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

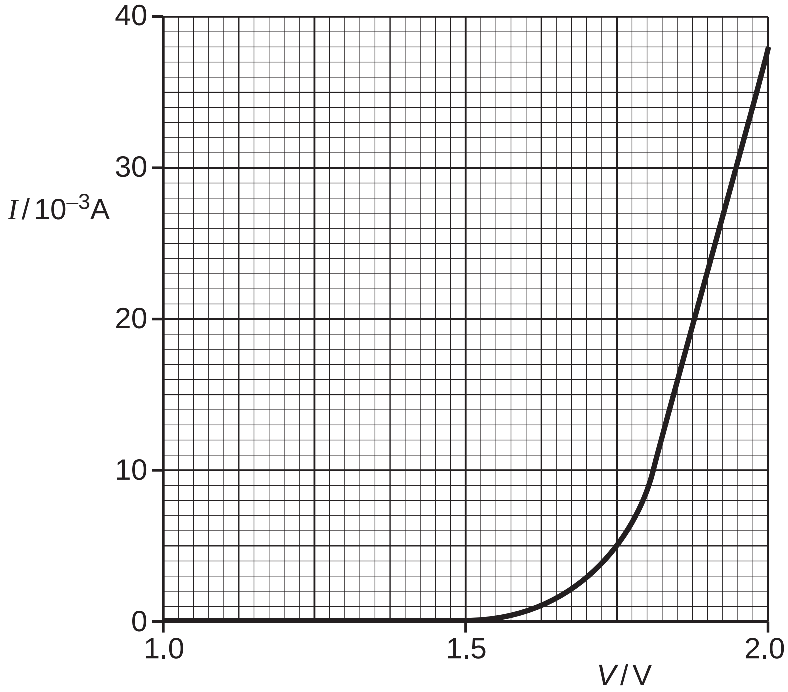

Fig. 4.1

(i) Describe the significant features of the graph in terms of current, voltage and resistance.

In your answer you should make clear how the features of the graph are related to the action of an LED.

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.... **[5]**

(ii) Calculate the resistance of the LED

1 at 1.2V

resistance = ………………. Ω **[1]**

2 at 1.9V.

resistance = …………….. Ω **[2]**

(b) In order to carry out an investigation to determine the I-V characteristic of an LED a student connects the circuit shown in Fig. 4.2.

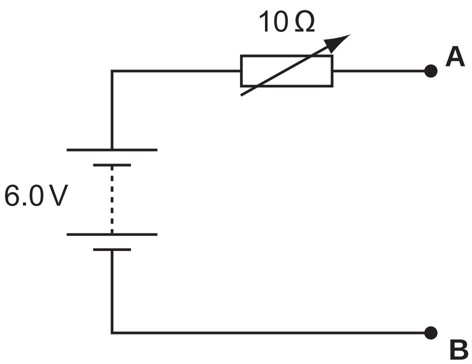

Fig. 4.2

On Fig. 4.2 add an LED with a 100 Ω resistor in series, an ammeter and a voltmeter to complete the circuit between terminals **A** and **B**. **[3]**

(c) When designing a circuit which includes an LED, it is normal practice to connect a resistor in series with the LED, in this case 100 Ω. Suggest and explain the purpose of this resistor.

....

....

.... **[2]**

(d) Another student uses the 10 Ω variable resistor as a potentiometer (potential divider) as shown in Fig. 4.3. The rest of the circuit is then completed between terminals **A** and **B** as for Fig. 4.2 in **(b)**.

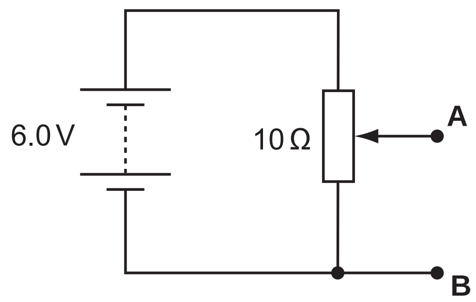

Fig. 4.3

Explain why the circuit of Fig. 4.3 is more suitable for obtaining the *I*-*V* characteristic of the LED than the circuit of Fig. 4.2.

....

....

....

....

