering experiment lead to the nuclear model?
Answer: It showed that atoms have a dense, positively charged nucleus.
Solution: The unexpected deflections of alpha particles could not be explained by the plum pudding model. Rutherford concluded that the atom has a small central nucleus where most of the mass and positive charge are found, and electrons orbit around it. This was the start of the nuclear model.

Q59. What did most alpha particles do in Rutherford's experiment?
Answer: Most passed straight through the gold foil.
Solution: Rutherford observed that the majority of the alpha particles went through without deflection, indicating that atoms are mostly empty space. This contradicted the plum pudding model which would have caused more resistance to the particles.

Q60. What did it mean when some alpha particles were deflected at large angles?
Answer: It meant they encountered a dense, positively charged centre.
Solution: Large deflections suggested that alpha particles came close to something massive and positively charged. This supported the idea of a small nucleus in the centre of the atom, which repelled the positively charged alpha particles.

Q61. What did the deflections of alpha particles suggest about the atom?
Answer: That the atom has a small, dense, positively charged nucleus.
Solution: The fact that only a few particles were deflected sharply showed that the nucleus must be small compared to the size of the atom. The rest of the atom is empty space, allowing most alpha particles to pass through.

Q62. Why did the plum pudding model fail to explain the scattering results?
Answer: It predicted uniform distribution of charge, so alpha particles should not deflect much.
Solution: In the plum pudding model, the positive charge was spread out, so deflections would be slight and uniform. The actual sharp deflections seen in the experiment proved the charge was concentrated in a nucleus, so the plum pudding model was incorrect.

Q63. What is the main difference between the plum pudding model and the nuclear model?
Answer: The plum pudding model had no nucleus, while the nuclear model did.
Solution: The plum pudding model described the atom as a diffuse ball of positive charge with electrons scattered inside. In contrast, the nuclear model has a central nucleus containing protons, with electrons orbiting around the outside.

Q64. Who proposed the nuclear model of the atom?
Answer: Ernest Rutherford proposed the nuclear model.
Solution: After analysing the results of the alpha scattering experiment in 1909, Rutherford suggested a new model where the atom has a small dense nucleus containing all the positive charge and most of the mass, surrounded by orbiting electrons.

Q65. In the nuclear model, where is most of the mass of the atom found?
Answer: Most of the mass is found in the nucleus.
Solution: Protons and neutrons, which have nearly all the mass of an atom, are located in the nucleus. Electrons have very little mass, so the nucleus accounts for almost all the atom's weight.

Q66. Why is the nucleus considered dense in the nuclear model?
Answer: Because it contains nearly all the mass in a very small volume.
Solution: The nucleus is tiny compared to the overall size of the atom but contains the protons and neutrons. This means that a lot of mass is concentrated in a small space, which is the definition of density.

Q67. How are electrons arranged in Bohr's adaptation of the nuclear model?
Answer: Electrons are arranged in fixed orbits at set distances from the nucleus.
Solution: Bohr modified the nuclear model by proposing that electrons travel in circular orbits, or energy levels, around the nucleus. These orbits are at specific distances, and electrons can move between them by absorbing or releasing energy.

Q68. Why did Bohr suggest that electrons orbit at fixed distances?
Answer: Because it matched the observed patterns of atomic spectra.
Solution: Bohr found that if electrons orbited at fixed distances, it could explain why atoms absorb and emit light at specific wavelengths. This agreed with experimental data and helped make the model more accurate.

Q69. What evidence supported Bohr's idea of fixed electron orbits?
Answer: The pattern of lines in atomic emission spectra matched Bohr's predictions.
Solution: When elements are heated or electrified, they emit light at specific wavelengths. Bohr's model explained these emissions as electrons moving between fixed energy levels, releasing energy as light. The match between predicted and observed lines supported his model.

Q70. How did Bohr's model differ from Rutherford's model?
Answer: Bohr's model added fixed electron orbits to Rutherford's nuclear model.

Solution: Rutherford's model had electrons orbiting a nucleus but didn't explain their behaviour. Bohr improved this by suggesting that electrons move in specific, stable orbits and only jump between them by absorbing or emitting energy.

Q71. What was the limitation of Rutherford's atomic model?
Answer: It couldn't explain why electrons didn't spiral into the nucleus.
Solution: According to physics, orbiting electrons should emit energy and spiral inward. Rutherford's model didn't solve this problem, making it unstable in theory. Bohr's model fixed this by introducing stable energy levels.

Q72. Why was Bohr's model considered an improvement over previous models?
Answer: Because it explained electron stability and matched experimental data.
Solution: Bohr's model explained why electrons stay in stable orbits and how atoms absorb or emit specific energies of light. It provided a clearer understanding of atomic structure and matched the results of experiments.

Q73. How did new experiments lead to changes in atomic theory?
Answer: New experiments gave evidence that didn't fit old models, forcing scientists to revise them.
Solution: Scientific theories must match experimental data. When alpha scattering showed unexpected results, the plum pudding model couldn't explain them. So scientists created new models, like the nuclear and Bohr models, to better describe observations.

Q74. What is meant by the term 'scientific model'?
Answer: A scientific model is a simplified idea or representation that explains how something works.
Solution: Models help scientists describe and predict natural phenomena. Atomic models represent what atoms might look like based on current evidence. As new data appears, models are tested, refined, or replaced to better match reality.

Q75. How can scientific models change over time?
Answer: They change when new evidence shows the current model is incomplete or incorrect.
Solution: Scientific models are not fixed truths. They are updated as better tools and experiments provide new observations. For example, the solid sphere model was replaced by the plum pudding model, then the nuclear model, then Bohr's model — all based on improved evidence.

Q76. Who discovered the proton?
Answer: Ernest Rutherford discovered the proton.
Solution: During further investigations into atomic structure after the alpha particle scattering experiment, Rutherford observed that hydrogen nuclei were emitted from other atoms during collisions. He identified these as fundamental particles with a positive charge and called them protons. This discovery showed that the positive charge in the nucleus came from smaller particles.

Q77. What did scientists realise about positive charge in the nucleus?
Answer: They realised it was made up of smaller particles called protons.

Solution: As the nuclear model developed, scientists found that the nucleus wasn't just a general positive mass, but it was composed of specific particles. Experiments showed that this positive charge could be divided into equal parts, each with a charge of +1. These were identified as protons, which became key to understanding atomic number.

Q78. What are protons and what charge do they carry?
Answer: Protons are subatomic particles with a positive charge of +1.
Solution: Protons are found in the nucleus of every atom. They define the identity of an element because the number of protons is the atomic number. Each proton has a relative mass of 1 and a charge of +1. This positive charge helps balance the negative electrons around the nucleus.

Q79. Why was the discovery of the proton important in atomic structure?
Answer: It explained the source of positive charge in the nucleus and helped define atomic number.
Solution: Before the discovery of protons, the positive charge in atoms was not fully understood. Identifying the proton showed that this charge came from distinct particles. This allowed scientists to link atomic number to the number of protons, giving a clearer understanding of how elements differ from each other.

Q80. How was the existence of neutrons discovered?
Answer: The neutron was discovered through experiments showing extra mass in the nucleus not due to protons.
Solution: Scientists observed that some atomic nuclei were heavier than could be explained by protons alone. These extra mass units had no charge, so they couldn't be electrons or protons. Eventually, experiments by James Chadwick showed that these neutral particles existed, and he named them neutrons.

Q81. Who provided evidence for the existence of neutrons?
Answer: James Chadwick provided the evidence for neutrons.
Solution: In 1932, James Chadwick carried out experiments where he bombarded beryllium with alpha particles and observed radiation that could not be explained by known particles. He concluded that the radiation was made of neutral particles with mass similar to protons — neutrons.

Q82. Why was the discovery of the neutron significant?
Answer: It completed the understanding of atomic structure and explained isotopes.
Solution: Without the neutron, scientists couldn't explain why atoms of the same element could have different masses. Neutrons helped explain isotopes, atomic mass, and nuclear stability. They also played a crucial role in understanding nuclear reactions like fission.

Q83. Why did it take so long to discover the neutron?
Answer: Because neutrons have no charge and are difficult to detect.
Solution: Unlike protons and electrons, neutrons do not interact with electric or magnetic fields, making them invisible to many detection methods. Early experiments were not sensitive enough to

detect particles without charge, so it wasn't until advanced techniques were used that their presence was confirmed.

Q84. How did the discovery of the neutron change the nuclear model?
Answer: It added neutrons to the nucleus and explained atomic mass and isotopes more accurately.
Solution: Before neutrons were discovered, the nucleus was thought to contain only protons. This couldn't explain the full mass of atoms or why some atoms of the same element had different masses. Adding neutrons to the model gave a complete picture of the nucleus and led to a better understanding of atomic stability.

Q85. Why is it important that scientific theories are tested by experiments?
Answer: Because only through experiments can we know if a theory correctly explains nature.
Solution: A scientific theory must match observations and evidence. If an experiment shows results that don't fit a theory, the theory must be changed or replaced. Testing ensures theories stay accurate and up to date. For example, the plum pudding model was replaced after the alpha scattering experiment.

Q86. What does the development of the atomic model tell us about scientific progress?
Answer: It shows that science improves over time through evidence and better understanding.
Solution: The atomic model has changed many times—from Dalton's solid sphere to Bohr's electron orbits—each based on new discoveries. This shows that science is not fixed; it grows as more experiments are done and better explanations are found. Science is a continuous process of improvement.

Q87. How does the nuclear model explain atomic mass better than previous models?
Answer: It includes both protons and neutrons in the nucleus, which account for nearly all the atom's mass.
Solution: Earlier models didn't explain why some atoms of the same element had different masses. The nuclear model includes neutrons, which have mass but no charge. Together, the number of protons and neutrons (mass number) gives a more accurate total atomic mass.

Q88. What charge does the nucleus of an atom carry according to the nuclear model?
Answer: The nucleus carries a positive charge.
Solution: The nucleus contains protons, which are positively charged, and neutrons, which are neutral. Since neutrons have no charge, the net charge of the nucleus comes entirely from the protons. Therefore, the nucleus always has a positive charge.

