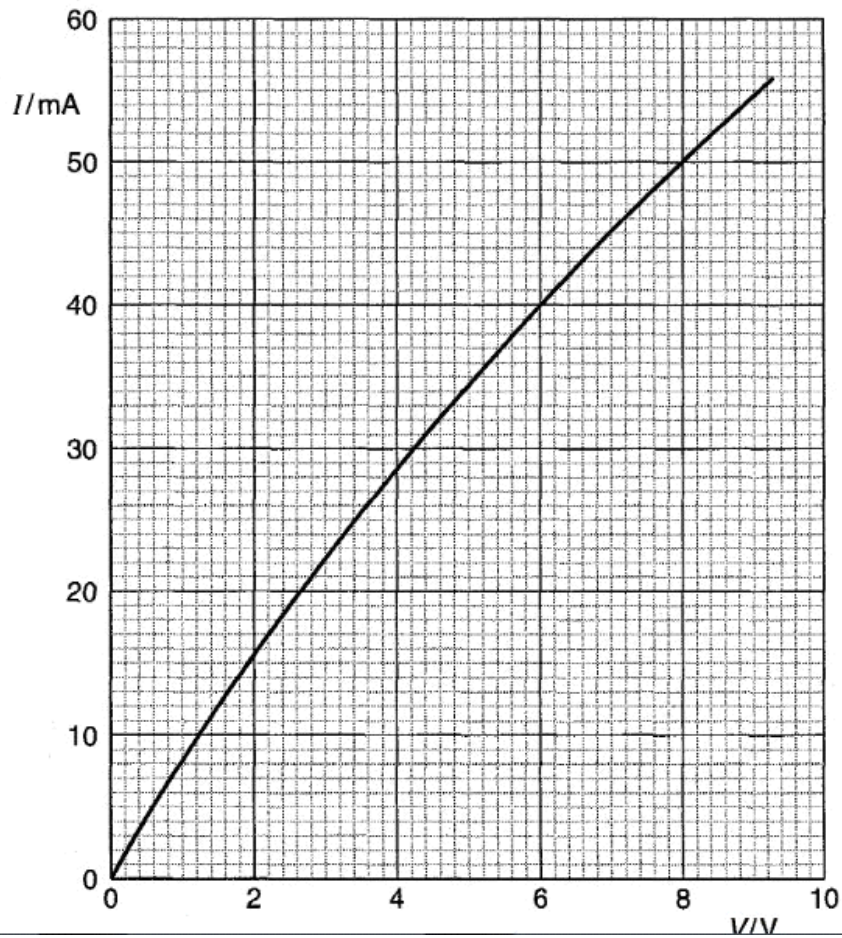**Q1.**

5   A filament lamp operates normally at a potential difference (p.d.) of 6.0 V. The variation with p.d. V of the current I in the lamp is shown in Fig. 5.1.

(a) Use Fig. 5.1 to determine, for this lamp,

    (i) the resistance when it is operating at a p.d. of 6.0 V,

resistance = ... Ω

    (ii) the change in resistance when the p.d. increases from 6.0 V to 8.0 V.

change in resistance = ... Ω

[4]

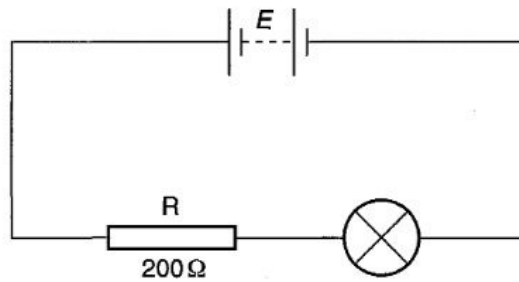**(b)** The lamp is connected into the circuit of Fig. 5.2.

Fig. 5.2

2

R is a fixed resistor of resistance 200 Ω. The battery has e.m.f. *E* and negligible internal resistance.

(i) On Fig. 5.1, draw a line to show the variation with p.d. *V* of the current *I* in the resistor R.

(ii) Determine the e.m.f. of the battery for the lamp to operate normally.

e.m.f. = ... V

[4]

Q2.

7 A household electric lamp is rated as 240 V, 60 W. The filament of the lamp is made from tungsten and is a wire of constant radius 6.0×10^{-6} m. The resistivity of tungsten at the normal operating temperature of the lamp is 7.9×10^{-7} Ω m.

(a) For the lamp at its normal operating temperature,

  (i) calculate the current in the lamp,

current = ... A

(ii) show that the resistance of the filament is 960 Ω.

[3]

(b) Calculate the length of the filament.

length = ... m [3]

(c) Comment on your answer to **(b)**.

....

.... [1]

Q3.

8   A thermistor has resistance $3900\,\Omega$ at $0\,°C$ and resistance $1250\,\Omega$ at $30\,°C$. The thermistor is connected into the circuit of Fig. 8.1 in order to monitor temperature changes.
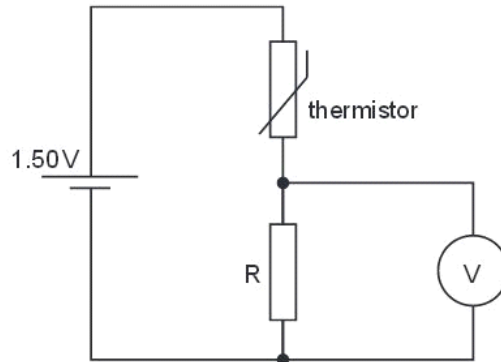

Fig. 8.1

The battery of e.m.f. $1.50\,V$ has negligible internal resistance and the voltmeter has infinite resistance.

