

- 1 This question is about the use of a thermistor fitted inside a domestic oven as a temperature sensor in a potential divider circuit.

Fig. 2.1 shows the potential divider circuit in which the component  $R_2$  is connected in parallel to the input of an electronic circuit that switches the mains supply to the heating element in the oven on or off.

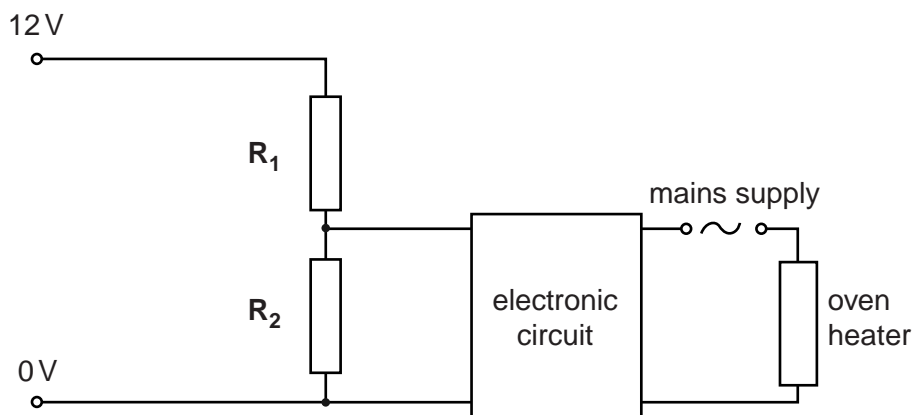


Fig. 2.1

- (a)  $R_1$  is a variable resistor and  $R_2$  is the thermistor. The circuit symbols for  $R_1$  and  $R_2$  are incomplete. Complete these circuit symbols on Fig. 2.1. [2]
- (b) It is required that the p.d. across the thermistor  $R_2$  is 7.0V when at a temperature of 180°C. The variation of resistance with temperature for  $R_2$  is shown in Fig. 2.2.

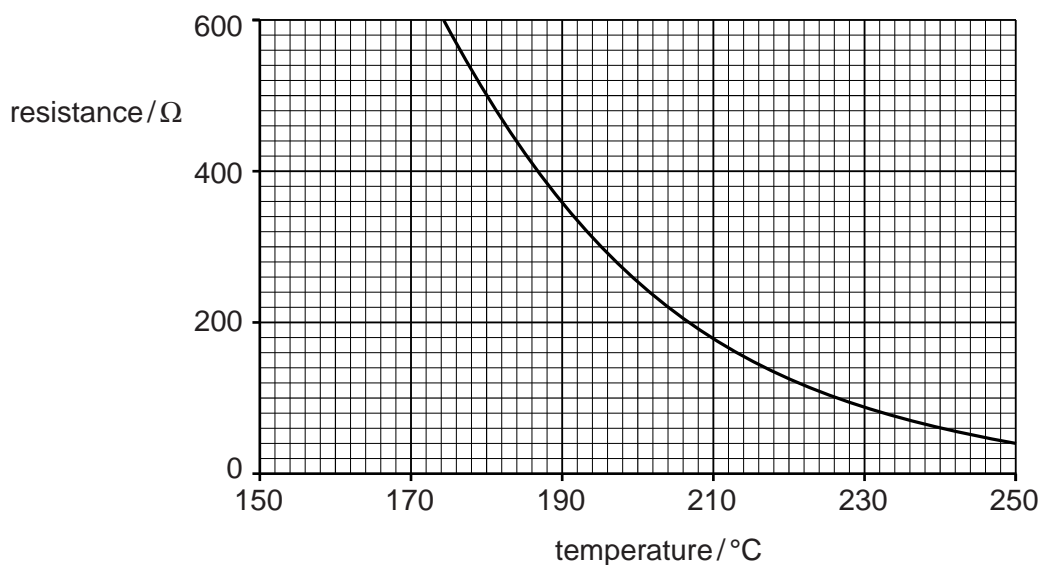


Fig. 2.2

- (i) Use Fig. 2.2 to determine the resistance of  $R_2$  at a temperature of 180°C.

resistance = ..... Ω [1]

(ii) When the temperature is  $180^{\circ}\text{C}$  the p.d. across  $R_2$  is  $7.0\text{V}$ . Calculate the current in  $R_2$ .

current = ..... A [1]

(iii) The electronic circuit draws a negligible current. Show that the resistance of the variable resistor  $R_1$  must be about  $350\Omega$ .