Q89. Why were electrons not found inside the nucleus in Bohr's model?
Answer: Because electrons orbit the nucleus in fixed paths, not within the nucleus.
Solution: Bohr suggested that electrons move in defined energy levels or shells around the nucleus. If electrons were inside the nucleus, they would collapse into the positive charge due to attraction. Fixed orbits keep electrons at stable distances, avoiding this collapse.

Q90. How do fixed electron orbits prevent electrons from spiralling into the nucleus?
Answer: They restrict electrons to specific energy levels, preventing energy loss.
Solution: Bohr proposed that electrons can only occupy certain orbits where they don't radiate energy. This stops them from gradually losing energy and spiralling inward. Electrons can move to other levels only by absorbing or emitting fixed amounts of energy.

Q91. What is one reason models are replaced in science?
Answer: Because new evidence shows the current model doesn't fully explain observations.
Solution: Scientific models are based on the best available data. When experiments like the alpha scattering experiment showed results the plum pudding model couldn't explain, scientists had to change their model to something more accurate, like the nuclear model.

Q92. How did experimental results challenge the plum pudding model?
Answer: The deflection of alpha particles showed the positive charge was concentrated, not spread out.
Solution: In the plum pudding model, alpha particles should pass through with little deflection. But many were deflected at large angles, and some even bounced back. This meant that the positive charge had to be in a small, dense centre, which the model didn't predict.

Q93. What does the atomic model tell us about the internal structure of matter?
Answer: It shows that matter is made of atoms with a nucleus and electrons in shells.
Solution: The atomic model describes atoms as having a central nucleus containing protons and neutrons, with electrons in defined orbits. This structure explains mass, charge, chemical behaviour, and how atoms bond and react. It gives a deep understanding of what matter is made of.

Q94. Why was it important to test the structure of atoms using scattering experiments?
Answer: Because these experiments revealed the arrangement of particles inside atoms.
Solution: The alpha scattering experiment gave unexpected results that showed the presence of a dense, positively charged nucleus. Without such tests, scientists would have no way to know what atoms look like inside or how subatomic particles are arranged.

Q95. What did the scattering experiment show about empty space in atoms?
Answer: It showed that atoms are mostly empty space.
Solution: Since most alpha particles passed through the gold foil without deflection, Rutherford concluded that atoms must be mostly empty space, with only a small part—the nucleus—causing deflections. This changed the view of atoms from solid spheres to mostly empty structures.

Q96. What was one unexpected result from the alpha scattering experiment?
Answer: Some alpha particles were deflected at large angles or bounced back.
Solution: Based on the plum pudding model, this was not expected. The sharp deflections suggested the alpha particles had hit something dense and positively charged, leading Rutherford to conclude that there was a central nucleus in the atom.

Q97. How did Rutherford interpret the deflection of a few alpha particles?
Answer: He said they had collided with a dense, positively charged nucleus.
Solution: Since a few alpha particles bounced back, Rutherford concluded that they had struck a very small, dense area with a strong positive charge. This area was later named the nucleus and became a key part of the nuclear model of the atom.

Q98. What does the term 'nuclear' refer to in the nuclear model?
Answer: It refers to the central nucleus of the atom.
Solution: The word "nuclear" comes from "nucleus," which is the dense core of the atom containing protons and neutrons. The nuclear model focuses on this part of the atom and explains atomic mass and charge based on it.

Q99. Why do we need models to describe atoms?
Answer: Because atoms are too small to see, so models help us understand and predict their behaviour.
Solution: Scientific models give us a way to visualise and explain things we can't see directly. Atoms are extremely small, so we rely on models to describe their structure, interactions, and how they form substances. These models guide experiments and help explain results.

Q100. How do atomic models help scientists understand chemical behaviour?
Answer: They show how electrons are arranged, which affects how atoms react.
Solution: The arrangement of electrons, especially in the outer shell, determines how atoms form bonds and take part in reactions. Models like Bohr's help explain why certain elements are reactive, how molecules form, and why elements in the same group behave similarly.

Q101. What is meant by the term radioactive decay?
Answer: Radioactive decay is the process by which an unstable atomic nucleus loses energy by emitting radiation.
Solution:
During radioactive decay, an unstable nucleus changes into a more stable one by releasing particles or energy. This can include the release of alpha particles, beta particles, or gamma rays. The atom may change into a different element depending on the type of decay. This process happens naturally and cannot be controlled.

Q102. Why is radioactive decay described as a random process?
Answer: Radioactive decay is described as a random process because it is impossible to predict exactly when a specific nucleus will decay.
Solution:
Even though we can estimate how many atoms will decay over a period using probability, we cannot say when any one atom will decay. Each atom behaves independently, and decay happens without a pattern. This randomness is due to quantum mechanics and the nature of unstable nuclei.

Q103. What happens to the nucleus during radioactive decay?
Answer: During radioactive decay, the nucleus of an unstable atom changes by emitting radiation, making it more stable.
Solution:
The change depends on the type of decay: in alpha decay, the nucleus loses two protons and two neutrons; in beta decay, a neutron changes into a proton and an electron is emitted; in gamma decay, the nucleus releases energy but does not change its particles. This process transforms the atom into a different isotope or a new element.

Q104. What is the unit used to measure the activity of a radioactive source?
Answer: The unit used to measure the activity of a radioactive source is the becquerel (Bq).
Solution:
Activity refers to the number of decays happening per second. One becquerel means one nuclear decay per second. It is a standard unit used internationally to quantify radioactivity levels in samples.

Q105. Define the term 'activity' in relation to a radioactive source.
Answer: Activity is the number of radioactive decays occurring per second in a radioactive material.
Solution:
It tells us how active a radioactive source is. The more atoms that decay per second, the higher the activity. It is measured in becquerels (Bq). For example, if 100 atoms decay in 1 second, the activity is 100 Bq.

Q106. What does count-rate measure in a radioactive experiment?
Answer: Count-rate measures the number of radiation detections per second by a detector like a Geiger-Müller tube.
Solution:
It is used to find out how much radiation is being emitted by a radioactive source. The higher the count-rate, the more radiation is being detected. This can help in comparing different sources or measuring shielding effects.

Q107. Name one device that can be used to detect nuclear radiation.
Answer: A Geiger-Müller (GM) tube is commonly used to detect nuclear radiation.
Solution:
This device clicks or shows a reading when it detects radiation. It works by ionising the gas inside the tube, causing a flow of current that can be counted. It is sensitive to alpha, beta, and gamma radiation.

Q108. What is an alpha particle made of?
Answer: An alpha particle is made of two protons and two neutrons.
Solution:
This means it is the same as a helium nucleus. Because it contains four nucleons, it is relatively heavy and has a +2 charge. It is emitted during alpha decay and has strong ionising power.

Q109. How many protons are in an alpha particle?
Answer: There are two protons in an alpha particle.
Solution:
Since an alpha particle is a helium nucleus, and helium has two protons, the number of protons in an alpha particle is 2. This gives it a positive charge.

Q110. How many neutrons are in an alpha particle?
Answer: There are two neutrons in an alpha particle.
Solution:
The total mass number of an alpha particle is 4 (2 protons + 2 neutrons). Subtracting the 2 protons leaves 2 neutrons. These contribute to the mass but not the charge.

Q111. What is a beta particle?
Answer: A beta particle is a high-speed electron emitted from the nucleus during beta decay.
Solution:
It forms when a neutron turns into a proton, and an electron is released. This electron is the beta particle. It has a negative charge and less mass than an alpha particle.

Q112. What happens in the nucleus during beta decay?
Answer: In beta decay, a neutron in the nucleus changes into a proton and emits an electron (beta particle).
Solution:
This changes the atomic number of the element, creating a new element. The mass number stays the same because only the type of nucleon changes, not the total number.

Q113. What is a gamma ray?
Answer: A gamma ray is a high-energy electromagnetic wave emitted from a nucleus.
Solution:
It usually happens after alpha or beta decay when the nucleus has excess energy. Gamma rays carry no charge or mass but are very penetrating and travel at the speed of light.

Q114. Which type of nuclear radiation is electromagnetic?
Answer: Gamma radiation is the type of nuclear radiation that is electromagnetic.
Solution:
Unlike alpha and beta particles, gamma rays are not made of particles. They are waves of energy similar to X-rays but more energetic, and they are not affected by electric or magnetic fields.

Q115. Which type of nuclear radiation has the greatest ionising power?
Answer: Alpha radiation has the greatest ionising power.
Solution:
Because alpha particles are large and carry a +2 charge, they strongly interact with matter and can ionise atoms easily. However, they do not travel far and are easily stopped.

Q116. Which nuclear radiation can be stopped by paper?

Answer: Alpha radiation can be stopped by a sheet of paper.

Solution:

Even a few centimetres of air or the outer layer of skin can stop alpha particles. Their low penetration makes them easy to block but still dangerous if inhaled or ingested.

Q117. Which nuclear radiation can travel furthest in air?

Answer: Gamma radiation can travel the furthest in air.

Solution:

Since gamma rays are electromagnetic waves, they are not easily stopped and can travel several metres in air. They require thick lead or concrete for proper shielding.

Q118. Which type of nuclear radiation has the least ionising power?

Answer: Gamma radiation has the least ionising power.

Solution:

Although it is very penetrating, it does not interact with matter easily, so it causes less ionisation compared to alpha and beta particles.

Q119. What happens to the mass and charge of a nucleus after alpha decay?

Answer: After alpha decay, the mass number decreases by 4 and the atomic number decreases by 2.

Solution:

This is because an alpha particle contains 2 protons and 2 neutrons. Losing it reduces the charge (number of protons) and the overall mass of the nucleus.

Q120. What happens to the charge of the nucleus during beta decay?

Answer: During beta decay, the charge of the nucleus increases by 1.

Solution:

A neutron changes into a proton and an electron. The proton stays in the nucleus, increasing its positive charge by one, while the electron (beta particle) is emitted.

Q121. Why does the mass of the nucleus stay the same during beta decay?

Answer: The mass stays the same because a neutron changes into a proton, and both have similar mass.

Solution:

The total number of nucleons (protons + neutrons) does not change. Only the type changes, so the mass number remains constant.