(a)   The voltmeter is to read $1.00\,V$ at $0\,°C$. Show that the resistance of resistor R is $7800\,\Omega$.

[2]

(b)   The temperature of the thermistor is increased to $30\,°C$. Determine the reading on the voltmeter.

reading = ... V [2]

5

(c) The voltmeter in Fig. 8.1 is replaced with one having a resistance of $7800\,\Omega$.
Calculate the reading on this voltmeter for the thermistor at a temperature of $0\,°C$.

reading = ... V [2]

Q4.

6 Two parallel metal plates P and Q are situated $8.0\,cm$ apart in air, as shown in Fig. 6.1.
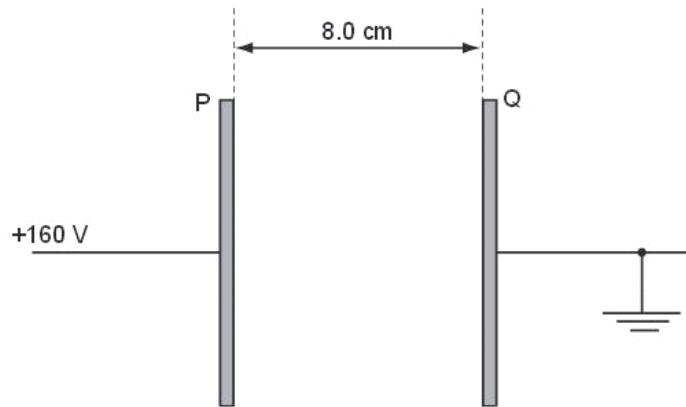

8.0 cm

P

Q

+160 V

Fig. 6.1

Plate Q is earthed and plate P is maintained at a potential of $+160\,V$.

(a) (i) On Fig. 6.1, draw lines to represent the electric field in the region between the plates. [2]

(ii) Show that the magnitude of the electric field between the plates is $2.0 \times 10^3\,V\,m^{-1}$.

[1]

6

(b) A dust particle is suspended in the air between the plates. The particle has charges of $+1.2\times10^{-15}$ C and -1.2×10^{-15} C near its ends. The charges may be considered to be point charges separated by a distance of 2.5 mm, as shown in Fig. 6.2.
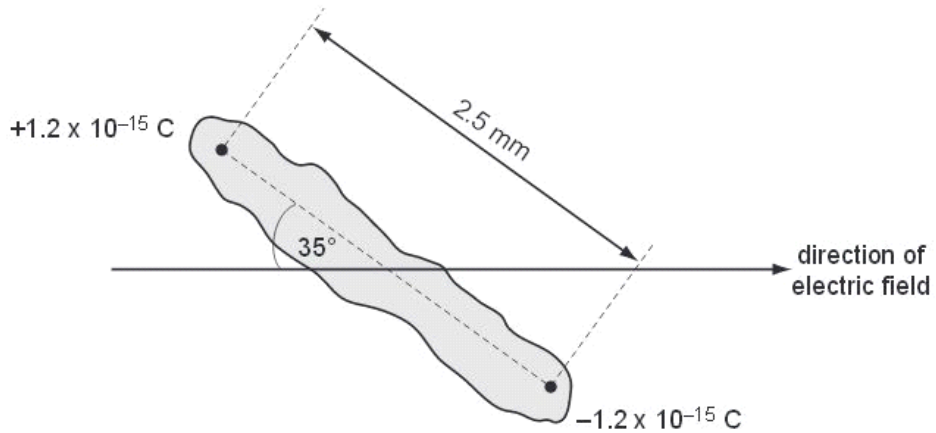
Fig. 6.2

The particle makes an angle of 35° with the direction of the electric field.

(i) On Fig. 6.2, draw arrows to show the direction of the force on each charge due to the electric field. [1]

(ii) Calculate the magnitude of the force on each charge due to the electric field.

force = ... N [2]

(iii) Determine the magnitude of the couple acting on the particle.

couple = ... Nm [2]

7

(iv) Suggest the subsequent motion of the particle in the electric field.

....

....

....[2]

Q5.

7 **(a)** Define the *resistance* of a resistor.

....

