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 $= A - Z = 14 - 6 = \mathbf{8}$

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

$$^{14}_{6}\mathrm{C} \rightarrow \ ^{14}_{7}\mathrm{N} + \ ^{0}_{-1}\beta + \ ^{0}_{0}\bar{\nu}$$

- 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: $m_\alpha v_\alpha = m_R v_R$

$$v_R = \frac{m_\alpha v_\alpha}{m_R} = \frac{(4\ \mathrm{u})(1.6\times10^{7}\ \mathrm{m\ s^{-1}})}{222\ \mathrm{u}} = \mathbf{2.9\times10^{5}}\ \mathrm{m\ s^{-1}}$$

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 u)
- γ: charge 0, mass 0