Q122. What is the effect of gamma emission on the nucleus?

Answer: Gamma emission reduces the energy of the nucleus without changing its mass or charge.

Solution:

It happens when the nucleus is in an excited state and releases excess energy. This stabilises the nucleus but does not change its structure.

Q123. Why is gamma radiation used in medical treatments?

Answer: Gamma radiation is used in medical treatments because it can kill cancer cells deep inside the body without surgery.

Solution:

Its high penetration allows it to reach tumours that cannot be removed easily. It can be focused to reduce damage to healthy tissues.

Q124. Why are alpha emitters not suitable for internal medical use?

Answer: Alpha emitters are not suitable for internal use because they are highly ionising and cause severe damage to tissues if inhaled or ingested.

Solution:

Although they can't travel far, once inside the body they can ionise cells and damage DNA very quickly, leading to harmful side effects.

Q125. Why are beta sources often used in thickness monitoring?

Answer: Beta sources are used in thickness monitoring because beta particles can partially pass through materials, making it possible to measure thickness.

Solution:

If the material is too thick, fewer beta particles pass through. If it's too thin, more pass through. The detector picks up this change and helps control thickness in manufacturing.

Q126. What kind of material can stop beta particles?

Answer: A few millimetres of aluminium can stop beta particles.

Solution: Beta particles are electrons emitted during radioactive decay. They are more penetrating than alpha particles but can be stopped by materials such as aluminium, plastic, or even thick paper. A sheet of aluminium around 3–5 mm thick is usually enough to stop most beta radiation.

Q127. What kind of material is needed to stop gamma rays?

Answer: Thick layers of lead or concrete are needed to stop gamma rays.

Solution: Gamma rays are electromagnetic waves with high energy. They are very penetrating and require dense materials to absorb or weaken them. Lead is most commonly used because of its high atomic number and density, which help reduce gamma radiation effectively. Thick concrete is also used in building nuclear shielding.

Q128. Why is lead used to shield against gamma radiation?

Answer: Lead is used because it is very dense and can absorb gamma rays effectively.

Solution: Gamma rays can penetrate most materials, but lead's high density and atomic number make it excellent at absorbing gamma radiation. It reduces the intensity of radiation through a process called attenuation, which is why lead is used in x-ray rooms and nuclear facilities.

Q129. How can the activity of a radioactive source be measured?

Answer: The activity is measured using a radiation detector like a Geiger-Müller tube and is recorded in becquerels (Bq).

Solution: To measure activity, place a detector near the radioactive source. The detector counts how many decays occur per second. This count is converted into becquerels (1 Bq = 1 decay per second). More advanced devices may show digital readings or graph the decay over time.

Q130. What does it mean if a source has an activity of 500 Bq?
Answer: It means 500 radioactive decays are happening every second in the source.
Solution: The unit becquerel (Bq) measures how many nuclei decay each second. So, 500 Bq means 500 nuclei are emitting radiation every second. This helps scientists understand how strong or dangerous a radioactive sample is.

Q131. What is the difference between activity and count-rate?
Answer: Activity is the number of decays per second in the source, while count-rate is the number of detections per second by the detector.
Solution: Activity is measured in Bq and shows how active a sample is. Count-rate depends on distance from the source, type of radiation, and detector sensitivity. Count-rate is usually lower than activity because not all radiation is detected.

Q132. What symbol is used to represent an alpha particle in nuclear equations?
Answer: The symbol for an alpha particle is ${}^{4}_{2}He$.
Solution: This symbol shows the alpha particle has a mass number of 4 (2 protons + 2 neutrons) and an atomic number of 2 (2 protons). It is identical to a helium nucleus and is used in nuclear equations to show alpha decay.

Q133. What symbol is used to represent a beta particle in nuclear equations?
Answer: The symbol for a beta particle is ${}^{0}_{-1}e$.
Solution: In nuclear equations, beta particles are shown as electrons with almost no mass (0) and a charge of -1. Sometimes the Greek letter β is used instead of e. This shows that a neutron has turned into a proton and released an electron.

Q134. What must be balanced in a nuclear equation?
Answer: The total atomic numbers and mass numbers must be balanced.
Solution: Just like in chemical equations, conservation laws apply. The total charge (atomic number) and total mass number on both sides of the equation must be equal. This ensures mass and charge are conserved during the nuclear process.

Q135. In alpha decay, what happens to the atomic number of the nucleus?
Answer: The atomic number decreases by 2.
Solution: An alpha particle contains 2 protons. When it is emitted, the nucleus loses those 2 protons, so the atomic number decreases by 2. This changes the element to a different one with 2 fewer protons.

Q136. In alpha decay, what happens to the mass number of the nucleus?
Answer: The mass number decreases by 4.

Solution: An alpha particle has 2 protons and 2 neutrons, which together equal a mass of 4. When it is emitted from the nucleus, the original atom's mass number drops by 4.

Q137. In beta decay, what happens to the atomic number?
Answer: The atomic number increases by 1.
Solution: In beta decay, a neutron turns into a proton and emits an electron (beta particle). The new proton stays in the nucleus, increasing the atomic number by 1, while the mass number remains unchanged.

Q138. In beta decay, why does the proton number increase?
Answer: It increases because a neutron changes into a proton.
Solution: When a neutron decays into a proton and emits a beta particle, the proton remains in the nucleus. This increases the number of protons by 1, which also changes the element to a new one with a higher atomic number.

Q139. How does the emission of a neutron affect the mass number?
Answer: The mass number decreases by 1.
Solution: A neutron has a mass of 1 and no charge. When it is emitted, the number of nucleons (protons + neutrons) in the nucleus decreases by 1, reducing the mass number. The atomic number remains the same.

Q140. How does a nuclear equation show the conservation of mass and charge?
Answer: It shows that the total mass and atomic numbers before and after the reaction are equal.
Solution: Every nuclear equation must balance the total mass number (top numbers) and atomic number (bottom numbers) on both sides. This shows that no mass or charge is lost or gained, following the law of conservation.

Q141. What type of nuclear radiation changes both mass and charge of the nucleus?
Answer: Alpha radiation changes both the mass and charge.
Solution: Alpha particles contain 2 protons and 2 neutrons. When emitted, the mass number drops by 4, and the atomic number drops by 2, changing the element and reducing its mass and charge.

Q142. Which nuclear radiation leaves the mass and charge of the nucleus unchanged?
Answer: Gamma radiation leaves both mass and charge unchanged.
Solution: Gamma rays are just energy waves. When emitted, they remove excess energy from the nucleus but do not affect the number of protons or neutrons. The element remains the same.

Q143. Write the nuclear equation for the alpha decay of uranium-238.
Answer: $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$
Solution:
Start with uranium-238 (atomic number 92).
Alpha decay removes an alpha particle ($^{4}_{2}He$).

Subtract 4 from the mass (238 − 4 = 234) and 2 from the atomic number (92 − 2 = 90).
This gives thorium-234 as the daughter nucleus.

Q144. Write the nuclear equation for the beta decay of carbon-14.

Answer: ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

Solution:

Carbon-14 has 6 protons.
In beta decay, one neutron changes to a proton, increasing the atomic number by 1.
Mass remains the same (14), atomic number becomes 7 (nitrogen).
A beta particle (${}^{0}_{-1}e$) is emitted.

Q145. How do you identify the new atomic number after a beta decay?

Answer: Add 1 to the original atomic number.

Solution: In beta decay, a neutron turns into a proton, increasing the atomic number by 1. For example, if the original atomic number is 6, after beta decay it becomes 7.

Q146. What happens to the neutron during beta decay?

Answer: It changes into a proton and emits an electron.

Solution: The neutron is unstable and splits into a proton (which stays in the nucleus) and an electron (beta particle) which is ejected. This increases the atomic number by 1.

Q147. What is the role of radiation in smoke detectors?

Answer: It helps detect smoke by ionising air and creating a current, which drops when smoke enters.

Solution: Smoke detectors often use alpha particles to ionise air between two plates, allowing current to flow. If smoke enters, it blocks the ionisation, reducing the current and triggering the alarm.

Q148. Why are radioactive sources with short half-lives sometimes used?

Answer: They decay quickly, reducing long-term radiation risk.

Solution: A short half-life means the source becomes inactive sooner. This is useful in medical or industrial applications where long-term exposure is not desired, like tracers or sterilisation.

Q149. How does the range in air differ for alpha, beta, and gamma radiation?

Answer: Alpha travels a few centimetres, beta several metres, and gamma even further.

Solution: Alpha is stopped quickly by air; beta travels further but is still limited. Gamma rays can travel tens or hundreds of metres and need thick shielding to stop.

Q150. What safety precautions are important when working with radioactive materials?

Answer: Use shielding, keep distance, limit time of exposure, and use tools for handling.

Solution: Lead shielding reduces exposure, tongs keep hands away, and reducing time near sources lowers risk. Protective clothing and secure storage are also essential to ensure safety in labs or medical use.

Q151. What does it mean when we say that radioactive decay is a random process?
Answer: It means that we cannot predict exactly when a specific unstable nucleus will decay.
Solution: Radioactive decay happens without any set pattern. Each nucleus has a certain chance of decaying in a given time, but no one can predict when a particular nucleus will decay. The process is based on probability, which makes it random. This randomness is why we rely on averages like half-life to describe decay over time.

Q152. How does the random nature of radioactive decay relate to the concept of half-life?
Answer: Half-life represents the average time it takes for half of the unstable nuclei to decay, despite the randomness of each individual decay.
Solution: Because radioactive decay is random, we cannot say exactly which nucleus will decay next, but for a large number of nuclei, the pattern becomes predictable. The half-life shows how long it takes, on average, for half the nuclei in a sample to decay. It is a statistical measure used to describe the decay of many nuclei over time.

Q153. What is meant by the term half-life of a radioactive isotope?
Answer: It is the time taken for half the nuclei in a sample of a radioactive isotope to decay or for its activity to fall to half.
Solution: For example, if a sample has 1,000 radioactive nuclei, only 500 will remain after one half-life. After the second half-life, 250 remain. This process continues until most of the radioactive atoms have decayed. The half-life is constant for a given isotope and does not change with temperature or pressure.