....[1]

(b) In the circuit of Fig. 7.1, the battery has an e.m.f. of 3.00 V and an internal resistance r. R is a variable resistor. The resistance of the ammeter is negligible and the voltmeter has an infinite resistance.
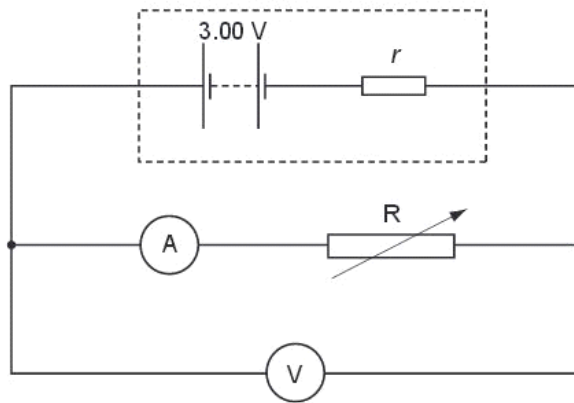
Fig. 7.1

The resistance of R is varied. Fig. 7.2 shows the variation of the power P dissipated in R with the potential difference V across R.
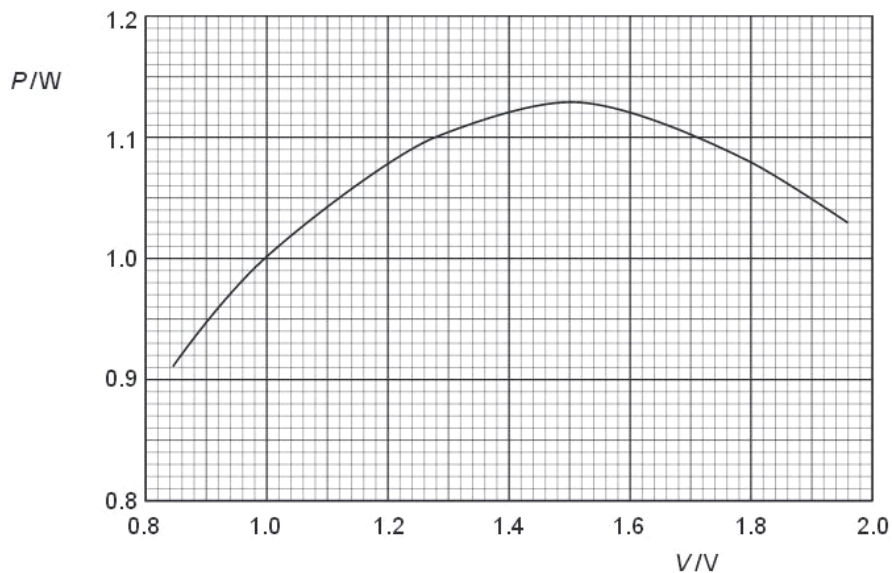
Fig. 7.2

(i) Use Fig. 7.2 to determine

    1. the maximum power dissipation in R,

               maximum power = ... W

    2. the potential difference across R when the maximum power is dissipated.

              potential difference = ... V

                                                        [1]

(ii) Hence calculate the resistance of R when the maximum power is dissipated.

                                        resistance = ... Ω [2]

(iii) Use your answers in **(i)** and **(ii)** to determine the internal resistance *r* of the battery.

r= .... Ω [3]

(c) By reference to Fig. 7.2, it can be seen that there are two values of potential difference *V* for which the power dissipation is 1.05 W.
State, with a reason, which value of *V* will result in less power being dissipated in the internal resistance.

....

....

....

....[3]

Q6.

7 A circuit contains three similar lamps A, B and C. The circuit also contains three switches, S_1, S_2 and S_3, as shown in Fig. 7.1.
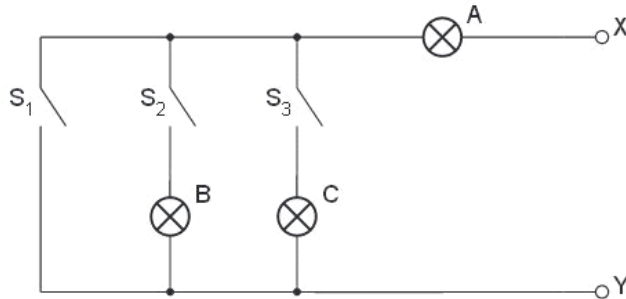

Fig. 7.1

One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 7.2 shows the readings of the ohm-meter for different switch positions.

| | switch | | meter reading |
S$_1$	S$_2$	S$_3$	/ Ω
open	open	open	∞
closed	open	open	15 Ω
open	closed	open	30 Ω
open	closed	closed	15 Ω

Fig. 7.2

(a) Identify the faulty lamp, and the nature of the fault.

faulty lamp: ....

nature of fault: .... [2]

(b) Suggest why it is advisable to test the circuit using an ohm-meter that causes negligible current rather than with a power supply.

....

.... [1]

(c) Determine the resistance of one of the non-faulty lamps, as measured using the ohm-meter.

resistance = ... Ω [1]

(d) Each lamp is marked 6.0 V, 0.20 A.

Calculate, for one of the lamps operating at normal brightness,

(i) its resistance,

resistance = ... Ω [2]

(ii) its power dissipation.

power = ... W [2]

(e) Comment on your answers to **(c)** and **(d)(i)**.

....

....

....[2]

Q7.

2 (a) Define *electric field strength*.

....

