

(Question B1 continued)

Part 2 Radioactive decay

- (a) Describe the phenomenon of natural radioactive decay. [3]

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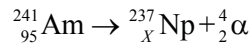
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- (b) A nucleus of americium-241 (Am-241) decays into a nucleus of neptunium-237 (Np-237) in the following reaction.



- (i) State the value of X . [1]

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- (ii) Explain in terms of mass why energy is released in the reaction in (b). [2]

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(Question B1, part 2 continued)

(iii) Define *binding energy* of a nucleus. [1]

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(iv) The following data are available.

Nuclide	Binding energy per nucleon / MeV
americium-241	7.54
neptunium-237	7.58
helium-4	7.07

Determine the energy released in the reaction in (b). [3]

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Part 2 Radioactive decay

- (a) emission of (alpha/beta/gamma) particles/photons/electromagnetic radiation;
 nucleus becomes more (energetically) stable;
 constant probability of decay (per unit time);
 is random process;
 activity/number of unstable nuclei in sample reduces by half over constant time intervals/exponentially;
 not affected by temperature/environment / is spontaneous process; **[3 max]**
- (b) (i) 93; **[1]**
- (ii) mass of products is less than mass of reactants / there is a mass defect;
 mass is converted into energy (according to equation $E = mc^2$); **[2]**
- (iii) the (minimum) energy required to (completely) separate the nucleons in a nucleus / the energy released when a nucleus is assembled from its constituent nucleons; **[1]**
- (iv) calculation of binding energies as shown below;
 americium-241 = $241 \times 7.54 = 1817.14$ MeV
 neptunium-237 = $237 \times 7.58 = 1796.46$ MeV
 helium-4 = $4 \times 7.07 = 28.28$ MeV
 energy released is the difference of binding energies;
 and so equals 7.60 MeV; **[3]**
Award [2 max] for an answer that multiplies by the number of neutrons or number of protons.
Ignore any negative sign in answer.