7 A solar cell is a device which converts light energy directly into electrical energy. Under the influence of light, a terminal potential difference (p.d.) is generated across the solar cell. This process is explained as follows.

A solar cell consists of three main layers: an N-type material layer, a Junction layer, and a P-type material layer.

There is an electric field across the Junction layer as shown in Fig. 7.1. When photons are incident on the solar cell, electron-hole pairs are generated in the Junction layer. Holes are positively charged carriers with charge $+e$. The electrons and holes move in opposite directions under the influence of the electric field, which sets up a terminal p.d. across the solar cell.

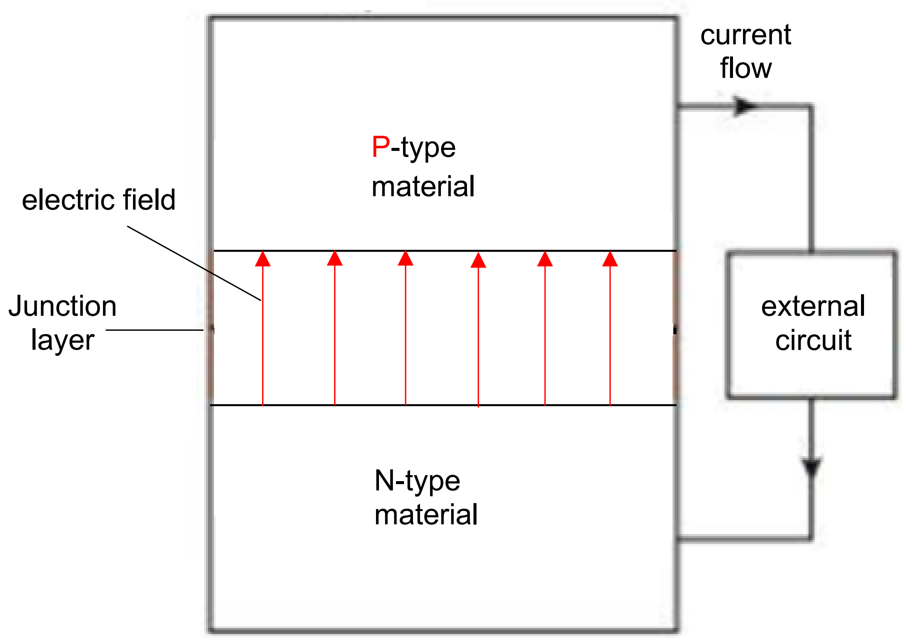

Fig. 7.1

Electron-hole pairs will be generated in the solar cell provided that the incident photon has an energy greater than a certain value known as the band gap energy of the material used.

The magnitude of the p.d. developed across the terminals of the solar cell depends on the intensity of light incident onto the solar cell.

The variation of the potential difference V across the cell with current I can be investigated using the circuit shown in Fig. 7.2.

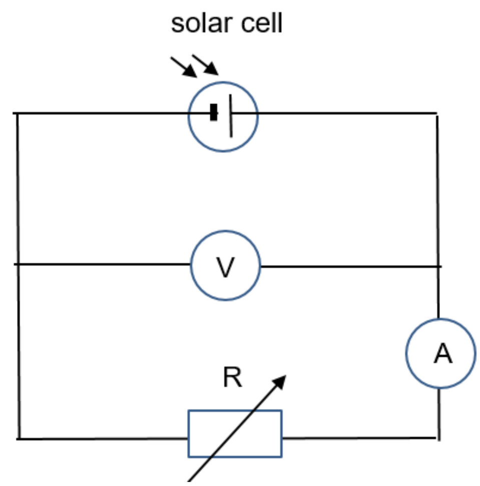

Fig. 7.2

R is a variable resistor with a maximum resistance of 7.0 Ω. The voltmeter has infinite resistance and the resistance of the ammeter is negligible.

Fig. 7.3 shows the variation of *I* with *V* for a particular cell of surface area 4.0×10^{-4} m^2 when illuminated normally with light intensity 1100 W m^{-2}.