....[1]

(b) Two flat parallel metal plates, each of length 12.0 cm, are separated by a distance of 1.5 cm, as shown in Fig. 2.1.
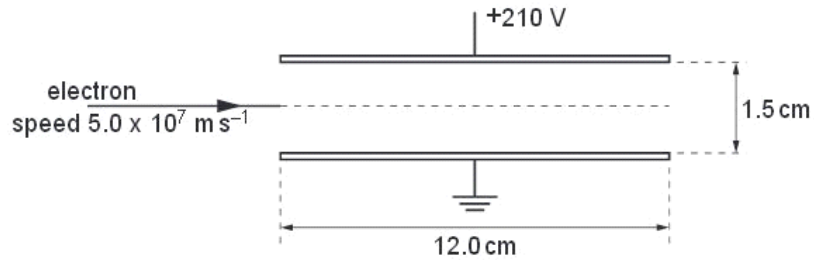

Fig. 2.1

The space between the plates is a vacuum.
The potential difference between the plates is 210 V. The electric field may be assumed to be uniform in the region between the plates and zero outside this region.
Calculate the magnitude of the electric field strength between the plates.

field strength = ...N C^{-1} [1]

(c) An electron initially travels parallel to the plates along a line mid-way between the plates, as shown in Fig. 2.1. The speed of the electron is 5.0×10^7 m s^{-1}.

For the electron between the plates,

(i) determine the magnitude and direction of its acceleration,

acceleration = ... m s^{-2}

direction ....[4]

(ii) calculate the time for the electron to travel a horizontal distance equal to the length of the plates.

time = ... s [1]

14

(d) Use your answers in (c) to determine whether the electron will hit one of the plates or emerge from between the plates.

[3]

Q8.

6 A car battery has an internal resistance of $0.060\,\Omega$. It is re-charged using a battery charger having an e.m.f. of 14 V and an internal resistance of $0.10\,\Omega$, as shown in Fig. 6.1.
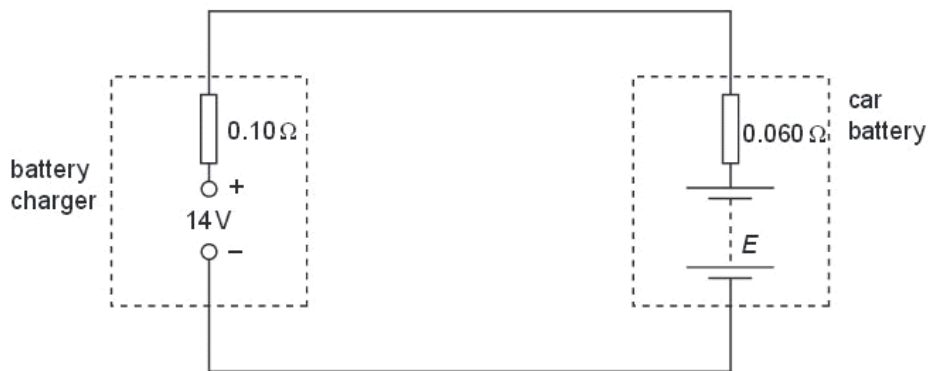
Fig. 6.1

(a) At the beginning of the re-charging process, the current in the circuit is 42 A and the e.m.f. of the battery is E (measured in volts).

(i) For the circuit of Fig. 6.1, state

1. the magnitude of the total resistance,

resistance = ... Ω

2. the total e.m.f. in the circuit. Give your answer in terms of E.

e.m.f. = ... V

[2]

15

(ii)   Use your answers to **(i)** and data from the question to determine the e.m.f. of the car battery at the beginning of the re-charging process.

e.m.f. = ...V [2]

(b)   For the majority of the charging time of the car battery, the e.m.f. of the car battery is 12V and the charging current is 12.5A. The battery is charged at this current for 4.0 hours. Calculate, for this charging time,

(i)   the charge that passes through the battery,

charge = ... C [2]

(ii)   the energy supplied from the battery charger,

energy = ...J [2]

(iii) the total energy dissipated in the internal resistance of the battery charger and the car battery.

energy = ... J [2]

(c) Use your answers in (b) to calculate the percentage efficiency of transfer of energy from the battery charger to stored energy in the car battery.

efficiency = ...% [2]

Q9.

6 An electric heater consists of three similar heating elements A, B and C, connected as shown in Fig. 6.1.
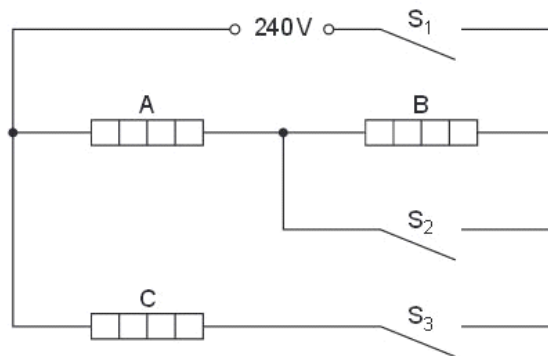
Fig. 6.1

Each heating element is rated as 1.5kW, 240V and may be assumed to have constant resistance.
The circuit is connected to a 240V supply.

(a) Calculate the resistance of one heating element.

resistance = ... Ω [2]

(b) The switches S_1, S_2 and S_3 may be either open or closed.

Complete Fig. 6.2 to show the total power dissipation of the heater for the switches in the positions indicated.

S_1	S_2	S_3	total power / kW
open	closed	closed	....
closed	closed	open	....
closed	closed	closed	....
closed	open	open	....
closed	open	closed	....

[5]

Fig. 6.2

Q10.

