

6 Figure 7 shows the nuclei of four atoms.

|                               |                               |                                  |                                  |
|-------------------------------|-------------------------------|----------------------------------|----------------------------------|
| 234<br>U<br>92<br>uranium-234 | 235<br>U<br>92<br>uranium-235 | 238<br>Pu<br>94<br>plutonium-238 | 238<br>Am<br>95<br>americium-238 |
|-------------------------------|-------------------------------|----------------------------------|----------------------------------|

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)

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(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.

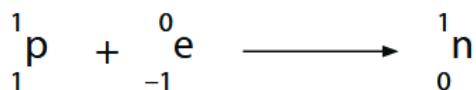
Calculate the average energy released per second by the generator after 263 years.

(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

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

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| <b>Question number</b> | <b>Answer</b> | <b>Mark</b> |
|------------------------|---------------|-------------|
| <b>6(a)</b>            | B             | <b>(1)</b>  |

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

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

| <b>Question number</b> | <b>Answer</b>  | <b>Mark</b> |
|------------------------|--|-------------|
| <b>6(c)(i)</b>         | An answer that combines the following points of application of knowledge and understanding to provide a logical description: <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> | <b>(2)</b>  |

| <b>Question number</b> | <b>Answer</b> | <b>Mark</b> |
|------------------------|---------------|-------------|
| <b>6(c)(ii)</b>        | C             | <b>(1)</b>  |