**8** Read the following article and then answer the questions that follow.

## Solar Vehicles

A solar vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic cells contained in solar panels convert the sun's energy directly into electric energy. The term "solar vehicle" usually implies that solar energy is used to power all or part of a vehicle's propulsion. Solar power may be also used to provide power for communications or controls or other auxiliary functions. Solar vehicles are not sold as practical day-to-day transportation devices at present, but are primarily demonstration vehicles and engineering exercises, often sponsored by government agencies.

The design of a solar vehicles is severely limited by the amount of energy input into the car. Solar cars are built for solar car races and also for public use. Even the best solar cells can only collect limited power and energy over the area of a car's surface. This limits solar cars to ultralight composite bodies to save weight.

In an experiment, a prototype model of a solar powered vehicle was put to a 200 km test run. Solar vehicles weighing more than 1000 kg are generally impractical. To keep the vehicle light and efficient, the motor and battery are often carefully selected. For the prototype, the selected motor has an average power output of 1.1 kW with a corresponding efficiency of 92%. It is also capable of delivering a power output of 4.5 kW for peak performance. The selected battery operates at 50 V and has a charge capacity of 60 A h.

Solar cars are often fitted with gauges and wireless telemetry, to carefully monitor the car's energy consumption, solar energy capture and other parameters. Wireless telemetry is typically preferred as it frees the driver to concentrate on driving, which can be dangerous in such a small, lightweight car. The solar cells used has an electrical efficiency (ability of solar cell to convert solar energy to electrical energy) of 26 %. The total surface area of solar cells collecting solar energy was kept to an optimum value of 7.7 $m^2$. The 200 km journey was eventually completed with an average speed of 67 km $h^{-1}$. During the test run, an average solar energy intensity of 0.90 kW $m^{-2}$ was recorded.

**(a)** Calculate the total amount of energy collected by the solar cells during its 200 km journey.

total energy = ..... J [3]

**(b)** Calculate the amount of energy in **(a)** which was transformed into electrical energy.

electrical energy = ..... kW h [2]

**(c)** When the motor was operating at *average power output*, show that the total power being supplied by the battery is 1.2 kW.

[2]

**(d)** The surface area of a solar cell is $6.4 \times 10^{-3}$ $m^2$. Determine

**(i)** how many cells can be fitted onto the solar vehicle,

no of solar cells = ..... [1]

**(ii)** how much energy does each cell, assumed identical, collect during the 200 km journey.

energy collected by each cell = ..... J [2]

**(e)** If the total resistive force on the vehicle is directly proportional to the square of the speed of the vehicle, determine the constant speed with which the vehicle is travelling when it operates at its *peak power.*

speed = ..... km $h^{-1}$ [3]

**(f)** By reference to **(c)**, calculate the discharge current from the fully charged battery under conditions of darkness.

discharge current = ..... A [1]

**(g)** Hence, calculate the time for the battery to become fully discharged.

Time taken = ..... hr [2]

**(h)** You are told that the average solar energy intensity received is 0.90 kW $m^{-2}$. Name two factors which could affect its actual value.

**1.** .....

.....

**2.** .....

..... [2]

**(i)** Solar powered vehicles tend to be flat and wide. Give one reason for each of the two features stated.

**1.** .....

.....

**2.** .....

..... [2]

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