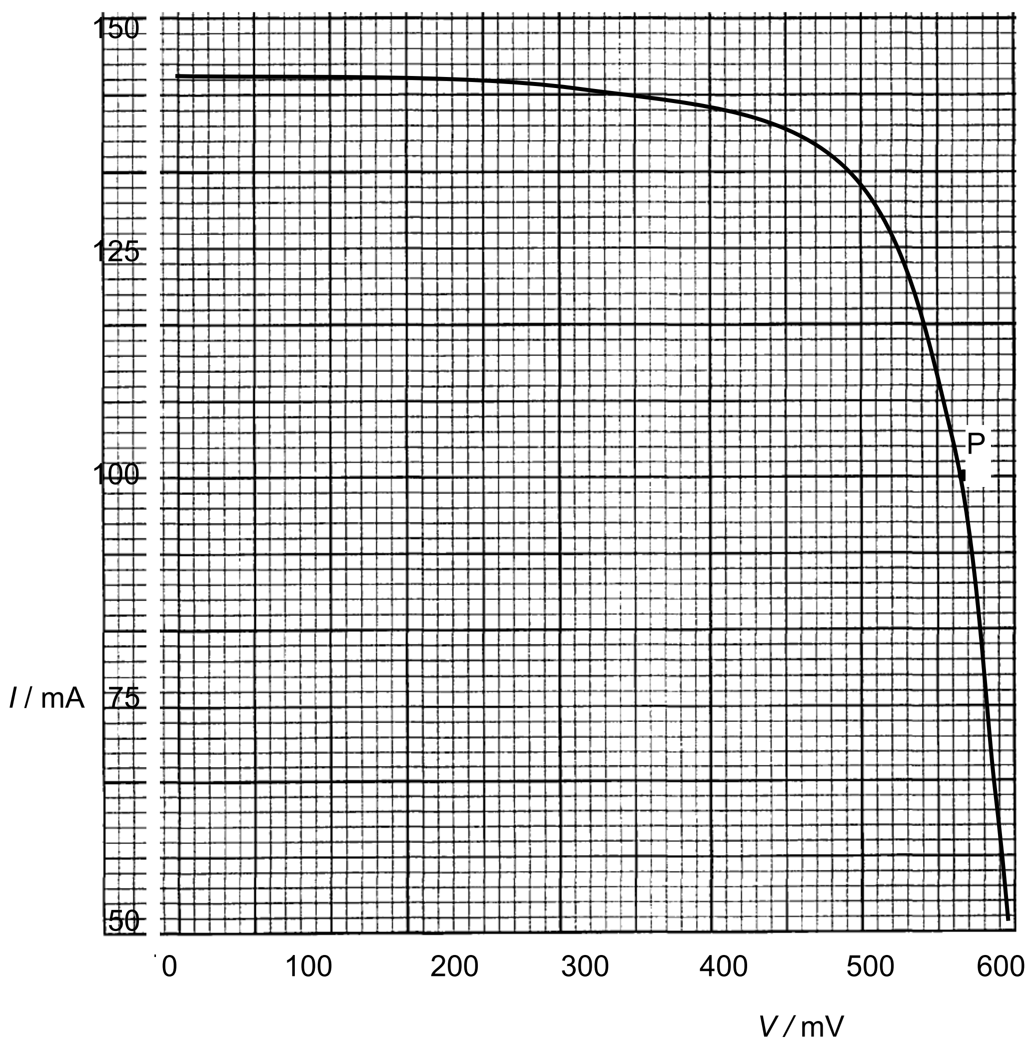

Fig. 7.3

(a) **(i)** State why a p.d. is set up across the solar cell only for a limited range of frequencies of photons.

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…… [1]

(ii) Explain why the p.d. across the solar cell increases with the intensity of the incident light.

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…… [2]

(b) **(i)** Explain how the graph shows that the e.m.f. of the solar cell is 550 mV.

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…………………………………………………………………………………… [1]
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(ii) Explain why the experiment data needed to be extrapolated to obtain the trend from P to the point when V = 550 mV.

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(c) **(i)** From Fig. 7.3, determine the power dissipation in the load resistor for point P.