6   Two vertical parallel metal plates are situated 2.50 cm apart in a vacuum. The potential difference between the plates is 350 V, as shown in Fig. 6.1.
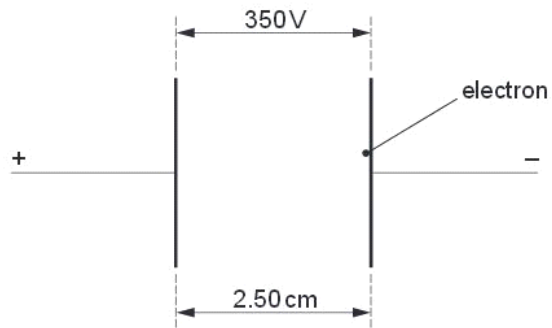
Fig. 6.1

An electron is initially at rest close to the negative plate and in the uniform electric field between the plates.

(a) (i)   Calculate the magnitude of the electric field between the plates.

electric field strength = ... N C^{-1} [2]

(ii)   Show that the force on the electron due to the electric field is 2.24×10^{-15} N.

[2]

(b) The electron accelerates horizontally across the space between the plates. Determine

    (i) the horizontal acceleration of the electron,

acceleration = ... ms^{-2} [2]

    (ii) the time to travel the horizontal distance of 2.50 cm between the plates.

time = ... s [2]

(c) Explain why gravitational effects on the electron need not be taken into consideration in your calculation in **(b)**.

....

....

.... [2]

Q11.

7   A network of resistors, each of resistance R, is shown in Fig. 7.1.
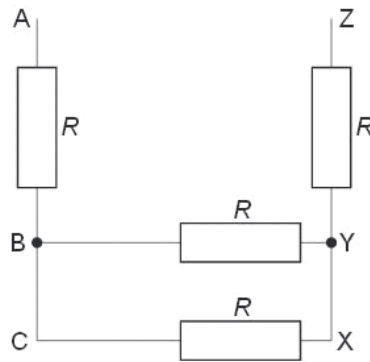
Fig. 7.1

(a) Calculate the total resistance, in terms of R, between points

   (i)   A and C,

   resistance = ... [1]

   (ii) B and X,

   resistance = ... [1]

   (iii) A and Z.

   resistance = ... [1]

21

(b) Two cells of e.m.f. E_1 and E_2 and negligible internal resistance are connected into the network in **(a)**, as shown in Fig. 7.2.

Fig. 7.2

The currents in the network are as indicated in Fig. 7.2.

Use Kirchhoff's laws to state the relation

(i) between currents I_1, I_2 and I_3,

.... [1]

(ii) between E_2, R, I_2 and I_3 in loop BCXYB,

.... [1]

(iii) between E_1, E_2, R, I_1 and I_2 in loop ABCXYZA.

.... [1]

Q12.

7 **(a)** A network of resistors, each of resistance R, is shown in Fig. 7.1.
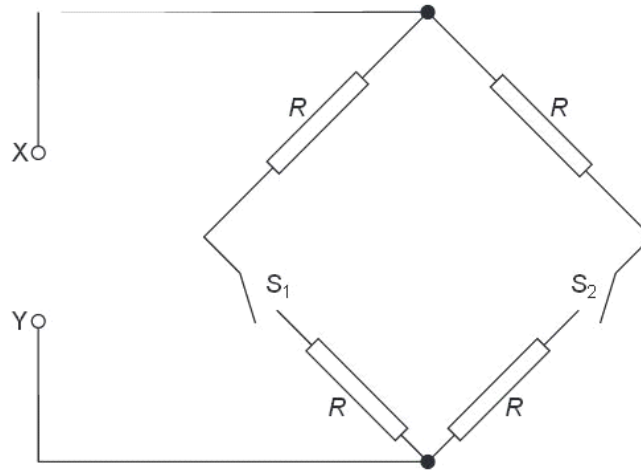
Fig. 7.1

Switches S_1 and S_2 may be 'open' or 'closed'.

Complete Fig. 7.2 by calculating the resistance, in terms of R, between points X and Y for the switches in the positions shown.

switch S_1	switch S_2	resistance between points X and Y
open	open	....
open	closed	....
closed	closed	....

Fig. 7.2

[3]

(b) Two cells of e.m.f. E_1 and E_2 and negligible internal resistance are connected into a network of resistors, as shown in Fig. 7.3.
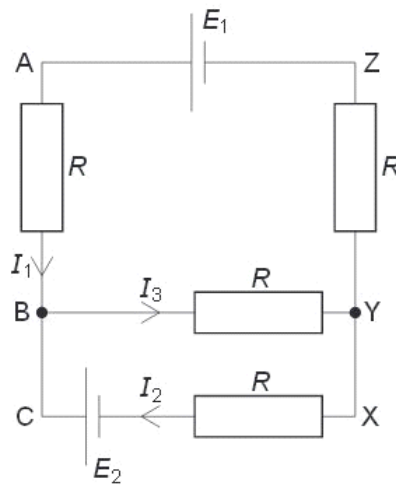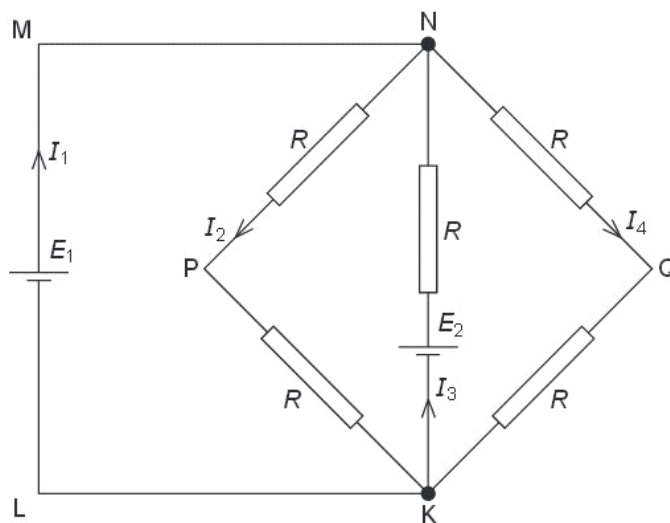

