1 The maximum power input to a domestic fan heater is 2.6 kW when connected to the 230 V mains supply. The electric circuit of the fan heater consists of two heating elements (resistors) rated at 1.5 kW and 1.0 kW, a motor rated at 100 W and three switches.

(a) **(i)** Show that the resistance of the 1.5 kW heating element is about 35 Ω.

[2]

(ii) The 1.5 kW heating element is made from a wire of cross-sectional area $7.8 \times 10^{-8}\,\text{m}^2$ and resistivity $1.1 \times 10^{-6}\,\Omega\,\text{m}$. Calculate the length of the wire.

length = ... m **[3]**

(b) With only the first switch closed, the fan rotates; closing the second switch gives the heater an output of 1.5 kW and closing the third switch increases the output to 2.5 kW. The elements will not heat up unless the fan is switched on. The heater cannot give an output of 1.0 kW.

Complete the circuit diagram of Fig. 1.1 to show the fan, the heating elements and the switches connected so that the heater will work as described. Label the switches and the elements.

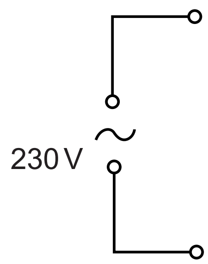

Fig. 1.1

[3]

(c) Both heating elements are made of wire of the same resistivity and length.

(i) Explain, without calculation, why the diameter d of the 1.0 kW heater wire must be less than the diameter D of the 1.5 kW heater wire, designed for use with a 230 V supply.

....

....

.... **[2]**

(ii) Show that d is approximately equal to $0.8\,D$.

[3]

(d) Circle the correct fuse for the plug of this appliance from the values below.

3 A   **A**   **1 A**   **1 A**

Justify your choice.

....

....

.... **[2]**

(e) **(i)** Define the *kilowatt-hour*.

....

.... **[1]**

(ii) Calculate, to the nearest penny, the cost of using the heater for 4.0 hours with only **one** of the heating elements switched on. The cost of 1 kWh is 18 p.

cost = ... p **[2]**

2 Fig. 1.1 shows the *I-V* characteristic of a 6.0 V 1.5 W filament lamp.

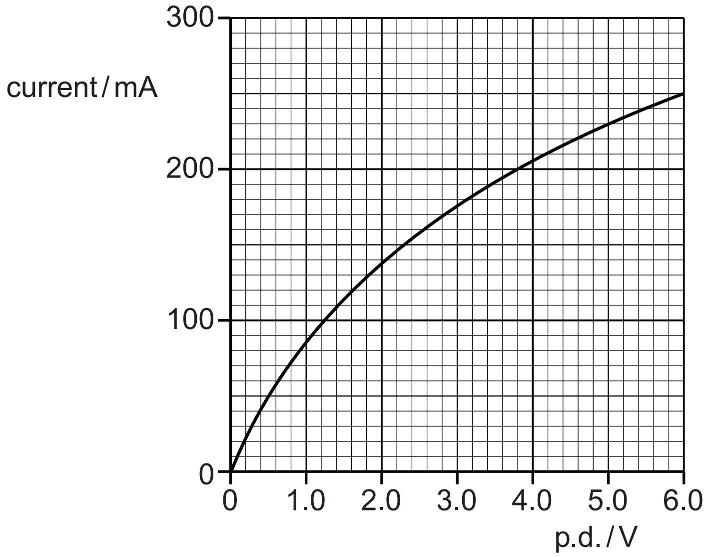

Fig. 1.1

(a) **(i)** State how Fig. 1.1 shows that the filament lamp does not obey Ohm's law.

....

.... **[1]**

(ii) Explain how Fig. 1.1 shows that the resistance of the filament lamp is about 10 Ω when the current is between zero and 50 mA.

[2]

(iii) Explain why the resistance of the filament lamp is much larger (about 25 Ω) at 6.0 V.

....

....

....

.... **[2]**

(b) A student designs a circuit for a night light using the filament lamp of part **(a)** and a light-dependent resistor (LDR). The circuit is shown in Fig. 1.2.

