1 Fig. 1.1 shows the I–V characteristic of a slice of semiconducting material.

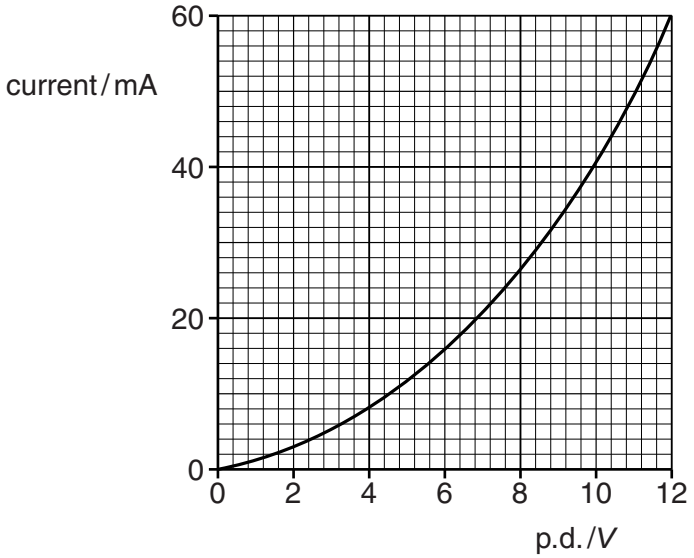

Fig. 1.1

(a) (i) Define *resistance*.

.....

..... **[1]**

(ii) Show that the resistance of the slice is about 250 Ω when there is a current of 40 mA in it.

[2]

(b) The dimensions of the slice are shown in Fig. 1.2.

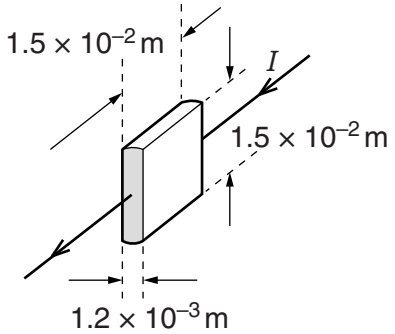

Fig. 1.2

Calculate the resistivity ρ of the semiconducting material when there is a current I of 40 mA in the slice.

ρ = ... Ω m **[3]**

(c) Explain how the I–V characteristic shows that the resistivity of the semiconducting material decreases with increasing temperature.

In your answer you should explain how you are aware that the temperature of the slice changes.

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..... **[4]**

[Total: 10]

2 **(a)** The battery in an electric car has an e.m.f. of 24 V. It can provide a current of 200 A to the motor for a period of 4.0 hours.

(i) Define the term *electromotive force* (e.m.f.) for the battery.

.....

.....

..... **[2]**

(ii) Show that the total charge Q that can be delivered by the battery is about 3×10^6 C.

[2]

(iii) Calculate the total energy E that can be supplied by the battery at a constant e.m.f. of 24 V.

E = ... J **[2]**

(b) The charger for the battery has a 30 V output supplying a current I. The total resistance of the circuit is indicated by one resistor **R** in Fig. 2.1. The positive terminal of the battery is connected to **X**.

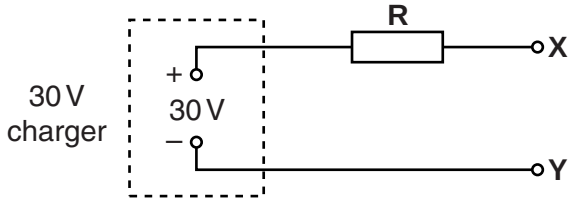

Fig. 2.1

(i) Complete the circuit by drawing the correct symbol for the battery between **X** and **Y** on Fig. 2.1. The battery has negligible internal resistance. **[1]**

(ii) The potential difference across the battery remains at 24 V. The current I provided by the battery charger is constant at 120 A. Show that the value of the resistance of **R** is 0.050 Ω.

[2]

(iii) Calculate the power lost in **R** as the battery is charging.

power lost = ...W **[2]**

(iv) The efficiency of the charging process is given by the equation

$$\text{efficiency} = \frac{\text{input power from charger} - \text{power loss in } \mathbf{R}}{\text{input power from charger}}.$$

Calculate its value as a percentage.

efficiency = ...% **[3]**

(c) (i) Show that it takes about 7 hours to charge a completely flat battery.

[2]

(ii) Calculate the cost of charging the battery at 26p per kWh.

cost = ... p **[1]**

[Total: 17]