Q154. How is the count rate from a radioactive source expected to change over time?
Answer: The count rate decreases over time as fewer radioactive nuclei are available to decay.
Solution: As radioactive atoms decay, their number drops, leading to fewer decay events per second. This results in a lower count rate, which can be measured using a Geiger-Müller detector. The decrease in count rate follows a predictable exponential pattern linked to the half-life of the isotope.

Q155. What happens to the number of undecayed nuclei in a sample after one half-life?
Answer: After one half-life, the number of undecayed nuclei is reduced by half.
Solution: If a sample begins with 2,000 undecayed nuclei, only 1,000 will remain after one half-life. After another half-life, 500 will remain. The number of undecayed nuclei continues to halve with each half-life, demonstrating the exponential nature of radioactive decay.

Q156. Why does the rate of decay decrease over time in a radioactive material?
Answer: The rate of decay decreases because fewer radioactive nuclei are left to decay.
Solution: As radioactive atoms decay, they turn into stable atoms that do not emit radiation. The remaining number of unstable atoms decreases over time, resulting in a lower activity and slower decay rate. This is why the count rate drops with time, even though each nucleus still decays randomly.

Q157. How can a graph of count rate versus time be used to estimate half-life?
Answer: By identifying the time it takes for the count rate to fall to half its original value.
Solution: Plot count rate on the vertical axis and time on the horizontal axis. Find the point where the count rate is half the original value, and then check the corresponding time. That time is the half-life. Repeat this for the next half to confirm accuracy. The shape of the curve should be smooth and exponential.

Q158. Why can we not predict when an individual radioactive nucleus will decay?
Answer: Because each nucleus decays randomly and independently, governed by probability.
Solution: There is no physical sign or pattern that indicates when a particular nucleus will decay. Each one has a fixed chance of decaying in a certain time, but which one decays and when is completely random. This is why we rely on statistical methods to describe decay for large groups of atoms.

Q159. Describe a method to determine the half-life of a radioactive isotope using experimental data.
Answer: Measure the count rate at regular intervals, plot a graph, and determine the time it takes to halve.
Solution: Use a Geiger-Müller tube to measure the count rate of a radioactive sample at fixed time intervals. Subtract background radiation from each reading. Plot a graph of corrected count rate versus time. Find the time where the count rate halves. That time is the half-life. Repeat for further halves to improve accuracy.

Q160. What is the significance of measuring the activity of a radioactive source at regular time intervals?
Answer: It allows scientists to observe how quickly the source decays and to calculate its half-life.
Solution: By recording the activity (in Bq) at set times, the rate of decay can be tracked. This information helps in determining how long a source remains hazardous and when it will become safe. It also allows calculation of half-life and ensures proper handling and disposal of the radioactive material.

Q162. How does knowing the half-life of a radioactive isotope help in its safe use?
Answer: It helps determine how long the material will remain hazardous and informs decisions about storage, use, and disposal.
Solution: A short half-life means the material decays quickly and becomes safe sooner, useful in medical treatments. A long half-life requires long-term storage and shielding. Knowing the half-life ensures proper safety planning and risk management for both users and the environment.

Q163. What is meant by net decline in radioactive emissions?
Answer: It is the total reduction in radioactive emissions or activity from the original level after a given time or number of half-lives.
Solution: Net decline shows how much radiation has decreased. For example, if the activity falls

from 800 Bq to 200 Bq, the net decline is 600 Bq. It can also be shown as a ratio, such as 1/4 if it has decreased to a quarter of its original activity. It helps track how much radiation remains.

Q164. How do you calculate the net decline after two half-lives?

Answer: Divide the original activity by 2 twice, then subtract the result from the original.

Solution:

Step 1: Let initial activity = A.

Step 2: After one half-life = A ÷ 2.

Step 3: After two half-lives = A ÷ 4.

Step 4: Net decline = A − (A ÷ 4) = ¾A.

So, after two half-lives, 75% of the original activity has declined, meaning only 25% remains.

Q165. A radioactive source has an initial count rate of 800 Bq. What will the count rate be after three half-lives?

Answer: The count rate will be 100 Bq after three half-lives.

Solution:

Step 1: Initial count rate = 800 Bq.

Step 2: After 1st half-life = 800 ÷ 2 = 400 Bq.

Step 3: After 2nd half-life = 400 ÷ 2 = 200 Bq.

Step 4: After 3rd half-life = 200 ÷ 2 = 100 Bq.

So, the final count rate is 100 Bq.

Q166. How can the net decline in activity be expressed as a ratio?

Answer: By dividing the final activity by the original activity and expressing it as a fraction.

Solution:

For example, if a source starts at 800 Bq and falls to 200 Bq, then:

Ratio = Final ÷ Initial = 200 ÷ 800 = 1/4.

This means the net decline is 3/4 or 75%. Expressing it as a ratio like 1:4 helps compare how much has decayed and how much is left.

Q167. Why is it helpful to express the decline in activity as a ratio rather than an absolute value?

Answer: Ratios allow easier comparison across different samples and do not depend on the starting amount.

Solution: A ratio gives a relative measure, showing what fraction remains regardless of original size. For example, a ratio of 1/8 tells you the same information whether you start with 80 or 8,000 Bq. It makes calculations and comparisons easier, especially when dealing with multiple sources.

Q168. How many half-lives must pass for a sample's activity to fall to one eighth of its original value?

Answer: Three half-lives must pass for the activity to reduce to one eighth.

Solution:

Step 1: After 1 half-life = ½ remains.

Step 2: After 2 half-lives = ½ × ½ = ¼ remains.
Step 3: After 3 half-lives = ¼ × ½ = ⅛ remains.
So, 3 half-lives are needed to reduce activity to one eighth of the original value.

Q169. Explain the relationship between the number of half-lives and the remaining proportion of undecayed nuclei.
Answer: With each half-life, the number of undecayed nuclei is halved, leading to an exponential decrease.
Solution:
After 1 half-life = ½ remains.
After 2 half-lives = ¼ remains.
After 3 half-lives = ⅛ remains.
This pattern continues, showing exponential decay. The formula used is:
Remaining fraction = $(½)^n$, where n = number of half-lives.

Q170. What is radioactive contamination?
Answer: It is the unwanted presence of radioactive materials on surfaces, equipment, or people.
Solution: Contamination happens when radioactive atoms escape their container and stick to skin, clothes, or tools. These atoms can decay and emit harmful radiation. Contamination poses health risks and requires careful decontamination procedures to remove or isolate the source.

Q171. What makes radioactive contamination hazardous?
Answer: The radioactive atoms continue to emit radiation, which can cause damage to living tissue.
Solution: Contaminated surfaces can expose people to radiation even after the source is removed. If radioactive materials enter the body through ingestion, inhalation, or open wounds, they can irradiate tissues from inside, leading to increased health risks such as cancer.

Q172. How is the type of radiation emitted important when considering contamination?
Answer: Different types of radiation cause different levels of harm, especially inside the body.
Solution: Alpha particles are highly ionising and dangerous if inhaled or ingested, but safe outside the body. Beta and gamma can penetrate tissues, so they pose risks externally as well. The type of radiation affects how contamination is cleaned up and how much shielding is required.

Q173. Why does contamination continue to be dangerous even after the source is removed?
Answer: Because the contaminating radioactive atoms can remain and keep decaying, emitting harmful radiation.
Solution: Removing the visible source doesn't eliminate the radioactive particles that may have spread. These atoms can continue to emit radiation for a long time depending on their half-life, so the area or object remains hazardous until thoroughly cleaned or decontaminated.

Q174. What is the difference between irradiation and contamination?
Answer: Irradiation is exposure to radiation without contact with radioactive material, while contamination involves radioactive material touching or entering an object or person.

Solution: In irradiation, radiation passes through the object, but the object itself doesn't become radioactive. In contamination, radioactive particles are transferred to the object and continue to emit radiation, making it a source of hazard.

Q175. Why does an object exposed to radiation not become radioactive?
Answer: Because the object does not absorb or retain the radioactive atoms that emit the radiation.
Solution: Irradiation only affects the object temporarily as radiation passes through. Since the object does not take in radioactive nuclei, it does not become a source of radiation. Only contamination, where radioactive atoms settle on or enter the object, can make it hazardous after exposure.

Q176. In what ways can radioactive contamination be spread?
Answer: It can be spread through air, contact with surfaces, fluids, or improper handling of radioactive materials.
Solution: Contaminated dust or vapours can travel through the air and settle on other surfaces. People can unknowingly carry radioactive particles on clothes or equipment. Spills and leaks during experiments or medical use can also spread contamination if not managed properly.

Q177. Why is internal contamination usually more dangerous than external irradiation?
Answer: Internal contamination exposes body tissues directly to radiation for longer periods.
Solution: If radioactive materials are inhaled, swallowed, or enter through wounds, they can emit radiation inside the body. Alpha particles, which are harmless outside, become very damaging internally. Internal sources are harder to remove and can continue causing harm as long as they remain active.

Q178. What kind of precautions can be taken to avoid radioactive contamination?
Answer: Use of gloves, tongs, protective suits, sealed containers, and clean procedures can help avoid contamination.
Solution: Wearing gloves and protective clothing prevents direct contact. Using tongs keeps radioactive sources at a safe distance. Sealed containers prevent spills. Clean areas reduce the risk of spreading particles. Proper training ensures everyone knows how to safely handle radioactive materials.

Q179. How can radioactive contamination be detected?
Answer: It can be detected using radiation detectors like Geiger-Müller tubes or contamination monitors.
Solution: A Geiger-Müller detector can identify areas where radiation levels are higher than normal. Contamination monitors are moved over clothing, skin, and surfaces to find radioactive particles. These tools are essential in nuclear medicine, laboratories, and power plants for safety checks.

Q180. Why is it important to handle radioactive materials with tongs or robotic arms?
Answer: To maintain distance and reduce direct exposure to radiation.
Solution: Radiation intensity decreases with distance. Using tongs or robotic arms keeps the

operator's body away from the source, reducing the dose received. It also prevents physical contact, which helps avoid contamination and protects sensitive body parts like the hands and eyes.