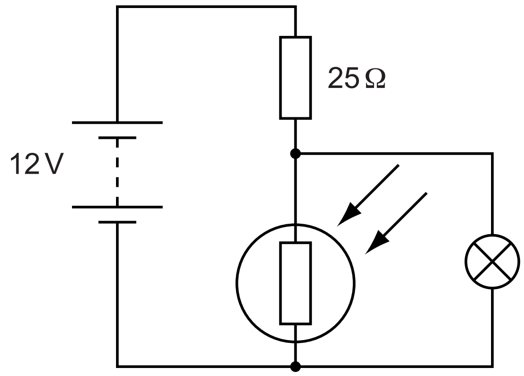

Fig. 1.2

This LDR has a resistance of about 1 Ω in daylight and 1000 Ω in the dark.

Show that the circuit will cause the lamp to be off in the day and on at night as long as the light from the lamp does not shine on the LDR.

In your answer you should explain clearly with or without calculation how the circuit functions to cause the lamp to be off in daylight and on in the dark.

....

....

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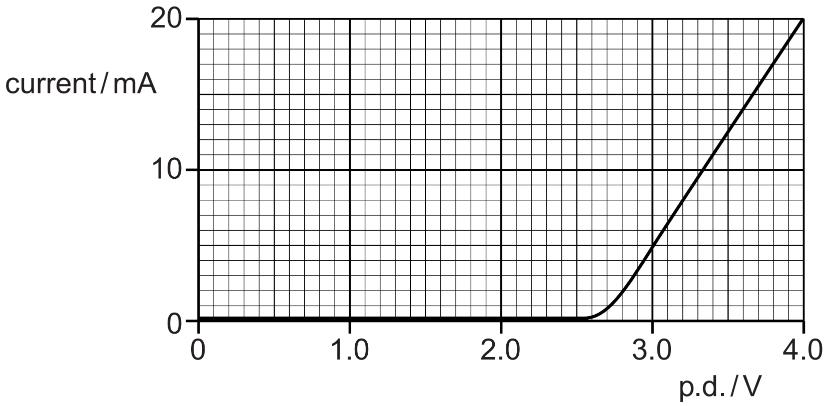
.... **[5]**

[Total: 10]

3 Fig. 4.1 shows the *I-V* characteristic of a blue light-emitting diode (LED).



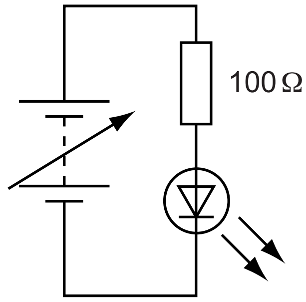


Fig. 4.1 **Fig. 4.2**

(a) **(i)** The data for plotting the *I-V* characteristic is collected using the components shown in Fig. 4.2. By drawing on Fig. 4.2 complete the circuit showing how you would connect the two meters needed to collect these data. **[1]**

(ii) When the current in the circuit of Fig. 4.2 is 20 mA calculate the terminal potential difference across the supply.

terminal p.d. = ... V **[3]**

(b) The energy of each photon emitted by the LED comes from an electron passing through the LED. The energy of each blue photon emitted by the LED is 4.1×10^{-19} J.

(i) Calculate the energy of a blue photon in electron volts.

energy = ... eV **[1]**

(ii) Explain how your answer to **(i)** is related to the shape of the curve in Fig. 4.1.

....

....

....

.... **[2]**

(c) Calculate for a current of 20 mA

(i) the number *n* of electrons passing through the LED per second

n = ... s^{-1} **[2]**

(ii) the total energy of the light emitted per second

energy per second = ... J s^{-1} **[2]**

(iii) the efficiency of the LED in transforming electrical energy into light energy.

efficiency = ... **[2]**

(d) The energy of a photon emitted by a red LED is 2.0 eV. The current in this LED is 20 mA when the p.d. across it is 3.4 V. Draw the *I-V* characteristic of this LED on Fig. 4.1. **[2]**

[Total: 15]