3.27 Radioactivity, Half-Life and Nuclear Uses: Test Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Alpha, β and γ are three types of nuclear radiation emitted by unstable nuclei.

(a) State what an α particle consists of. **(1)**

(b) State what a β particle is. **(1)**

(c) State which of α, β or γ radiation has no mass and no charge. **(1)**

(d) Put α, β and γ radiation in order of increasing penetrating power (least penetrating first). **(1)**

(Total for Question 1 is 4 marks)

---

2 Radioactive decay is described as a random process, and the activity of a source is measured in becquerels (Bq).

(a) Explain what is meant by describing radioactive decay as random. **(2)**

(b) State what is meant by a source having an activity of 1 Bq. **(1)**

(Total for Question 2 is 3 marks)

© Revision Library | revisionlibrary.co.uk

3 The table below shows the approximate contribution of different sources to average UK background radiation exposure.

Radon gas (from rocks and soil): 50%
Medical (X-rays and treatments): 14%
Cosmic rays (from space): 12%
Ground and buildings: 14%
Food and drink: 8%
Nuclear industry, fallout and other man-made sources: 2%

Source of background radiation	Contribution (%)
Radon gas (from rocks and soil)	50%
Medical (X-rays and treatments)	14%
Cosmic rays (from space)	12%
Ground and buildings	14%
Food and drink	8%
Nuclear industry, fallout and other man-made sources	2%

(a) State two sources of background radiation from the table that are natural (not caused by human activity). **(1)**

(b) Calculate the total percentage of background radiation from man-made sources shown in the table. **(2)**

.....

(c) A pilot flies at high altitude for much of their working life. Explain why their annual radiation dose from background radiation is likely to be higher than average. **(2)**

.....

.....

(Total for Question 3 is 5 marks)

© Revision Library | revisionlibrary.co.uk

4 After α or β decay, a nucleus is sometimes left in an excited (higher-energy) state. It loses this extra energy by emitting γ radiation. Technetium-99m (99/43 Tc) is an excited nucleus used in medical imaging.

(a) Complete the nuclear equation for technetium-99m emitting γ radiation to form technetium-99 in its stable (ground) state. **(1)**

(b) Explain why the mass number and atomic number of the nucleus do not change when it emits γ radiation. **(1)**

(c) Neutrons can also be emitted from unstable nuclei, for example during nuclear fission (covered later in this pack). State the charge of a neutron, and explain why neutron radiation can still be hazardous despite having no charge. **(2)**

(Total for Question 4 is 4 marks)

5 When a uranium-235 nucleus (235/92 U) absorbs a slow-moving neutron (1/0 n), it can undergo fission to form xenon-140 (140/54 Xe), an isotope of strontium (Sr), and 2 further neutrons. This content applies to separate/triple Physics only.

(a) Use conservation of mass number and atomic number to determine the mass number and atomic number of the strontium nuclide formed. **(3)**

(b) State the type of nuclear reaction taking place, and describe, in terms of mass, how energy is released during the reaction. **(2)**

(Total for Question 5 is 5 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 3.27 Radioactivity, Half-Life and Nuclear Uses: Test Pack

Question 1

(a) 2 protons and 2 neutrons (a helium nucleus), oe **B1**

(a) Answer: 2 protons and 2 neutrons (a helium nucleus).

(b) a fast-moving/high-energy electron, emitted from the nucleus, oe **B1**

(b) Answer: A fast-moving electron emitted from the nucleus.

(c) γ (radiation), cao **B1**

(c) Answer: Gamma radiation.

(d) α, then β, then γ, cao **B1**

(d) Answer: Alpha, then β, then γ.

Question 2

(a) it is impossible to predict which particular nucleus in a sample will decay next, or exactly when any individual nucleus will decay, oe **B1**

(a) each nucleus has the same constant probability of decaying in a given time interval, regardless of external conditions (e.g. temperature, pressure) or how long it has already existed, oe **B1**

(a) Answer: It is impossible to predict when any individual nucleus will decay; each nucleus has an equal, constant probability of decaying in a given time, unaffected by external conditions.

(b) one decay (nuclear disintegration) per second, cao **B1**

(b) Answer: One decay per second.

Question 3

(a) any two of: radon gas; cosmic rays; ground and buildings; food and drink (both needed for the mark), oe **B1**

(a) Answer: Radon gas and cosmic rays (or any two natural sources from the table).

(b) identifies medical (14%) and nuclear industry/fallout (2%) as the man-made sources **M1**

(b) 14 + 2 = 16%, cao **A1**

(b) Answer: 16%

(c) at high altitude there is less atmosphere above to absorb cosmic rays, so exposure to cosmic radiation is greater than at ground level, oe **B1**

(c) because the pilot spends a large amount of time flying, their cumulative dose over a year builds up to be higher than someone mostly at ground level, oe **B1**

(c) Answer: Less atmosphere at altitude absorbs less cosmic radiation, and the pilot's large amount of flying time increases their cumulative annual dose.

Question 4

(a) 99/43 Tc -> 99/43 Tc + γ radiation (no change in mass number or atomic number), cao **B1**

(a) Answer: 99/43 Tc -> 99/43 Tc + γ radiation

(b) γ radiation is electromagnetic radiation/energy, with no mass and no charge, so no particles are lost from the nucleus, oe **B1**

(b) Answer: Gamma radiation has no mass and no charge, so its emission does not change the number of protons or neutrons in the nucleus.

(c) the charge of a neutron is 0 (neutral), cao **B1**

(c) neutrons are highly penetrating and can be absorbed by nuclei in the body, which can make previously stable nuclei unstable/radioactive, or can transfer energy through collisions, causing ionisation indirectly, oe **B1**

(c) Answer: Charge = 0. Although uncharged, neutrons penetrate deeply and can be absorbed by nuclei (making them unstable) or cause ionisation indirectly through collisions.

Question 5

(a) atomic number: 92 + 0 = 54 + Z(Sr) + 0, so Z(Sr) = 38 **M1**

(a) mass number: 235 + 1 = 140 + A(Sr) + 2, so A(Sr) = 94 **M1**

(a) strontium-94 (atomic number 38, mass number 94), cao **A1**

(a) Answer: Strontium-94 (atomic number 38, mass number 94).

(b) nuclear fission, cao **B1**

(b) the total mass of the products (fragments and neutrons) is very slightly less than the total mass before the reaction; this 'missing' mass is converted into a large amount of energy, released mainly as kinetic energy of the fragments and neutrons, oe **B1**

(b) Answer: Nuclear fission. A small amount of mass is converted into a large amount of energy, released mainly as kinetic energy of the fission products.

© Revision Library | revisionlibrary.co.uk