

Solutions

Each answer shows the steps, then the **result**.

2.1

- any two: the atom is **mostly empty space**; there is a **tiny, dense nucleus**; the nucleus is **positively charged**; most of the atom's **mass** is in the nucleus

2.2

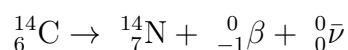
- protons = $Z = 6$; electrons (neutral atom) = $Z = 6$
- neutrons = $A - Z = 14 - 6 = 8$

2.3

- atoms of the **same element** (same proton number) with **different numbers of neutrons**

2.4

- nucleon number A and proton number Z both balance



- the last particle is an (electron) **antineutrino**

3.1 A

- an α particle is a helium nucleus: massive and doubly charged, so it ionises heavily, loses energy fast and stops in a sheet of paper
- B** β needs a few millimetres of aluminium; **C** γ and **D** X-rays need centimetres of lead. Heavier and more charged means *less* penetrating

3.2

(a) any three: **charge** (proton number), **nucleon number**, **(linear) momentum**, **mass–energy**

(b) the parent was stationary, so momentum is conserved: $m_\alpha v_\alpha = m_R v_R$

$$v_R = \frac{m_\alpha v_\alpha}{m_R} = \frac{(4 \text{ u})(1.6 \times 10^7 \text{ m s}^{-1})}{222 \text{ u}} = \mathbf{2.9 \times 10^5 \text{ m s}^{-1}}$$

3.3

- a β -decay also emits an (anti)**neutrino**
- the (anti)neutrino **shares** the released energy with the β -particle in varying proportions, so the β energy varies

3.4

- α : charge $+2e$, mass 4 u
- β^- : charge $-e$, mass ≈ 0 ($1/1836 \text{ u}$)
- γ : charge 0 , mass 0