

6 Figure 7 shows the nuclei of four atoms.

$\begin{array}{c} 234 \\ \text{U} \\ 92 \\ \text{uranium-234} \end{array}$	$\begin{array}{c} 235 \\ \text{U} \\ 92 \\ \text{uranium-235} \end{array}$	$\begin{array}{c} 238 \\ \text{Pu} \\ 94 \\ \text{plutonium-238} \end{array}$	$\begin{array}{c} 238 \\ \text{Am} \\ 95 \\ \text{americium-238} \end{array}$
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Figure 7

(a) Which two nuclei have the same number of neutrons?

(1)

- ☐ A plutonium-238 and uranium-235
- ☐ B uranium-235 and americium-238
- ☐ C uranium-234 and americium-238
- ☐ D americium-238 and plutonium-238

(b) (i) State what is meant by the term 'half-life'.

(1)

(ii) Plutonium-238 is used in spacecraft to provide heat to power generators.

One of these generators contains 925 g of plutonium-238 when it is manufactured.

One gram of plutonium-238 has a power density of 0.54 W/g.

Plutonium-238 has a half-life of 87.7 years.

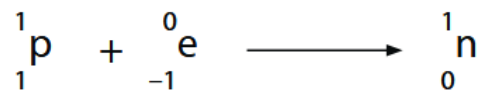
Calculate the average energy released per second by the generator after 263 years.

(4)

average energy released per second = ..... (J)

- (c) The nucleus of americium-238 can absorb an electron.

When this happens, one of the protons in the nucleus becomes a neutron, as shown in Figure 8.



**Figure 8**

- (i) Describe how absorbing an electron affects the proton number and the nucleon number of a nucleus.

(2)

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- (ii) Deduce which nucleus is formed when americium-238 absorbs an electron.

(1)

- ☐ **A** uranium-234
- ☐ **B** uranium-235
- ☐ **C** plutonium-238
- ☐ **D** americium-238

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**(Total for Question 6 = 9 marks)**

Question number	Answer	Mark
6(a)	B	(1)

Question number	Answer	Additional guidance	Mark
6(b)(i)	The time taken for the activity of a radioactive nuclide to halve (1)	accept for nuclide: isotope sample	(1)

Question number	Answer	Additional guidance	Mark
6(b)(ii)	<p>Determines number of half-lives and rounds (1)  <math>263/87.7 = 3</math></p> <p>Determines that 3 half-lives is <math>1/2 \times 1/2 \times 1/2 = 1/8</math> (1)</p> <p>Determines mass of Pu-238 after 3 half-lives (1)  <math>925/8 = 115.625</math> (g)</p> <p>Determines average energy released per second (1)  <math>115.625 \times 0.54 = 62.4</math> (J)</p>	<p>allow repeated division by 2  allow ecf from step 2 for 1 mark  (mass of Pu-238 after 1 half-life <math>925/2 = 462.5</math> (g))</p> <p>allow ecf from 1 half-life or from step 3</p>	(4)

Question number	Answer	Mark
6(c)(i)	<p>An answer that combines the following points of application of knowledge and understanding to provide a logical description:</p> <ul style="list-style-type: none"> <li>proton number/atomic number decreases by 1 (1)</li> <li>nucleon number/mass number remains unchanged (as p and n have same mass and mass of electron is (assumed) negligible) (1)</li> </ul>	(2)

Question number	Answer	Mark
6(c)(ii)	C	(1)