1 **(a)** A 12V 36W lamp is lit to normal brightness using a 12V car battery of negligible internal resistance. The lamp is switched on for one hour (3600 s). For the time of 1 hour, calculate

(i) the energy supplied by the battery

energy = ………………………….J **[2]**

(ii) the charge passing through the lamp

charge = …………………….unit……….**[3]**

(iii) the total number of electrons passing through the lamp.

number of electrons = ………………………… **[2]**

(b) The wires connecting the 36W lamp to the 12V battery are made of copper. They have a cross-sectional area of 1.1 x 10^{-7} m^2. The current in the wire is 3.0 A. The number *n* of free electrons per m^3 for copper is 8.0 x 10^{28} m^{-3}.

(i) Describe what is meant by the term *mean drift velocity* of the electrons in the wire.

....

....

.... **[2]**

(ii) Calculate the mean drift velocity *v* of the electrons in this wire.

v = …………………………..$m\,s^{-1}$ **[3]**

[Total: 12]

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 = ... unit .... **[3]**

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

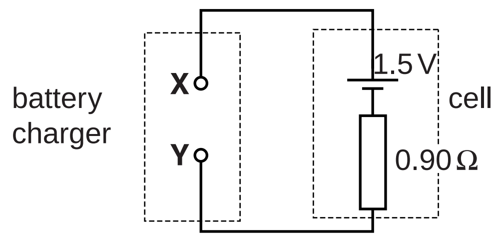


Fig. 3.1

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} = ... V **[2]**

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

[2]

(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.

....

....

....

....

....

....

.... **[5]**

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

(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)** Kirchhoff's first and second laws can be used to analyse any electrical circuit. They are a consequence of the conservation of physical quantities in the circuit.

(i) State Kirchhoff's **first** law and the physical quantity conserved.

[2]

(ii) State Kirchhoff's **second** law and the physical quantity conserved.

[2]

(b) A physical quantity is also conserved in the photoelectric effect. Describe and explain the photoelectric effect.

In your answer you should link the description to the conservation of this quantity.

[6]

[Total: 10]

4 **(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

....

....

....

....

.... **[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.

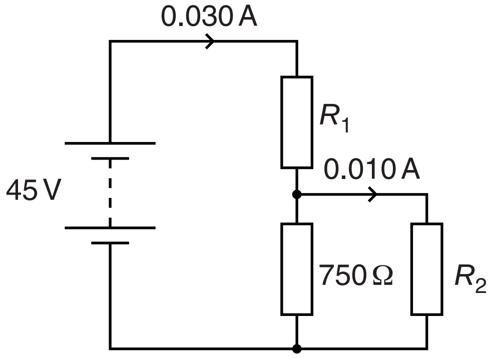


Fig. 3.1

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 Ω resistor

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

(ii) the p.d. V across the 750 Ω resistor

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

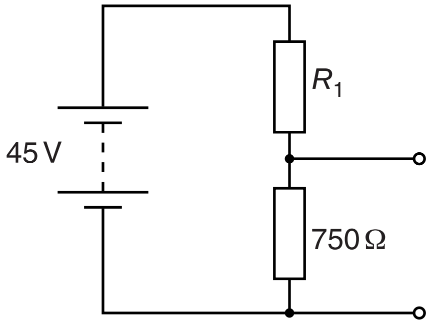
(iii) the resistances R_1 and R_2.

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.

....

....

....

....

....

....

....

.... **[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]