

GCSE Physics B (Twenty First Century Science)
J259/04 Depth in physics (Higher Tier)

Question Set 3

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, and Watney has a radioactive thermal generator. This contains radioactive plutonium-238 which emits alpha-particles, giving an isotope of uranium.

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



(ii) The plutonium emits 1.6×10^{15} alpha particles every second, each with an energy of 9.0×10^{-13} J.

The energy released is all transferred to the internal energy of the generator.

Show that the input power of the generator is about 1500 W. [3]

(iii) Watney uses the generator to heat up water for a bath. He heats 100 kg of water from 20 °C to 37 °C.

Show that it takes more than an hour (3600 s) for his bath to warm up using his 1500 W generator.

You can assume that all the input energy to the generator is transferred to the internal energy of the water.

Specific heat capacity of water = 4200 J/kg °C [5]

(b) To be rescued, Watney needs to drive a vehicle to a site 3200 km away. The vehicle is powered by batteries of capacity 18 kWh.

Watney knows that the vehicle can travel at 25 km/hour using 5 kW of power from the batteries to do this. When the batteries are discharged Watney has to wait until the next day to continue. He has solar panels to recharge the batteries after a day's travel.

(i) Use these data to calculate the smallest number of days it would take to drive to his destination.

Number of days = days [4]

(ii) Give **one** reason why it would actually take longer than the time calculated in (b)(i). [1]

Total Marks for Question Set 3: 16

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