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QUESTION WORKBOOK

Stable and unstable nuclei

Particles · Year 12

AQA 3.2.1.2 · CIE 11.1.6, 11.1.10, 11.1.11 · OCR A 6.4.1(e), 6.4.3(c)

19 questions · 60 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 Describe the strong nuclear force, including its approximate range and whether it is attractive or repulsive. [2]

A2 State how the mass number A and the proton number Z change when a nucleus emits an alpha particle. [2]

A3 State what a beta-minus particle is. [2]

A4 State the two quantities that must balance on each side of any nuclear decay equation. [2]

A5 State what an alpha particle consists of, and write the alpha particle in nuclide notation. [2]

SECTION B · Standard

B1 Uranium-238 decays by alpha emission to thorium (Th). Write the balanced nuclear equation, including mass and proton numbers. [4]

B2 Carbon-14 decays by beta-minus emission to nitrogen (N). Write the balanced nuclear equation, including the antineutrino. [4]

B3 Explain why the existence of the (anti)neutrino was proposed to account for observations of beta-minus decay. [3]

B4 In an unknown decay, the proton number increases by 1 while the mass number stays the same. State the type of decay and explain your reasoning. [3]

B5 In one section of a natural decay series, a bismuth-214 nucleus ($Z = 83$) decays by beta-minus emission, and the daughter nucleus then decays by alpha emission. Determine the nucleon number and the proton number of the final nucleus. [3]

B6 A freshly produced nuclide contains significantly more neutrons than the stable isotopes of the same element. State the decay mode expected and explain how the decay moves the nuclide towards stability. [3]

B7 In the beta-minus decay of carbon-14 the total energy released is 0.156 MeV. In one particular decay the emitted electron is measured to carry 0.049 MeV of kinetic energy. Calculate the energy carried away by the antineutrino. Assume that the recoil energy of the nucleus is negligible. [3]

B8 Radon-220 (Z = 86) decays by alpha emission to a nuclide X. Determine the nucleon number and the proton number of X, and identify X from the following elements: lead (Z = 82), bismuth (Z = 83), polonium (Z = 84), astatine (Z = 85). [3]

SECTION C · Stretch

C1 Radium-226 decays by alpha emission to radon (Rn). Write the balanced nuclear equation and state the number of neutrons in the radon nucleus produced. [4]

C2 Describe how the strong nuclear force between two nucleons varies with their separation, referring to the separations at which it is repulsive, attractive and effectively zero. [4]

C3 Explain why very large nuclei tend to be unstable. [3]

C4 A student measures the kinetic energies of the electrons emitted by a radioactive source and finds that every electron carries the same energy. Deduce whether these electrons can be beta-minus particles. [3]

C5 The nuclide used in domestic smoke detectors, americium-241 (Z = 95), decays by alpha emission to neptunium (Np). A data sheet claims that the daughter nucleus produced contains more than 140 neutrons. Deduce whether the claim is correct.

[4]

C6 Compare alpha decay with beta-minus decay. In your answer you should describe what is emitted in each case, state how the nucleon number and the proton number change, and explain the role of the antineutrino in beta-minus decay.

[6]