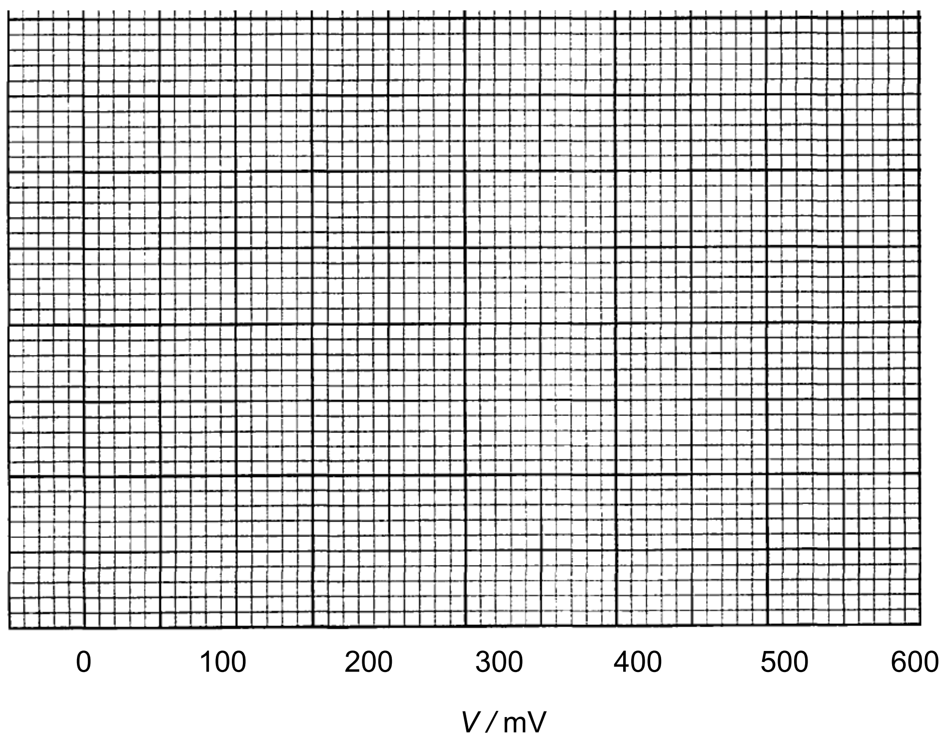
power dissipation = ………………………………..…. W [2]

(ii) On Fig. 7.3, shade an area that represents the power dissipation calculate in **(c)(i).** [1]

(iii) From Fig. 7.3, estimate the maximum power dissipation in the load resistor. Show your working.

maximum power = ………………………………….. W [2
]

(iv) On Fig. 7.4, sketch the graph of power output P_o of the cell against V. Label and include a suitable scale on the vertical axis.



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(d
) Calculate the maximum efficiency of conversion of light energy into electrical energy.

maximum efficiency = ... [2]

(e) A number of solar cells are connected to a load resistor L as shown in Fig. 7.5.

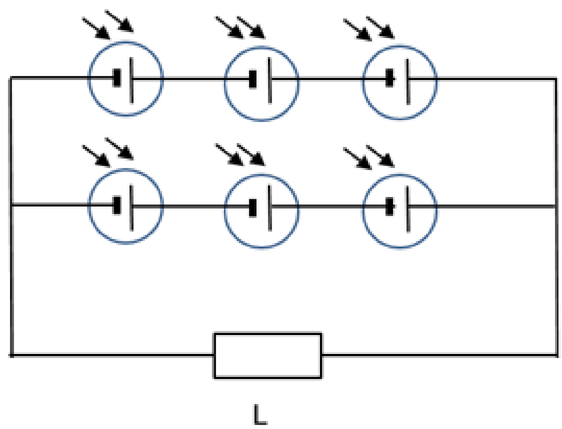

Fig. 7.5

The resistance of L has been adjusted so that each cell gives the maximum power estimated in **(c)(iii)**.

Calculate

(i) the potential difference across L,

potential difference = ... V [1]

(ii) the current through L.

current = ... A [1]

(f) Suppose each cell is operating at maximum power estimated in **(c)(iii)**. Draw a suitable network of cells so that the cells may be used to provide an output power of approximately 5 kW at 30 V.

[3
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-- END OF PAPER