

## Solutions

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**2.1** Two protons and two neutrons – the same as a helium nucleus.

**2.2** Most ionising: alpha. Longest range in air: gamma.

**2.3** Beta: alpha would not pass through any metal foil; gamma would pass almost unaffected, so the count could not track small thickness changes; beta is partly absorbed by thin metal, so count-rate follows thickness.

**3.1** Not alpha – paper would stop it (count unchanged through paper). Not only beta – 5 mm aluminium stops beta, yet counts remain. Gamma – reduced by lead and by aluminium; the observed halving by thick lead confirms gamma.

**3.2** A neutron in the nucleus turns into a proton; the atomic number increases by 1 while the mass number is unchanged – the high-speed electron is ejected.

**3.3** (a) Gamma: the most penetrating radiation – it passes through the boxes and sterilises the contents without contact. (b) So the source does not need frequent replacement (activity stays high for years). (b→c) The syringes were irradiated, not contaminated: irradiation exposes them to radiation but does not transfer radioactive material, so nothing radioactive remains on them.