Q181. Why should people working with radioactive materials wear protective clothing?
Answer: Protective clothing helps prevent radioactive contamination and reduces exposure to radiation.
Solution: Wearing gloves, aprons, and full-body suits creates a barrier that prevents radioactive particles from settling on the skin or being absorbed. It also reduces the risk of spreading contamination to others. Protective clothing is especially important when handling unsealed sources or during clean-up procedures.

Q182. What is the purpose of using lead shielding during irradiation procedures?
Answer: Lead shielding is used to absorb harmful radiation and protect people nearby from exposure.
Solution: Lead has a high atomic number and density, which makes it very effective at stopping gamma rays and X-rays. It reduces the intensity of radiation that passes through, lowering the dose received by medical staff or technicians. This keeps radiation exposure within safe limits during imaging or treatment.

Q183. How is radioactive waste handled to minimise contamination risks?
Answer: Radioactive waste is carefully sealed, labelled, stored in secure facilities, and monitored to prevent leaks or spread.
Solution: Waste is separated by activity level and half-life. Low-level waste may be buried or stored temporarily. High-level waste is stored in shielded containers deep underground. Protective equipment and procedures are used during handling. Strict regulations ensure the environment and public remain safe from exposure.

Q184. In medical applications, how is radiation used in a way that avoids contamination?
Answer: Radiation is used in sealed sources or directed beams, so the radioactive material does not come into contact with patients or staff.
Solution: Techniques like external beam radiotherapy or medical imaging use machines that emit radiation without releasing radioactive substances. Even when radioactive tracers are used inside the body, they are chosen to decay quickly and be excreted safely, minimising contamination and long-term exposure.

Q185. How can the effects of radiation exposure be minimised during medical imaging?
Answer: By using the lowest possible dose, limiting exposure time, shielding sensitive areas, and targeting the radiation precisely.
Solution: Doctors follow ALARA (As Low As Reasonably Achievable) principles. Lead aprons and shields protect areas not being scanned. Only necessary scans are done, and equipment is calibrated for safety. Medical staff may step behind barriers or leave the room to avoid unnecessary exposure.

Q186. Why is it important to store radioactive materials in sealed containers?
Answer: To prevent the release of radioactive particles and protect people and the environment from contamination.
Solution: Sealed containers isolate the material, stop it from spreading, and reduce radiation exposure. Materials are stored in labelled, shielded containers made of lead or thick plastic. These containers are placed in secure, monitored areas to prevent leaks or theft and ensure safe long-term storage.

Q187. Why is it important to distinguish between contamination and irradiation in safety procedures?
Answer: Because the risks and safety measures are different for each.
Solution: Irradiation involves exposure to radiation from a source, while contamination involves actual radioactive material being present on or in an object or person. Contamination can be carried and continue emitting radiation. Correctly identifying the hazard ensures the proper safety response—cleaning versus shielding.

Q188. Why must studies on the effects of radiation be published and peer-reviewed?
Answer: To ensure the results are accurate, reliable, and trustworthy.
Solution: Peer review allows other experts to check the methods, data, and conclusions. It prevents the spread of incorrect or biased findings. Publishing helps share information with the scientific community, improves knowledge, and guides safety regulations. It builds confidence in the use of radiation in society.

Q189. How does peer review help improve the reliability of scientific findings?
Answer: Peer review involves evaluation by other scientists, which helps identify errors and confirm the validity of the results.
Solution: Reviewers check that the methods are appropriate, the conclusions match the data, and the research follows ethical standards. They may suggest improvements or reject poor-quality work. This process filters out unreliable studies and ensures that published research is more accurate and useful.

Q190. Why must the results of radiation studies be shared with scientists around the world?
Answer: So that knowledge is shared, safety standards improve globally, and scientific progress is faster.
Solution: Radiation affects people everywhere, so sharing findings ensures that best practices are adopted internationally. It helps low-resource countries learn from others. Global collaboration speeds up innovation in medicine, industry, and energy. Shared knowledge also supports emergency responses in case of accidents.

Q191. How does peer review prevent the spread of false information in science?
Answer: It ensures that only well-tested, accurate findings are published.
Solution: Peer reviewers challenge unsupported claims, check data, and confirm results. They reject

or revise weak studies. This process removes errors before publication, preventing unreliable or misleading information from influencing public policy or scientific understanding.

Q192. What kind of organisations might be involved in reviewing radiation safety studies?
Answer: Scientific journals, regulatory bodies, universities, and international health or nuclear safety agencies.
Solution: Journals like *The Lancet* or *Nature* use peer review. Organisations like the IAEA (International Atomic Energy Agency), WHO, and national radiation safety authorities also review studies to guide policy and approve safe practices. Universities contribute through academic peer-reviewed research.

Q193. How can peer-reviewed studies influence safety regulations for radiation use?
Answer: They provide reliable evidence that regulators use to create rules and guidelines.
Solution: Studies may show how much radiation is safe, what protective gear is needed, or how long exposure should last. Regulators use this data to update laws, improve workplace safety, and ensure medical and industrial radiation use stays within safe limits for people and the environment.

Q194. Why is public confidence increased when research is peer-reviewed?
Answer: Because people trust findings that have been checked and approved by independent experts.
Solution: Peer review adds credibility and transparency to research. When the public knows a study has been evaluated by scientists, they are more likely to believe the results. This is especially important in sensitive areas like radiation, where safety and trust are essential.

Q195. How can peer review affect government policy on radioactive waste disposal?
Answer: It provides scientific evidence that supports or challenges proposed waste management plans.
Solution: Governments rely on peer-reviewed studies to decide where and how to store radioactive waste. If research shows risks or flaws in a plan, it may be revised. Evidence from multiple studies can lead to stricter safety measures, better technology, or public acceptance of a disposal site.

Q196. What is the benefit of international collaboration in radiation research?
Answer: It leads to better data, shared expertise, and stronger global safety standards.
Solution: Researchers from different countries bring unique skills, equipment, and perspectives. They can compare results across regions, conduct large-scale studies, and solve problems faster. Shared knowledge improves safety regulations, medical treatments, and environmental protection worldwide.

Q197. Why might long-term studies be important in understanding radiation's effects?
Answer: Because some effects, like cancer or genetic damage, may appear years after exposure.
Solution: Short-term studies may miss delayed effects. Long-term research tracks people or animals over decades to find links between radiation and health problems. This helps scientists understand

safe exposure levels, plan protective measures, and guide the use of radiation in medicine and industry.

Q198. How can the public be educated about the risks of radiation through published studies?
Answer: By translating scientific findings into simple, clear information that helps people make informed choices.
Solution: Public health bodies, schools, and media use peer-reviewed research to create fact sheets, videos, and lessons. This counters myths, explains how radiation works, and builds awareness about safety. Education helps reduce fear and encourages responsible use of radiation technologies.

Q199. What role do scientific journals play in ensuring radiation studies are reliable?
Answer: They require peer review, follow strict publishing standards, and reject poor-quality research.
Solution: Journals select expert reviewers to assess every study's methods and conclusions. They ensure transparency, ethical approval, and data integrity. By publishing only high-quality work, journals act as gatekeepers and promote trustworthy science in the radiation field.

Q200. How can misinformation about radiation be prevented through peer review and open access research?
Answer: Peer review filters incorrect studies, and open access makes reliable information available to everyone.
Solution: Peer review checks facts and blocks errors before publication. Open access means the public, students, and professionals can read trusted research freely. This prevents false claims from spreading and helps people base their opinions and actions on solid evidence.

Q201. What is meant by background radiation?
Answer: Background radiation is the low-level radiation that is always present in the environment.
Solution: This radiation comes from natural sources such as rocks and cosmic rays, and man-made sources such as nuclear fallout and medical equipment. It surrounds us all the time and varies based on location and lifestyle, even when there is no nearby radioactive source.

Q202. Name two natural sources of background radiation.
Answer: Two natural sources are radioactive rocks like granite and cosmic rays from space.
Solution: Radioactive rocks contain isotopes such as uranium and radon gas, which emit radiation. Cosmic rays are high-energy particles from space that interact with the Earth's atmosphere, contributing to radiation levels, especially at high altitudes or near the poles.

Q203. Name two man-made sources of background radiation.
Answer: Two man-made sources are fallout from nuclear weapons testing and radiation from medical procedures.
Solution: Nuclear testing in the past released radioactive particles into the environment. Medical

uses, such as X-rays and radioactive tracers, also increase radiation exposure. Though controlled, they contribute to the overall background radiation levels in society.

Q204. How can cosmic rays contribute to background radiation levels?
Answer: Cosmic rays from space constantly bombard the Earth and increase radiation exposure.
Solution: These high-energy particles interact with the atmosphere to produce secondary radiation like neutrons. People living at high altitudes or flying often receive higher doses due to reduced atmospheric shielding, making cosmic rays a significant natural radiation source.

Q205. Why does the amount of background radiation vary by location?
Answer: Because local geology and altitude affect the amount and type of radiation exposure.
Solution: Areas with high levels of uranium in the rocks, such as granite regions, emit more radiation. High-altitude places receive more cosmic radiation due to thinner atmosphere. Human activities, like nearby nuclear plants, can also influence background levels.

Q206. How can living near granite rocks affect your exposure to background radiation?
Answer: Granite contains radioactive elements that emit radiation, increasing local exposure.
Solution: Rocks like granite release radon gas, a radioactive substance that can build up indoors. Breathing in radon contributes to internal exposure, especially in poorly ventilated homes. This raises the average dose of radiation people receive in such areas.

Q207. How does working in the nuclear industry affect radiation dose?
Answer: Workers in the nuclear industry are more likely to be exposed to higher levels of radiation.
Solution: These workers handle radioactive materials or operate near reactors. Even with shielding and safety procedures, exposure is higher than average. Dosimeters monitor their dose, and legal limits are enforced to keep their exposure as low as reasonably achievable (ALARA).