Fig. 7.3

The currents in the network are as indicated in Fig. 7.3.

Use Kirchhoff's laws to state the relation

(i) between currents I_1, I_2, I_3 and I_4,

....[1]

(ii) between E_1, E_2, R, and I_3 in loop NKLMN,

....[1]

(iii) between E_2, R, I_3 and I_4 in loop NKQN.

....[1]

Q13.

5 **(a)** State what is meant by an *electric field*.

....

....[1]

(b) The electric field between an earthed metal plate and two charged metal spheres is illustrated in Fig. 5.1.

earthed
metal plate

charged
sphere
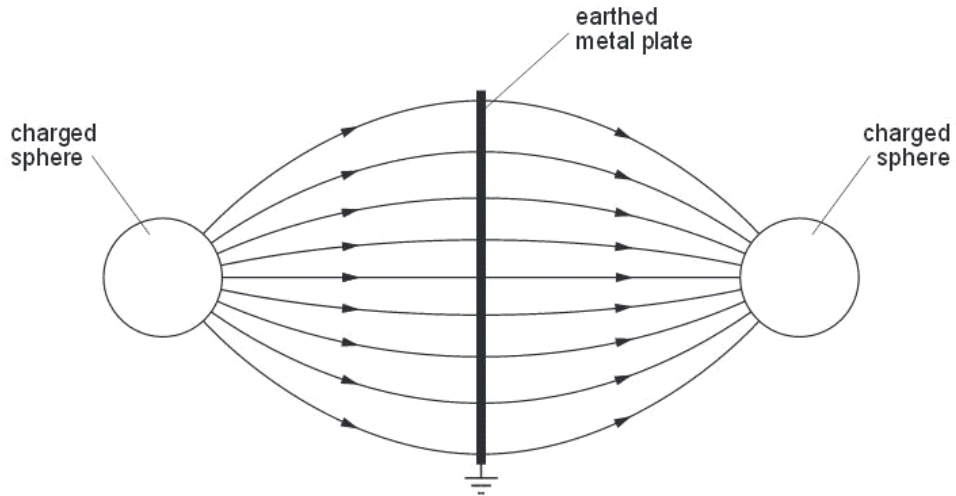
charged
sphere

(i) On Fig. 5.1, label each sphere with (+) or (–) to show its charge. [1]

(ii) On Fig. 5.1, mark a region where the magnitude of the electric field is

1. constant (label this region C), [1]

2. decreasing (label this region D). [1]

25

(c) A molecule has its centre P of positive charge situated a distance of 2.8×10^{-10} m from its centre N of negative charge, as illustrated in Fig. 5.2.
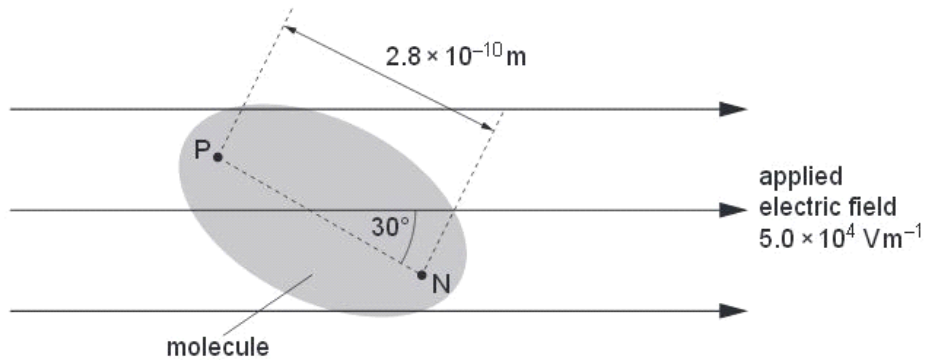
Fig. 5.2

The molecule is situated in a uniform electric field of field strength 5.0×10^4 V m^{-1}. The axis NP of the molecule is at an angle of 30° to this uniform applied electric field. The magnitude of the charge at P and at N is 1.6×10^{-19} C.

(i) On Fig. 5.2, draw an arrow at P and an arrow at N to show the directions of the forces due to the applied electric field at each of these points. [1]

(ii) Calculate the torque on the molecule produced by the forces in **(i)**.

torque = ... N m [2]

Q14.

