



ANSWER BOOK

Stable and unstable nuclei

Particles · Year 12

AQA 3.2.1.2 · CIE 11.1 · OCR A 6.4.1, 6.4.3

10 questions · 31 marks

NAVY EDITION

SECTION A · Warm-up

- A1** The strong nuclear force holds nucleons together. It is attractive over separations from about 0.5 fm to about 3 fm, and becomes repulsive at very small separations (below about 0.5 fm), which stops the nucleus collapsing. It is very short-ranged. [2]
- A2** A decreases by 4 and Z decreases by 2. [2]
- A3** A beta-minus particle is a fast-moving electron created in and emitted from the nucleus when a neutron changes into a proton. [2]

SECTION B · Standard

- B1** $^{238}_{92}\text{U} \rightarrow ^{234}_{90}\text{Th} + ^4_2\text{He}$ (the alpha particle). Mass numbers: $238 = 234 + 4$; proton numbers: $92 = 90 + 2$. [4]
- B2** $^{14}_6\text{C} \rightarrow ^{14}_7\text{N} + ^0_{-1}\text{e} + \text{anti-}\nu_{\text{e}}$. Mass numbers: $14 = 14 + 0$; charge: $6 = 7 + (-1)$. [4]
- B3** Beta particles are emitted with a range of kinetic energies up to a maximum, rather than a single fixed value. To conserve energy (and momentum), a second, unseen particle must carry away the balance; this was the antineutrino. [3]
- B4** Beta-minus decay. A neutron becomes a proton, so Z rises by 1 while A is unchanged (a proton and neutron have the same mass number), and an electron is emitted. [4]

SECTION C · Stretch

- C1** $^{226}_{88}\text{Ra} \rightarrow ^{222}_{86}\text{Rn} + ^4_2\text{He}$. The radon nucleus has $222 - 86 = 136$ neutrons. [4]
- C2** At separations below about 0.5 fm the force is strongly repulsive. From about 0.5 fm to about 3 fm it is attractive, peaking then falling. Beyond about 3 fm it is effectively zero, because the force is very short-ranged. [4]
- C3** The strong force acts only over a very short range, so a nucleon is attracted only to its nearest neighbours, whereas the electrostatic repulsion between protons acts across the whole nucleus. In large nuclei the long-range repulsion of many protons outweighs the short-range attraction, making them unstable. [3]