Q208. What is the link between occupation and increased radiation exposure?
Answer: Certain jobs involve more contact with radiation, leading to higher doses.
Solution: Occupations like radiographers, pilots, or nuclear technicians are exposed to more radiation than the general public. Their dose is monitored regularly, and protective equipment or procedures are used to reduce the risks associated with long-term exposure.

Q209. What units are used to measure radiation dose?
Answer: Radiation dose is measured in sieverts (Sv) or millisieverts (mSv).
Solution: The sievert measures the biological effect of radiation on the body. Since 1 sievert is a large dose, doses are usually given in millisieverts (1 Sv = 1000 mSv). This unit allows comparison of exposure from different sources like X-rays or background radiation.

Q210. How many millisieverts are in one sievert?
Answer: There are 1000 millisieverts in one sievert.
Solution:
Formula:

1 Sv = 1000 mSv
Example:
If a person receives a dose of 0.005 Sv, then in millisieverts:
0.005 × 1000 = 5 mSv

Q211. Why is background radiation always present?
Answer: Because natural and artificial radioactive sources are continuously around us.
Solution: The Earth contains radioactive elements in rocks, and cosmic rays constantly reach the surface. Human activities like medical imaging and nuclear power also add small amounts. Since these sources are widespread and ongoing, background radiation is always present.

Q212. How can flying at high altitudes increase your radiation exposure?
Answer: There is less atmospheric protection at high altitudes, so more cosmic radiation reaches the body.
Solution: When flying, especially on long flights or near the poles, exposure increases due to the thinner layer of air to shield cosmic rays. Airline crew and frequent travellers receive higher annual doses than people who stay at ground level.

Q213. How can medical procedures contribute to a person's radiation dose?
Answer: Procedures like X-rays, CT scans, and radiotherapy involve controlled exposure to radiation.
Solution: Although used for diagnosis or treatment, these procedures add to the total radiation dose a person receives. For example, a chest X-ray might give a small dose, while a CT scan gives more. Doses are kept as low as possible while still being effective.

Q214. Why is it important to monitor radiation dose in medical imaging?
Answer: To ensure the patient receives the minimum dose needed to get accurate results.
Solution: Radiation carries a risk of cell damage. Monitoring helps apply ALARA (As Low As Reasonably Achievable) principles to limit harm. It also avoids overexposure from repeated scans and helps compare cumulative doses to recommended safe limits.

Q215. Why might people who work in hospitals be exposed to higher radiation levels?
Answer: Because they work near X-ray machines, radioactive tracers, and radiotherapy equipment.
Solution: Doctors and radiographers handle patients undergoing scans or treatment. To reduce risk, they use shielding, wear dosimeters, and follow safety protocols. Even so, their exposure may be slightly higher than that of the general public.

Q216. How can nuclear accidents increase background radiation levels in the environment?
Answer: They release radioactive materials into the air, water, and soil.
Solution: In accidents like Chernobyl or Fukushima, radioactive isotopes such as iodine-131 and cesium-137 spread over large areas. This increases background levels in nearby regions and can contaminate food, water, and surfaces for years, depending on the isotopes' half-lives.

Q217. What is meant by the half-life of a radioactive isotope?
Answer: Half-life is the time it takes for half the radioactive atoms in a sample to decay.
Solution: If a substance starts with 100 atoms and has a half-life of 5 years, then after 5 years only 50 atoms remain radioactive. After 10 years, 25 remain. This exponential decay pattern helps predict how long a substance will remain hazardous.

Q218. Why is half-life an important factor in assessing the danger of a radioactive substance?
Answer: Because it tells how long the substance remains radioactive and hazardous.
Solution: A short half-life means the material loses most of its activity quickly but gives off high radiation in a short time. A long half-life means it remains dangerous for many years, requiring long-term storage or safety planning.

Q219. How does a short half-life affect the risk from radioactive material?
Answer: It means high activity in the short term but becomes safe quickly.
Solution: Such materials emit a lot of radiation in a short period, posing immediate risks. However, they decay rapidly and no longer pose a long-term hazard. These are often used in medical tracers for quick diagnosis without long-lasting radiation exposure.

Q220. Why might a substance with a long half-life be dangerous for many years?
Answer: Because it remains radioactive and continues to emit radiation for a long time.
Solution: Even though it may emit radiation slowly, it persists for decades or centuries. This makes disposal and shielding more complex. Examples include nuclear waste that needs secure underground storage for safety.

Q221. What happens to the radiation level of a substance as time passes?
Answer: It decreases as more of the radioactive nuclei decay.
Solution: The radiation level falls following the half-life pattern. For example, after 1 half-life, only half of the original activity remains. After 2 half-lives, only a quarter remains. This helps scientists and safety experts plan for decay and safe handling.

Q222. Why might a radioactive isotope with a short half-life be preferred for medical diagnosis?
Answer: Because it provides useful radiation for a short time and then becomes safe quickly.
Solution: A short half-life means the tracer emits detectable radiation while scanning, but doesn't stay in the body long. This reduces long-term exposure and risk. Isotopes like technetium-99m are commonly used for this reason.

Q223. Why is a long half-life useful in some industrial applications?
Answer: Because it provides a constant source of radiation over time without needing frequent replacement.
Solution: In thickness gauging or power generation, consistent activity is important. A long half-life ensures steady performance without losing effectiveness, making long-lived isotopes practical for equipment that must work over years.

Q224. How can the half-life of a substance affect how it is stored or disposed of?
Answer: Longer half-lives require long-term storage solutions and stronger safety measures.
Solution: Short-lived waste may be stored temporarily until it decays. Long-lived waste needs shielding and secure facilities like deep geological repositories. The half-life determines how long monitoring and containment must be maintained.

Q225. What kind of radioactive source would be most suitable for exploring internal organs?
Answer: A gamma-emitting isotope with a short half-life is most suitable.
Solution: Gamma rays pass through the body and can be detected outside, making them ideal for imaging. A short half-life ensures the tracer decays quickly, reducing long-term radiation exposure. Technetium-99m is a common example used in diagnostic scans.

Q226. How is nuclear radiation used to explore internal organs?
Answer: Nuclear radiation is used to explore internal organs by introducing a radioactive tracer into the body, which emits gamma rays. These rays can be detected by a gamma camera to produce images showing how well organs are functioning. It helps doctors examine blood flow, detect blockages, or monitor organ activity like in the heart or kidneys without the need for surgery.

Q227. What is a radioactive tracer and how is it used?
Answer: A radioactive tracer is a substance that contains a small amount of radioactive isotope. It is used in medical scans by being injected, inhaled, or swallowed. As it travels through the body, it emits radiation that can be detected externally to form images or track the activity of organs, allowing doctors to assess function or detect abnormalities.

Q228. Why must tracers used in the body have a short half-life?
Answer: Tracers must have a short half-life to ensure that they decay quickly and do not remain radioactive in the body for long. This minimises radiation exposure to healthy tissues and reduces the risk of long-term health effects, while still allowing enough time for diagnostic imaging to be completed effectively.

Q229. How are radioactive tracers introduced into the body?
Answer: Radioactive tracers can be introduced into the body by injection into the bloodstream, inhalation through gases, or ingestion in liquid or capsule form. The method depends on the organ or system being investigated. Once inside, the tracer travels through the body and emits detectable radiation used for imaging.

Q230. Why must the radiation emitted by a tracer be easily detectable outside the body?
Answer: The radiation must be easily detectable from outside the body to allow medical imaging devices like gamma cameras to capture clear images without invasive procedures. Detectable radiation ensures accurate diagnosis by providing real-time data on the function or structure of internal organs.

Q231. What type of radiation is most suitable for medical tracers and why?
Answer: Gamma radiation is most suitable for medical tracers because it penetrates tissues and can be easily detected from outside the body. It causes minimal ionisation, which reduces potential damage to healthy tissues, and allows clear imaging with devices like gamma cameras.

Q232. Why are alpha emitters not used as medical tracers?
Answer: Alpha emitters are not used as medical tracers because alpha particles have low penetration power and are quickly absorbed by body tissues. They cannot be detected outside the body and pose a high risk if ingested or injected due to their strong ionising effect, which can damage cells.

Q233. How is gamma radiation used to detect problems in organs?
Answer: Gamma radiation is used to detect problems in organs by tracking a radioactive tracer that emits gamma rays. As the tracer moves through the body, the gamma rays are picked up by a camera to form images. These images reveal abnormal functions such as blockages, reduced blood flow, or damaged tissue in organs like the heart or kidneys.

Q234. What is meant by using radiation to control or destroy unwanted tissue?
Answer: Using radiation to control or destroy unwanted tissue refers to targeting diseased or abnormal cells, like cancer cells, with high-energy radiation. This radiation damages the DNA of the cells, stopping them from growing or dividing, and eventually leads to their death. This is commonly used in cancer treatment.

Q235. How is radiation used in the treatment of cancer?
Answer: Radiation is used in cancer treatment through a process called radiotherapy. High doses of ionising radiation, such as X-rays or gamma rays, are directed at cancerous cells. This damages their DNA and prevents them from multiplying. Over time, the cancer cells die and are naturally removed by the body while healthy tissues are protected as much as possible.

Q236. What is external beam radiotherapy?
Answer: External beam radiotherapy is a cancer treatment method where high-energy radiation is delivered from a machine outside the body and focused on the tumour. The beams are precisely targeted to destroy cancer cells while avoiding as much damage to nearby healthy tissues as possible.

Q237. How is internal radiotherapy used to treat cancer?
Answer: Internal radiotherapy, also called brachytherapy, involves placing a small radioactive source inside or very close to the tumour. This allows a high dose of radiation to be delivered directly to cancer cells while limiting exposure to surrounding healthy tissue. It's often used for cancers like prostate, cervical, or womb cancer.

Q238. Why must the dose of radiation be carefully controlled during cancer treatment?
Answer: The radiation dose must be carefully controlled to ensure that enough energy is delivered

to kill cancer cells while minimising damage to surrounding healthy tissues. Overexposure can harm normal cells, while underexposure may not effectively treat the cancer. Proper dosing is essential for safe and effective treatment.