6   An electric heater is to be made from nichrome wire. Nichrome has a resistivity of $1.0 \times 10^{-6}\,\Omega\,m$ at the operating temperature of the heater.
The heater is to have a power dissipation of $60\,W$ when the potential difference across its terminals is $12\,V$.

(a) For the heater operating at its designed power,

(i)   calculate the current,

current = ... A [2]

(ii) show that the resistance of the nichrome wire is $2.4\,\Omega$.

[2]

(b) Calculate the length of nichrome wire of diameter $0.80\,mm$ required for the heater.

length = ... m [3]

(c) A second heater, also designed to operate from a 12V supply, is constructed using the same nichrome wire but using half the length of that calculated in **(b)**.
Explain quantitatively the effect of this change in length of wire on the power of the heater.

....

....

....

....[3]

Q15.

6 **(a)** A metal wire of constant resistance is used in an electric heater.
In order not to overload the circuit for the heater, the supply voltage to the heater is reduced from 230V to 220V.

Determine the percentage reduction in the power output of the heater.

reduction = ... % [2]

(b) A uniform wire AB of length 100 cm is connected between the terminals of a cell of e.m.f. 1.5V and negligible internal resistance, as shown in Fig. 6.1.
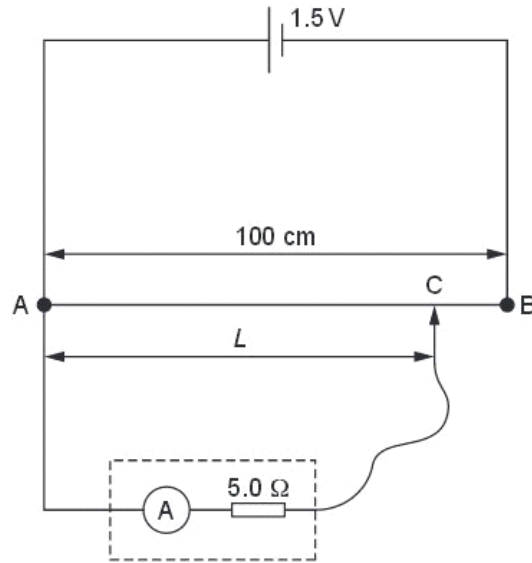
Fig. 6.1

An ammeter of internal resistance 5.0Ω is connected to end A of the wire and to a contact C that can be moved along the wire.

Determine the reading on the ammeter for the contact C placed

(i) at A,

reading = ... A [1]

(ii) at B.

reading = ... A [1]

29

(c) Using the circuit in **(b)**, the ammeter reading I is recorded for different distances L of the contact C from end A of the wire. Some data points are shown on Fig. 6.2.
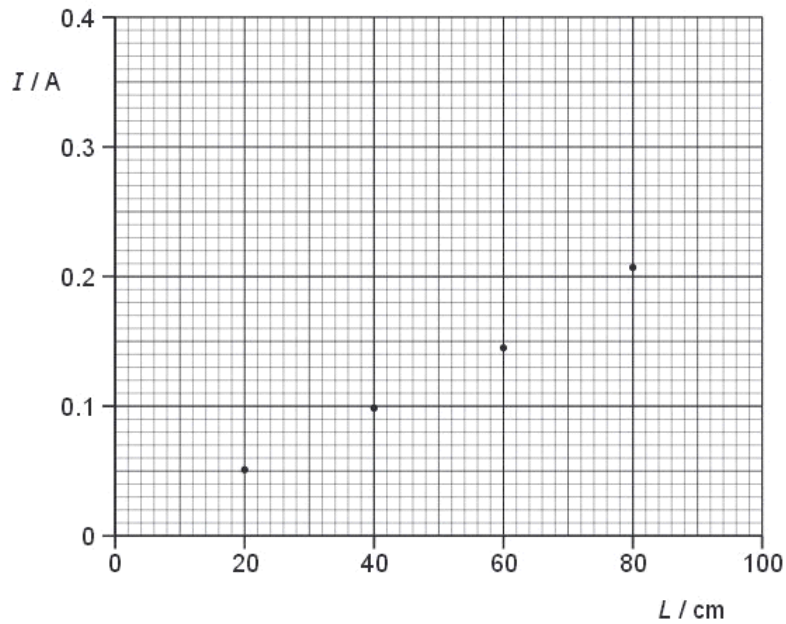
Fig. 6.2

(i) Use your answers in **(b)** to plot data points on Fig. 6.2 corresponding to the contact C placed at end A and at end B of the wire. [1]

(ii) Draw a line of best fit for all of the data points and hence determine the ammeter reading for contact C placed at the midpoint of the wire.

reading = ... A [1]

(iii) Use your answer in **(ii)** to calculate the potential difference between A and the contact C for the contact placed at the midpoint of AB.

potential difference = ... V [2]

(d) Explain why, although the contact C is at the midpoint of wire AB, the answer in **(c)(iii)** is **not** numerically equal to one half of the e.m.f. of the cell.

....

....

....[2]

Q16.

6 **(a)** **(i)** State what is meant by an *electric current*.

....

....[1]

(ii) Define *electric potential difference*.

....

....[1]

(b) The variation with potential difference V of the current I in a component Y and in a resistor R are shown in Fig. 6.1.