[2]

(iv)  $R_2$  is heated slowly. Show that the p.d. across  $R_2$  must fall to about  $5.0\text{V}$  when the temperature of  $R_2$  reaches  $200^{\circ}\text{C}$ .

[2]

(c) The thermistor  $R_2$  is fitted inside the oven. When the p.d. across  $R_2$  falls to  $5.0\text{V}$  the oven heater switches off. The oven cools until the p.d. across  $R_2$  rises to  $7.0\text{V}$  when the heater switches on again.

$R_1$  is adjusted to  $250\Omega$ . Calculate the temperatures at which the oven heater is switched on and off.

temperature on .....  $^{\circ}\text{C}$

temperature off .....  $^{\circ}\text{C}$  [4]

- 2 (a) A battery charger contains a microprocessor circuit so that it can charge an AA rechargeable cell at a constant current of 450 mA. It takes 4 hours 40 minutes to charge a 1.5 V cell from a fully discharged state.

(i) Calculate the charge  $Q$  passing through the cell during the charging process.

$Q = \dots\dots\dots$  unit  $\dots\dots\dots$  [3]

(ii) Fig. 3.1 shows the cell of internal resistance  $0.90 \Omega$  connected to the battery charger. Assume that the e.m.f. of the cell is 1.5 V.

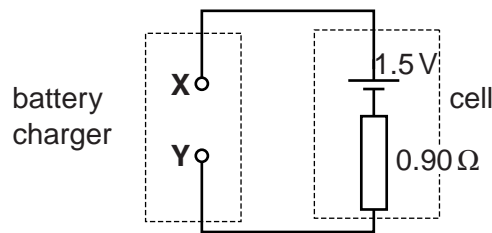


Fig. 3.1

1 State whether the terminal **X** of the battery charger is positive or negative.

.....

2 Mark the direction of the current in the circuit on Fig. 3.1. Label your arrow  $I$ . Give a reason for your choice.

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

3 Calculate the terminal p.d.  $V_{XY}$  between **X** and **Y** during the charging process.

$V_{XY} = \dots\dots\dots$  V [2]

4 Show that the mean rate of increase of energy stored in the cell during the charging process is about  $0.7 \text{ J s}^{-1}$ .

- (b) Explain how you would determine experimentally the e.m.f.  $E$  and internal resistance  $r$  of the charged cell. Include a circuit diagram with meters and a variable load resistor.



*In your answer you should state how the data collected is used to determine the values of  $E$  and  $r$ .*

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.....

.....

[5]

**(c)** A 6.0V 2.0W filament lamp has a resistance of  $18\Omega$  when lit to normal brightness. It is connected in series to four 1.5V cells each of internal resistance  $0.90\Omega$ .

**(i)** Explain, using calculations, why the lamp does not light to normal brightness.

**[3]**

**(ii)** It is found that by adding more cells in series it is possible to make the lamp light to normal brightness. Calculate the total number of cells needed in the circuit for this to occur. Show your working clearly.

number of cells = ..... **[2]**

- 3 (a) The following electrical quantities are often used when analysing circuits. The units given are alternatives to the units normally used for the quantities below. Draw a straight line from each quantity on the left to its correct unit on the right.

electromotive force	As
resistance	VC
energy	VA <sup>-1</sup>
charge	JC <sup>-1</sup>

[2]

- (b) The circuit in Fig. 2.1 consists of a cell and five resistors.

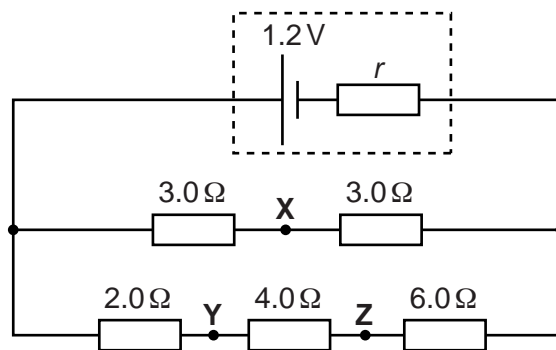


Fig. 2.1

The cell has e.m.f. 1.2V and internal resistance  $r$ . The current at point X is 0.16A.

- (i) Define *potential difference*.

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

- (ii) Explain what is meant by *internal resistance*.

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

(iii) Explain why the current at **X** must be twice the current at **Y** or **Z**.

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

(iv) Calculate the p.d. across the  $6.0\Omega$  resistor.

p.d. = ..... V [2]

(v) Suggest why the p.d.  $V_{XZ}$  between **X** and **Z** is zero.

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

(vi) Calculate the value of the internal resistance  $r$ .

$r =$  .....  $\Omega$  [4]

[Total: 15]