Q239. How do doctors balance the risks and benefits of radiation in treatment?
Answer: Doctors balance the risks and benefits by considering factors such as the severity of the disease, the patient's overall health, and the expected outcome of the treatment. They aim to maximise the benefit of killing cancer cells while minimising side effects and harm to healthy tissues through careful planning and precise targeting of radiation.

Q240. What are the side effects of using radiation to treat cancer?
Answer: Side effects of radiation treatment can include fatigue, skin irritation, hair loss in the treated area, nausea, and a temporary drop in blood cell counts. Long-term effects may involve scarring or damage to nearby organs, but these risks are managed by using accurate doses and targeting techniques.

Q241. How can radioactive implants be used in cancer treatment?
Answer: Radioactive implants are used in a treatment called brachytherapy. Small radioactive seeds or wires are placed inside or near the tumour. These implants release radiation over time, directly targeting cancer cells while reducing exposure to surrounding healthy tissue. Once the treatment is complete, the implant may be removed or left to decay naturally.

Q242. How do doctors ensure that healthy tissues are protected during radiotherapy?
Answer: Doctors use precise imaging and planning software to target the tumour while avoiding healthy tissues. Techniques like intensity-modulated radiation therapy (IMRT) or proton therapy help focus the dose. Shielding and patient positioning are also used to reduce exposure to non-cancerous tissues.

Q243. How does the use of radiation in medicine demonstrate the principle of risk versus benefit?
Answer: The use of radiation in medicine reflects the risk versus benefit principle by carefully evaluating whether the medical benefit (such as curing cancer or diagnosing a disease) outweighs the potential harm from radiation exposure. If the benefit of accurate diagnosis or successful treatment is greater than the small radiation risk, the procedure is justified.

Q244. Why might some patients be hesitant to undergo treatment involving radiation?
Answer: Some patients may fear the word "radiation" due to its association with cancer, nuclear accidents, or long-term health risks. They may worry about side effects, exposure to harmful rays, or misunderstand the safety measures involved. Clear communication and education are important to address these concerns.

Q245. What factors influence the perceived risk of using radiation in medical procedures?
Answer: Perceived risk can be influenced by a lack of understanding, media reports, cultural beliefs,

personal experiences, or fear of long-term effects like cancer. The type of procedure, dose of radiation, and how the information is explained by healthcare professionals also affect how risky the patient feels the procedure is.

Q246. How can data be used to evaluate the safety of radiation treatments?
Answer: Data from clinical trials, patient outcomes, and long-term studies help evaluate the effectiveness and safety of radiation treatments. By analysing statistics on survival rates, recurrence, and side effects, medical professionals can determine best practices and improve treatment protocols for better patient care.

Q247. Why is it important to inform patients about the risks of radiation in medical use?
Answer: Informing patients about the risks ensures they can make informed decisions and give proper consent. It builds trust between patients and doctors, reduces anxiety through understanding, and helps manage expectations about the procedure, side effects, and outcomes.

Q248. How does using standard form help when dealing with radiation data?
Answer: Standard form is useful for expressing very large or very small numbers, like radiation doses, in a simple and clear way. It makes calculations easier and reduces errors. For example, a dose of 0.000004 Sv can be written as 4×10^{-6} Sv, making it easier to compare with other doses.

Q249. How can you express a radiation dose of 0.002 Sv in standard form?
Answer:
Solution:
Step 1: Identify the number = 0.002 Sv
Step 2: Write it in standard form = 2×10^{-3} Sv

Q250. Why is standard form useful when comparing different levels of radiation dose?
Answer: Standard form allows scientists and doctors to quickly compare radiation doses that vary by several powers of ten. It simplifies reading and calculations, reduces confusion with decimals, and ensures accurate comparison between high and low doses used in different treatments or procedures.

Q251. What happens to a large, unstable nucleus during nuclear fission?
Answer: During nuclear fission, a large, unstable nucleus such as uranium-235 splits into two smaller nuclei of roughly equal size after absorbing a neutron. This process releases two or three free neutrons, gamma radiation, and a large amount of energy. The fission products, including the neutrons and smaller nuclei, move away with high kinetic energy. This energy is used in nuclear reactors to generate electricity.

Q252. Why is it necessary for an unstable nucleus to absorb a neutron before fission occurs?
Answer: Absorbing a neutron gives the unstable nucleus additional energy, making it even more unstable and causing it to split. Spontaneous fission is very rare, so the nucleus usually needs the trigger of a neutron collision to overcome the binding energy holding it together. This induced fission

results in the nucleus breaking apart, releasing energy and more neutrons that can continue the chain reaction.

Q253. What particles are released when a nucleus undergoes fission?
Answer: When a nucleus undergoes fission, it releases two or three neutrons, two smaller nuclei (called fission fragments), and gamma rays. All of these products carry kinetic energy. The free neutrons released may go on to trigger further fission reactions, allowing a chain reaction to occur if conditions allow.

Q254. Why is energy released during a nuclear fission reaction?
Answer: Energy is released in a nuclear fission reaction because the total mass of the fission products is slightly less than the mass of the original nucleus and the neutron. This lost mass is converted into energy, according to Einstein's equation $E=mc^2$. The energy appears as kinetic energy of the particles and gamma radiation. This is why fission can produce a large amount of energy from a small amount of fuel.

Q255. What is meant by a chain reaction in nuclear fission?
Answer: A chain reaction in nuclear fission occurs when the neutrons released from one fission event cause additional fission reactions in nearby nuclei. This results in a continuous series of fission events. If at least one of the released neutrons from each fission causes another fission, the reaction becomes self-sustaining. In reactors, this is controlled to produce steady energy; in weapons, it is uncontrolled and explosive.

Q256. Why is spontaneous fission considered a rare event?
Answer: Spontaneous fission is rare because large nuclei like uranium-235 are generally stable enough that they do not split on their own under normal conditions. They require an external neutron to become unstable enough to undergo fission. Without this trigger, the probability of spontaneous splitting is very low, making induced fission the primary method used in reactors.

Q257. How is a fission chain reaction controlled inside a nuclear reactor?
Answer: In a nuclear reactor, the fission chain reaction is controlled by using control rods made of materials like boron or cadmium. These rods absorb some of the free neutrons released during fission, preventing them from causing further fission events. By inserting or withdrawing the control rods, the number of neutrons available for further reactions is adjusted, keeping the reaction steady and safe.

Q258. What causes the explosion in a nuclear weapon?
Answer: The explosion in a nuclear weapon is caused by an uncontrolled fission chain reaction. In such weapons, the reaction is designed so that all the released neutrons cause more fission reactions rapidly. This leads to a sudden and massive release of energy in the form of heat, light, and pressure. Because there is no mechanism to absorb or slow down the reaction, the energy is released all at once, causing an explosion.

Q259. Why do fission products have high kinetic energy?

Answer: Fission products have high kinetic energy because when the large nucleus splits, the repulsive electrostatic forces between the positively charged fragments push them apart rapidly. This sudden separation gives the fission fragments a large amount of kinetic energy. This kinetic energy is then transferred to surrounding material as heat, which is used to generate electricity in nuclear reactors.

Q260. How can fission reactions lead to a self-sustaining chain reaction?

Answer: Fission reactions can lead to a self-sustaining chain reaction if, on average, at least one of the neutrons released by each fission event goes on to cause another fission. When the conditions are right, such as having enough fissile material at the right density and arrangement, the chain reaction can continue without any external input. This is carefully controlled in reactors and uncontrolled in weapons.

Q261. Why are only certain isotopes like uranium-235 used in nuclear fission?

Answer: Only certain isotopes like uranium-235 or plutonium-239 are used in nuclear fission because they are fissile, meaning they can absorb a neutron and then undergo fission. These isotopes have the right balance of protons and neutrons to be unstable enough to split after neutron absorption and release more neutrons to continue a chain reaction. Other isotopes may absorb neutrons but not split or may not release enough neutrons to sustain a chain reaction.

Q262. What is the role of control rods in a nuclear reactor?

Answer: Control rods in a nuclear reactor are used to control the rate of the fission chain reaction. They are made of materials like boron or cadmium that absorb neutrons. By inserting the rods into the reactor core, more neutrons are absorbed, slowing down or stopping the chain reaction. Removing the rods allows more neutrons to continue the reaction. This helps maintain a stable energy output.

Q263. What is the purpose of a moderator in a nuclear reactor?

Answer: A moderator in a nuclear reactor is used to slow down the fast-moving neutrons released during fission. Slower (thermal) neutrons are more likely to be absorbed by fissile nuclei like uranium-235 and cause further fission. Common moderator materials include water and graphite. Without a moderator, most of the neutrons would be too fast to cause efficient fission reactions.

Q264. Why are gamma rays emitted during nuclear fission?

Answer: Gamma rays are emitted during nuclear fission as a result of the rearrangement of protons and neutrons in the newly formed nuclei. These rays are a type of electromagnetic radiation that carry away excess energy from the fission products. Gamma radiation is part of the energy released in fission and is highly penetrating, requiring shielding to protect workers and the environment.

Q265. What are the typical characteristics of the two nuclei produced during fission?

Answer: The two nuclei produced during fission, called fission fragments, are usually smaller than the original nucleus and are often of unequal mass, though roughly similar in size. They are radioactive and unstable, often emitting beta radiation as they decay into stable elements. These fission products also have high kinetic energy, contributing to the thermal energy produced in the reactor.

Q266. How does the emission of neutrons help to continue a fission chain reaction?
Answer: The emission of neutrons during fission allows the chain reaction to continue. Each fission event releases two or three neutrons, and if at least one of them goes on to strike another fissile nucleus, another fission occurs. If this happens repeatedly, the reaction becomes self-sustaining. Controlling the number of neutrons available is key to maintaining a steady reaction in reactors.

Q267. What happens if a fission chain reaction is not controlled?
Answer: If a fission chain reaction is not controlled, it can escalate rapidly as more and more neutrons cause further fission reactions. This results in an exponential increase in energy output, leading to overheating and potentially a meltdown or explosion. In nuclear weapons, this uncontrolled reaction is what causes the massive destructive explosion.

