

**GCSE Physics B (Twenty First Century Science)**  
**J259/02** Depth in physics (Foundation Tier)

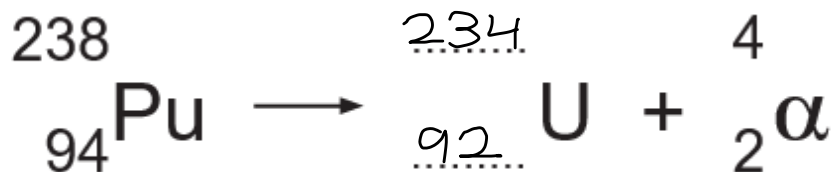
**Question Set 5**

1

There is a film about an astronaut named Mark Watney. He is left alone on the planet Mars. He has to use science to stay alive until he can be rescued.

(a) Mars is a cold planet. Watney uses a radioactive thermal generator to heat himself. The generator contains radioactive plutonium-238 which emits alpha-particles ( $\alpha$ ).

(i) Complete the radioactive decay equation for plutonium-238.



[2]

(ii) The radioactive plutonium-238 is sealed inside a case with thin walls made of aluminium. The plutonium-238 emits a large number of high energy alpha-particles each second.

**Two** of the following statements, taken together, explain why Watney is not at any risk from irradiation.

Tick (✓) **two** boxes.

Alpha particles cannot penetrate a thin sheet of paper.

Alpha radiation is never dangerous.

Alpha radiation is not part of the electromagnetic spectrum.

The aluminium in the case is thicker and denser than thin paper.

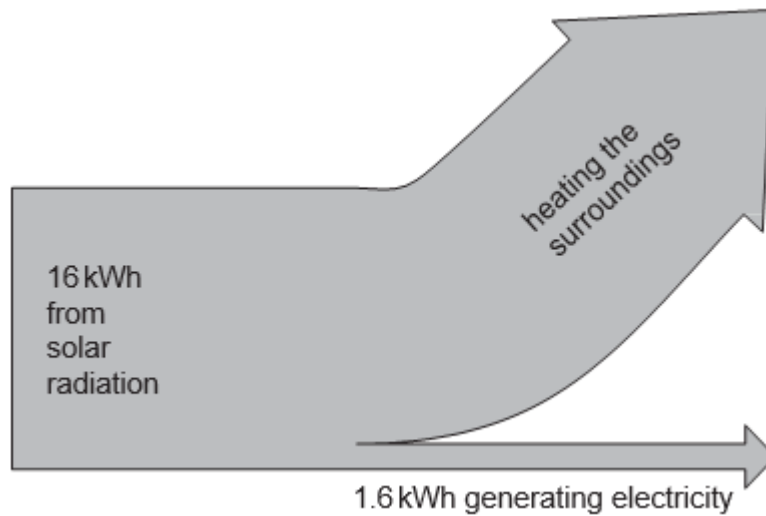
He always wears safety glasses when he handles the plutonium-238.

[2]

(b) To be rescued, Watney needs to travel 3200 km across Mars to a rocket.

He drives there using a battery-powered vehicle. The battery is recharged using solar panels.

The Sankey diagram in **Fig. 1.1** shows the energy transferred in one hour by the solar panels.



**Fig. 1.1**

(i) Calculate, as a percentage, the efficiency of the solar panels.

Use the equation:

$$\text{efficiency} = (\text{useful energy transferred} \div \text{total energy transferred}) \times 100$$

$$\text{Efficiency} = \frac{1.6}{16} \times 100 = 10\%$$

$$\text{Efficiency} = \dots\dots\dots 10 \dots\dots\dots \% \quad [3]$$

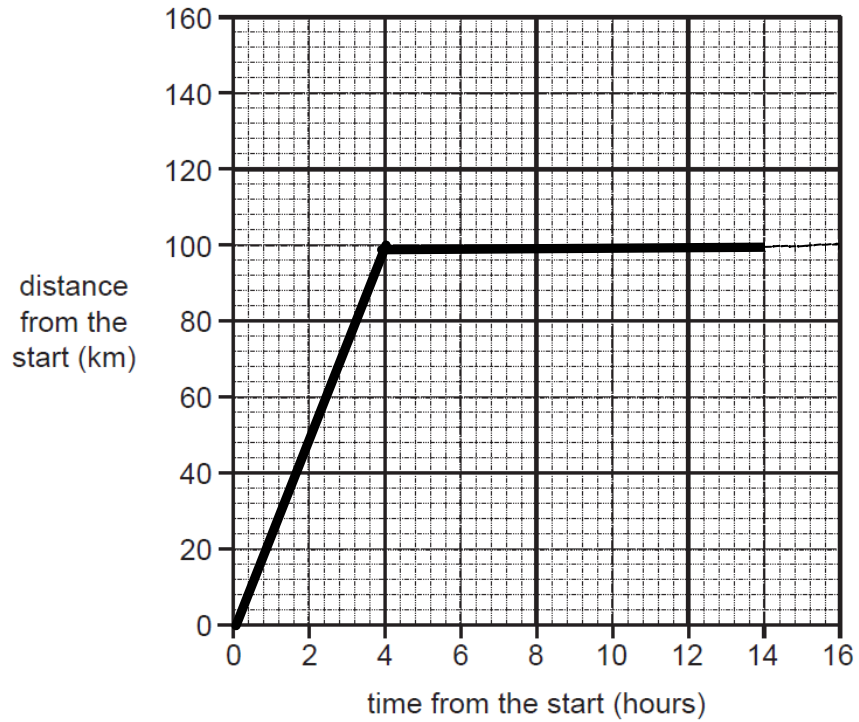
(ii) The rechargeable battery stores 18 kWh of energy.

Use data from **Fig. 1.1** to show that the solar panels need more than 10 hours to recharge the battery.

[2]

$$\frac{18}{1.6} = 11.25 \text{ hours}$$

- (c) Watney sets off on his journey to the rocket.  
He drives for 4 hours at a steady speed of 25 km/hour.  
He then stops to let the battery re-charge for 10 hours.  
Complete this distance-time graph.



[4]

**Total Marks for Question Set 5: 13**

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