Nuclear Physics: Decay, Half-Life & Binding Energy

Modern physics · 5 questions · step-by-step answers at the end

Name: Date: Score: / 5

USEFUL EQUATIONS

$^{A}_{Z}X$, $N = A - Z$ $N = N_0(½)^{t/T½}$ $E = \Delta m\, c^2$ $1\ \text{u} \leftrightarrow 931.5\ \text{MeV}$

$E_B = (Zm_p + Nm_n - m_{nucleus})c^2$

Questions

Show your working in the space under each question.

1. Polonium-210 (Z = 84) is an alpha emitter with a half-life of 138 days. What is the daughter, and what fraction remains after 414 days?

2. Uranium-238 (Z = 92) decays by alpha emission. Identify the daughter nucleus. If you start with 80 mg of a radioactive isotope with a half-life of 8 days, how much remains after 24 days?

3. Complete the reaction: $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + ?$

4. How much energy would converting 1.0 g of mass completely to energy release?

5. Radium-226 emits an alpha particle. What nucleus is left?

Step-by-step answers

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1. A = 206, Z = 82: **lead-206**. 414/138 = 3 half-lives, so **1/8** remains.

2. 1. Alpha decay: A = 238 − 4 = 234 and Z = 92 − 2 = 90, so the daughter is **thorium-234**: $^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$.

2. Half-life: 24 days = 3 half-lives, so 80 → 40 → 20 → **10 mg** remain.

Answer: Thorium-234; 10 mg

3. A: 236 = 141 + 92 + 3, and Z: 92 = 56 + 36, so the missing products are **3 neutrons**.

4. $E = mc^2 = (0.001)(9 \times 10^{16}) =$ **9×10^{13} J**, about the energy of a large power station running for a day.

5. A − 4 = 222 and Z − 2 = 86: **radon-222**.