Q268. What are the dangers of an uncontrolled fission chain reaction?
Answer: The dangers of an uncontrolled fission chain reaction include the release of massive amounts of energy in a short time, leading to explosions, radiation leaks, and environmental contamination. It can cause severe damage to equipment and buildings and pose serious health risks to people through radiation exposure, burns, or long-term effects like cancer.

Q269. Why must the fuel in a nuclear reactor be enriched?
Answer: Natural uranium contains mostly uranium-238, which is not fissile. To sustain a chain reaction, the concentration of uranium-235, which is fissile, must be increased. Enrichment increases the proportion of uranium-235 to about 3–5% in reactor fuel. This allows the fuel to support a steady chain reaction, making the reactor efficient for power generation.

Q270. What is the difference between nuclear fission and radioactive decay?
Answer: Nuclear fission is a process where a large nucleus splits into two smaller nuclei with the release of energy, neutrons, and radiation. It can be induced and is used in reactors and weapons. Radioactive decay, on the other hand, is a natural process where unstable nuclei emit particles or radiation to become more stable. It is spontaneous, random, and cannot be controlled.

Q271. Why is shielding necessary in a nuclear reactor?
Answer: Shielding is necessary in a nuclear reactor to protect workers, the public, and the environment from harmful radiation, especially gamma rays and neutrons released during fission. Materials like concrete and lead are used to absorb this radiation and prevent it from escaping the reactor. Without proper shielding, radiation exposure could cause serious health problems such as radiation sickness or long-term effects like cancer.

Q272. What happens to the neutrons released in a fission reaction?
Answer: The neutrons released in a fission reaction can follow three paths: they may be absorbed by another fissile nucleus to cause further fission, be absorbed by non-fissile materials and removed

from the chain reaction, or escape the reactor core entirely. In a controlled reaction, enough of these neutrons are absorbed to maintain a steady chain reaction without letting it grow uncontrollably.

Q273. How does a chain reaction differ in a nuclear reactor compared to a nuclear bomb?
Answer: In a nuclear reactor, the chain reaction is controlled using control rods and moderators to maintain a steady release of energy over time. In contrast, a nuclear bomb creates an uncontrolled chain reaction, where all available neutrons cause fission almost instantly. This leads to a rapid and massive release of energy, resulting in an explosion.

Q274. What is meant by critical mass in the context of nuclear fission?
Answer: Critical mass is the minimum amount of fissile material needed to maintain a self-sustaining chain reaction. If the mass of the material is below this level, too many neutrons escape or are absorbed without causing further fission, and the chain reaction stops. If the critical mass is reached or exceeded, the reaction can continue on its own.

Q275. What properties make uranium-235 suitable for nuclear fission?
Answer: Uranium-235 is suitable for nuclear fission because it is fissile, meaning it can absorb a slow-moving neutron and undergo fission. It releases a large amount of energy and multiple neutrons during the process, which can sustain a chain reaction. It is also more readily available and easier to work with compared to other fissile materials like plutonium-239.

Q276. What is the source of energy in a nuclear fission reaction?
Answer: The source of energy in a nuclear fission reaction comes from the conversion of mass into energy. When a large nucleus splits into smaller ones, the total mass of the products is slightly less than the original mass. This mass difference is converted into energy, as described by Einstein's equation $E = mc^2$, and is released as kinetic energy and radiation.

Q277. How can diagrams help explain the process of nuclear fission?
Answer: Diagrams can visually show the sequence of events in a fission reaction, such as neutron absorption, nucleus splitting, release of neutrons, and energy. They help students understand complex processes like chain reactions, the roles of control rods and moderators, and the difference between controlled and uncontrolled fission. Clear diagrams also aid memory and revision.

Q278. Why is nuclear fission considered a non-renewable energy source?
Answer: Nuclear fission is considered non-renewable because it relies on materials like uranium-235 and plutonium-239, which are finite and mined from the Earth. Once these resources are used up, they cannot be replaced within a human timescale. Unlike renewable sources, such as solar or wind, nuclear fuel reserves are limited.

Q279. What does it mean when a nucleus is described as unstable?
Answer: A nucleus is described as unstable when the forces holding it together are unbalanced due to too many or too few neutrons compared to protons. This causes the nucleus to spontaneously

change by emitting particles or radiation to become more stable. Such nuclei are radioactive and may undergo decay or fission.

Q280. How is the energy from fission reactions converted into electricity?
Answer: The energy from fission reactions heats water into steam. This steam is used to turn turbines, which are connected to generators. As the turbines spin, they generate electricity. This process is similar to how fossil-fuel power stations work, but the heat source is nuclear rather than chemical.

Q281. What is meant by induced fission?
Answer: Induced fission occurs when a nucleus is made to undergo fission by absorbing a neutron. This is different from spontaneous fission, where the nucleus splits on its own. Induced fission is used in reactors because it allows the process to be controlled and started when needed.

Q282. Why do power stations use chain reactions for energy generation?
Answer: Power stations use chain reactions because they allow a continuous release of energy from a small amount of fuel. Once started, the reaction sustains itself as long as enough fissile material and conditions are present. This makes it efficient and reliable for generating electricity on a large scale.

Q283. How do control rods prevent a nuclear reactor from overheating?
Answer: Control rods absorb excess neutrons in the reactor core, reducing the number of fission reactions taking place. By adjusting their position, operators can slow down or speed up the chain reaction. This control prevents the reactor from producing too much heat, which could lead to overheating or a meltdown.

Q284. What would happen if the control rods were removed from a working reactor?
Answer: If control rods were completely removed from a working reactor, there would be nothing to absorb the extra neutrons. This would allow the chain reaction to speed up uncontrollably, producing excessive heat and potentially causing the reactor to overheat or melt down, leading to a dangerous situation.

Q285. What role does the coolant play in a nuclear reactor?
Answer: The coolant in a nuclear reactor transfers the heat produced by the fission reactions to the steam generator or directly to the turbines. It also helps keep the reactor core at a safe temperature. Common coolants include water, gas, or liquid metal, depending on the reactor design.

Q286. How is the heat produced by nuclear fission used to drive turbines?
Answer: The heat from nuclear fission is used to boil water and create high-pressure steam. This steam flows through pipes to spin turbines. The turbines are connected to generators that convert the mechanical energy into electrical energy. After cooling, the steam condenses back into water and is reused.

Q287. What safety measures are built into nuclear reactors to manage fission?
Answer: Safety measures include control rods, shielding, containment buildings, emergency cooling systems, and multiple backup power supplies. These features help control the reaction, prevent radiation leaks, and maintain cooling in case of system failures. Regular inspections and safety protocols also reduce the risk of accidents.

Q288. What are the long-term risks of using nuclear fission for energy?
Answer: Long-term risks include radioactive waste that remains dangerous for thousands of years, the potential for accidents or meltdowns, and the threat of nuclear weapons development. Safe disposal, secure storage, and strict regulation are necessary to reduce these risks over time.

Q289. How does a nuclear fission reactor differ from a fusion reactor?
Answer: A nuclear fission reactor splits large nuclei to release energy, while a fusion reactor combines light nuclei. Fission produces radioactive waste and requires careful control of chain reactions. Fusion, if achieved, would produce less waste and be inherently safer, but is much harder to sustain due to the extreme conditions needed.

Q290. What is nuclear fusion?
Answer: Nuclear fusion is the process where two light atomic nuclei combine to form a heavier nucleus. This reaction releases a large amount of energy because some of the mass is converted into energy. Fusion is the process that powers the Sun and has the potential to provide clean energy if controlled on Earth.

Q291. What particles are involved in a typical nuclear fusion reaction?
Answer: A typical fusion reaction involves light nuclei such as deuterium and tritium (isotopes of hydrogen). When these nuclei fuse, they form helium and release a neutron along with a significant amount of energy. These reactions are being studied for energy production in fusion reactors.

Q292. What condition is necessary for nuclear fusion to occur?
Answer: For fusion to occur, the nuclei must overcome their electrostatic repulsion, which requires extremely high temperatures (millions of degrees) and pressures. These conditions give the particles enough kinetic energy to collide and fuse, releasing energy in the process.

Q293. Why is it difficult to achieve nuclear fusion on Earth?
Answer: It is difficult because fusion requires extremely high temperatures and pressures, like those found in the Sun. Creating and containing such conditions on Earth is technologically challenging. The plasma must be confined using magnetic fields or inertial confinement, and maintaining these conditions is complex and expensive.

Q294. What is released during a nuclear fusion reaction?
Answer: During fusion, a large amount of energy is released along with particles such as helium nuclei and neutrons. The energy comes from the conversion of mass into energy and is mostly carried away by the kinetic energy of the products and radiation.

Q295. How does the mass change during a fusion reaction?

Answer: In a fusion reaction, the total mass of the resulting nucleus and other products is slightly less than the mass of the original nuclei. This missing mass is converted into energy, according to $E = mc^2$. This mass-to-energy conversion is what makes fusion a powerful energy source.

Q296. Why does nuclear fusion release energy?

Answer: Nuclear fusion releases energy because the mass of the final products is less than the mass of the original particles. This mass difference is converted into energy using $E = mc^2$. The energy appears as kinetic energy of the particles and radiation.

Q297. What makes fusion reactions safer than fission reactions?

Answer: Fusion reactions are safer because they do not produce long-lived radioactive waste and cannot run away or melt down. If containment fails, the reaction stops immediately. Fusion fuel like hydrogen isotopes is also widely available and poses less risk of weapons misuse.

Q298. What happens to the nuclei during a fusion process?

Answer: During fusion, two light nuclei come close enough to overcome their electrostatic repulsion and combine into a single, heavier nucleus. This process releases energy and other particles like neutrons. The new nucleus is more stable, and the mass difference results in energy release.

Q299. How is the energy from fusion reactions related to mass?

Answer: The energy from fusion is related to the mass difference between the starting nuclei and the product. This lost mass is converted into energy using Einstein's formula $E = mc^2$. Even a small amount of mass produces a large amount of energy, making fusion very efficient.

Q300. What temperature is required for fusion to take place?

Answer: Fusion requires temperatures of around 10 million to 100 million degrees Celsius. At these temperatures, particles have enough energy to overcome repulsive forces between nuclei and allow fusion to occur. These conditions are difficult to create and sustain on Earth.