

Energy levels, radioactive decay and binding energy

AP Physics 2 (algebra-based) · Test answers (mark scheme)

Marks are shown for each step. Method marks are given for a correct relationship even if the arithmetic slips, but final answers need units.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 15

Question 1 Hydrogen transition (3 marks)

- a. $\Delta E = -1.51 - (-13.6) = \mathbf{12.1 \text{ eV}}$.
- b. $\lambda = 1240 / 12.1 = \mathbf{102.5 \text{ nm}}$, about 103 nm.
- c. **Ultraviolet**.

Marking: one mark each part.

Question 2 Absorption (2 marks)

- a. The **10.2 eV** photon.
- b. It matches the gap between $n = 1$ and $n = 2$ exactly ($-3.40 - (-13.6) = 10.2 \text{ eV}$). The 10.0 eV photon matches no gap and so passes through.

Marking: correct photon (1); matching reason (1).

Question 3 Alpha decay (2 marks)

- a. ${}^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + {}^4_2\text{He}$.
- b. Mass number ($210 = 206 + 4$) and charge or atomic number ($84 = 82 + 2$) are conserved.

Marking: balanced equation (1); both quantities (1).

Question 4 Beta decay (2 marks)

- a. Xenon-131: **A = 131, Z = 54**.
- b. A neutron turns into a proton, and an electron and an antineutrino are emitted.

Marking: one mark each part.

Question 5 Half-life calculation (3 marks)

- a. 36 h is 3 half-lives: $40 \rightarrow 20 \rightarrow 10 \rightarrow \mathbf{5.0 \text{ mg}}$.
- b. $40 \rightarrow 2.5 \text{ mg}$ needs 4 half-lives, so **48 h**.

Marking: number of half-lives (1); mass (1); time (1).

Question 6 Decay graph (3 marks)

- a. 800 falls to 400 in 6 hours, so **T = 6 h**.
- b. At 18 hours the rate is **100 per minute**.
- c. Each half-life removes only half of what is left, so some nuclei always remain.

Marking: one mark each part.

Question 7 Mass defect (3 marks)

- a. $E = 0.0150 \times 931.5 = \mathbf{14.0 \text{ MeV}}$.
- b. $13.97 \times 1.60 \times 10^{-13} = \mathbf{2.24 \times 10^{-12} \text{ J}}$.
- c. $E = \Delta m c^2$: lost mass appears as released energy.

Marking: one mark each part.

Question 8 Fusion and fission (2 marks)

- a. Light nuclei have low binding energy per nucleon; fusing moves them up the curve to a more tightly bound nucleus and the extra binding energy is released.
- b. Very heavy nuclei sit below the peak; splitting gives middle-sized nuclei that are more tightly bound per nucleon, so energy is released.

Marking: one mark each part.