.... **[3]**

[Total: 16]

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

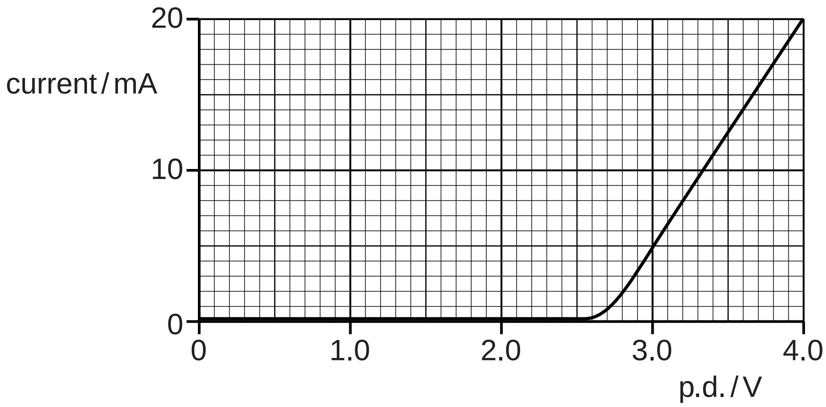

Fig. 4.1

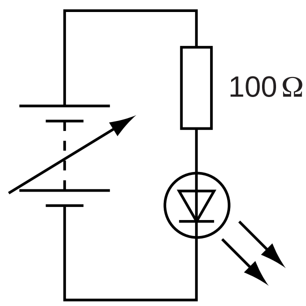

Fig. 4.2

(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]

3 **(a)** Kirchhoff's laws can be used to analyse any electrical circuit. State each of Kirchhoff's laws and the physical quantity associated with each law that is conserved in the circuit.

(i) Kirchhoff's first law

....

....

....

....

.... **[2]**

(ii) Kirchhoff's second law

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.... **[2]**

(b) The circuit in Fig. 3.1 consists of a battery of e.m.f. 45 V and negligible internal resistance and three resistors.

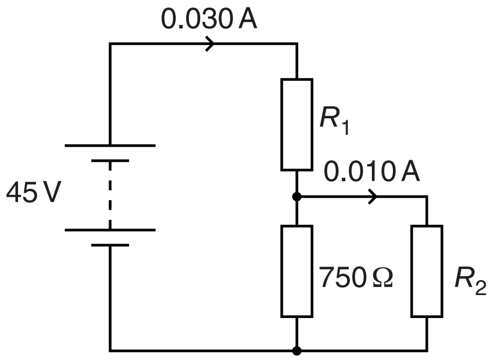


Fig. 3.1

The resistors have resistances R_1, R_2 and 750 Ω. The current in the resistor of resistance R_1 is 0.030 A. The current in the resistor of resistance R_2 is 0.010 A.

Calculate

(i) the current I in the $750\,\Omega$ resistor

I = ... A **[1]**

(ii) the p.d. V across the $750\,\Omega$ resistor

V = ...V **[1]**

(iii) the resistances R_1 and R_2.

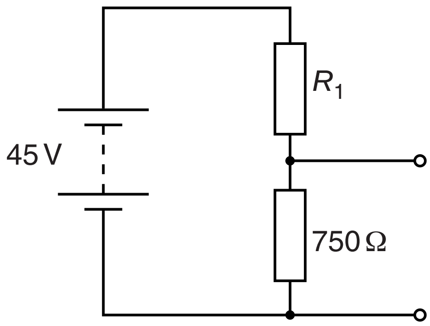
R_1 = ... Ω

R_2 = ... Ω

[2]

(c) The resistor of resistance R_2 is replaced in Fig. 3.1 by a light dependent resistor (LDR).

(i) Draw the circuit symbol for an LDR on Fig. 3.2 to complete this new circuit.



[1]

Fig. 3.2

(ii) The resistance of the LDR falls from about 1.5 kΩ to about 400 Ω as the light intensity increases. State and explain, without calculation, how the potential difference across the 750 Ω resistor varies as the intensity of the light incident on the LDR increases.

....

....

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....

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....

....

.... **[3]**

(iii) It is suggested that the LDR in the circuit of Fig. 3.2 is used to monitor changes in the light intensity.

1 Draw a suitable electrical meter in the LDR branch of the circuit on Fig. 3.2 to measure these changes.

2 State the electrical meter that you have chosen and suggest a sensible maximum scale reading.

....

....

....

[3]

[Total: 15]