Exercise walk-through

17.2
Radioactive decay (full E.3, SL)

International Baccalaureate · IB Diploma · Physics · SL

Nuclear · 2.1

Reasoning

Radioactive decay is spontaneous and random for an individual nucleus. Half-life describes the time for half the undecayed nuclei in a large population to decay, or for background-corrected activity to halve. half-life: Time for activity or undecayed population to halve. background radiation : Radiation measured apart from the investigated source.

Exercises 2.1·2.3

2.1 Define an isotope, and state what isotopes of an element share. [2]

2.2 State what is meant by the mass defect of a nucleus. [1]

2.3 Write the full nuclear equation for beta-minus decay of ${}^{14}_{6}C$. [2]

Exercises 2.1·2.3

2.1 Define an isotope, and state what isotopes of an element share. [2]

2.1 Nuclides of the same element with different neutron numbers; they share the same proton number Z (and chemical symbol).

2.2 State what is meant by the mass defect of a nucleus. [1]

2.2 The difference between the total mass of the separate nucleons and the mass of the assembled nucleus – the mass converted to binding energy.

2.3 Write the full nuclear equation for beta-minus decay of ${}^{14}_{6}C$. [2]

2.3 ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e + \bar{\nu}$.

Exercises 2.4·3.2

2.4 Place alpha, beta and gamma radiation in order of increasing penetrating ability. [1]

3.1 State the nuclear changes in A and Z for alpha decay, and write the equation for $^{226}_{88}Ra$ decaying by alpha emission. [3]

3.2 Two protons and two neutrons have total mass 4.0319 u; a helium-4 nucleus has mass 4.0026 u. Calculate the binding energy in MeV ($1\ u = 931.5\ \text{MeV/c}^2$) and the binding energy per nucleon. [4]

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2.4 Alpha, beta, gamma.

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3.1 A falls by 4 and Z falls by 2; ${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}\alpha$.

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3.2 $\Delta m = 4.0319 - 4.0026 = 0.0293\ u$; $E = 0.0293 \times 931.5 = 27.3$ MeV; per nucleon: $27.3/4 = 6.8$ MeV.

Exercises 3.3·3.4

3.3 Explain why a medical tracer isotope is chosen with a short half-life and gamma emission, referring to penetration and ionizing ability. [3]

3.4 A source reads 4200 counts/min above a background of 200 counts/min. Calculate the count rate after two half-lives, and state one assumption. [3]

Exercises 3.3·3.4

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3.3 Gamma penetrates body tissue to reach detectors outside while ionizing least along its path, minimizing damage; a short half-life means activity – and dose – fall quickly once the scan is done.

3.4 A source reads 4200 counts/min above a background of 200 counts/min. Calculate the count rate after two half-lives, and state one assumption. [3]

3.4 Source alone: $4200 - 200 = 4000$ counts/min; after two half-lives: $4000/4 = 1000$; the meter reads $1000 + 200 = 1200$ counts/min, assuming the background rate stays constant.