

9 (a) Explain what is meant by

(i) the *radioactive decay* of a nucleus, and

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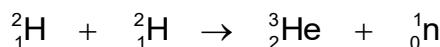
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(ii) *nuclear fusion*.

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(b) The nuclear fusion of two nuclei of deuterium is represented by the nuclear equation.



$$\text{Mass of a deuterium nucleus} = 3.345 \times 10^{-27} \text{ kg}$$

$$\text{Mass of a helium nucleus} = 5.008 \times 10^{-27} \text{ kg}$$

$$\text{Mass of a neutron} = 1.675 \times 10^{-27} \text{ kg}$$

(i) Calculate the energy released during the fusion reaction.

energy released = J [2]

- (ii) Calculate the energy released per kilogram of deuterium nucleus during the fusion reaction.

energy released per kg = J kg^{-1} [3]

- (c) Artificial pacemakers that are used to stimulate the heart may be designed to run on nuclear energy. Early types of such nuclear batteries contain 0.16 g of Plutonium-238 and produces 0.75 mW of power when new.

- (i) Given that the half-life of Plutonium-238 is 88 years, calculate its decay constant.

decay constant = s^{-1} [2]

- (ii) Hence determine the initial activity of 0.16 g of the Plutonium-238 source.

initial activity = s^{-1} [2]

- (iii) One of the decay chain of Plutonium-238 involves a series of alpha decays which leads to Uranium-234, followed by Thorium-230 and then to Radium-226. The half-life of Uranium-234 is 246,000 years.

1. Determine the change in mass per Plutonium-238 decay into Uranium-234.

change in mass = kg [2]

2. State one assumption made in (iii)1.

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- (iv) Suggest why it is important to investigate the decay chain of Plutonium-238 in the design of such a nuclear battery.

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- (d) Radioactivity as a source of radiation can have both good and bad effects. Some of the sources contributing to background radiation can be rocks and soil or medical treatment.

- (i) Name another source of background radiation which makes a major contribution.

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- (ii) Suggest why, when monitoring low radiation levels in the body for medical purposes, it is important to reduce background count rate to a minimum.

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END OF PAPER