

Radioactive decay and nuclear binding energy

Physics grades 11-12 (A Level · IB · Class 11-12) · Test

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

Answer all the questions. Show your working, give units, and use $c = 3.00 \times 10^8$ m/s, $1 \text{ u} = 931.5 \text{ MeV}/c^2$ and $\ln 2 = 0.693$. Total 20 marks. A calculator is allowed.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB E.3-E.5

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

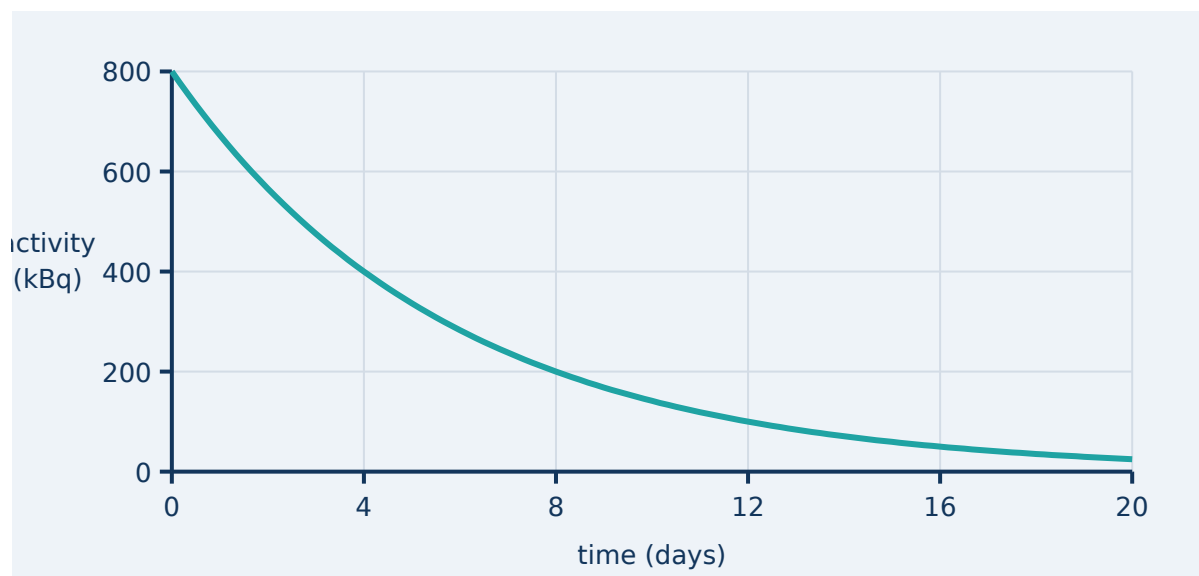
Question 1 A plutonium decay (3 marks)

Plutonium-239 ($Z = 94$) decays by emitting an alpha particle.

- Determine the nucleon number and proton number of the daughter nuclide. (2 marks)
- Name the daughter element (uranium has $Z = 92$). (1 mark)

Question 2 Reading a decay graph (3 marks)

The graph shows the activity of a sample of an isotope X.



Activity of isotope X.

- Use the graph to determine the half-life. (1 mark)
- Calculate the activity after 10 days. (2 marks)

Question 3 Polonium-210 source (3 marks)

A source contains 4.0×10^{16} nuclei of polonium-210, which has a half-life of 138 days.

- Calculate the decay constant in s^{-1} . (2 marks)
- Calculate the activity of the source. (1 mark)

Question 4 Binding energy of lithium-7 (3 marks)

Use atomic masses: hydrogen atom 1.007825 u, neutron 1.008665 u, lithium-7 atom 7.016004 u (lithium has $Z = 3$).

- Calculate the mass defect in u. (1 mark)
- Calculate the binding energy in MeV, using $1 \text{ u} = 931.5 \text{ MeV}/c^2$. (1 mark)
- Calculate the binding energy per nucleon. (1 mark)

Question 5 Why fusion and fission release energy (2 marks)

Use the shape of the graph of binding energy per nucleon against nucleon number to explain why both the fusion of light nuclei and the fission of heavy nuclei release energy.

Question 6 A chain reaction (3 marks)

Explain how a chain reaction occurs in a sample of uranium-235, and how control rods keep a reactor at a steady rate.

Question 7 Fusion conditions (2 marks)

Explain why nuclear fusion requires temperatures of millions of kelvin.

Question 8 Activity (1 mark)

Define the activity of a radioactive source and give its SI unit.