31
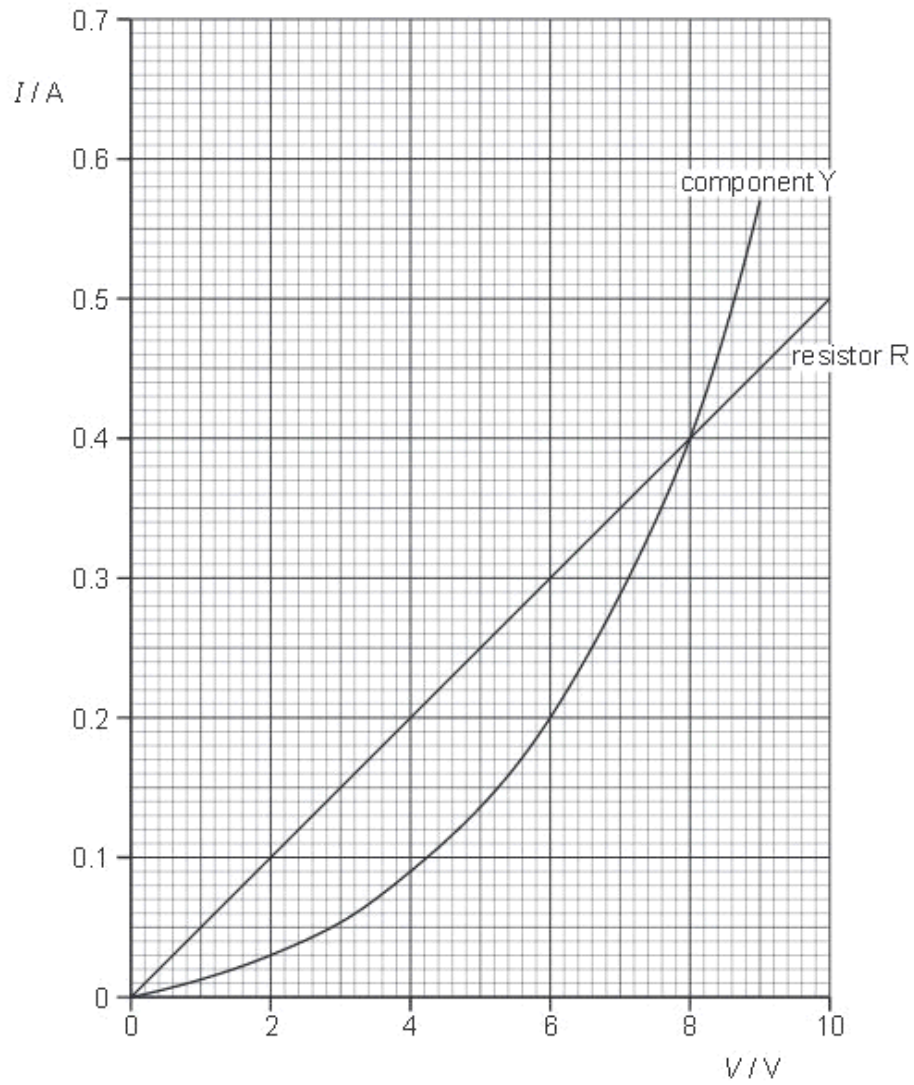
Use Fig. 6.1 to explain how it can be deduced that resistor R has a constant resistance of 20 Ω.

Exa

....

....

....[2]

(c) The component Y and the resistor R in **(b)** are connected in parallel as shown in Fig. 6.2.
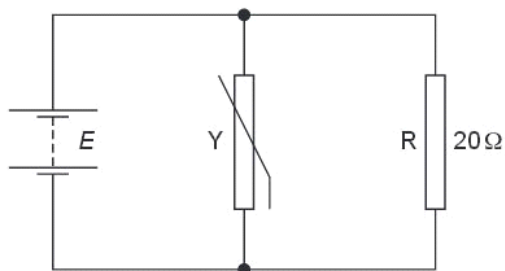
Fig. 6.2

A battery of e.m.f. E and negligible internal resistance is connected across the parallel combination.

Use data from Fig. 6.1 to determine

(i) the current in the battery for an e.m.f. E of 6.0 V,

current = ...A [1]

(ii) the total resistance of the circuit for an e.m.f. of 8.0 V.

resistance = ... Ω [2]

(d) The circuit of Fig. 6.2 is now re-arranged as shown in Fig. 6.3.
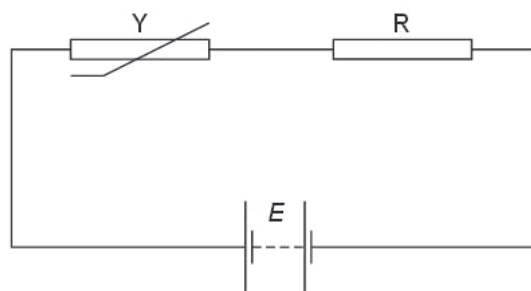
Fig. 6.3

The current in the circuit is 0.20 A.

(i) Use Fig. 6.1 to determine the e.m.f. E of the battery.

E = ...V [1]

(ii) Calculate the total power dissipated in component Y and resistor R.

power = ...W [2]

Q17.

5   (a) A variable resistor is used to control the current in a circuit, as shown in Fig. 5.1.

12V

I_1 R

A

6.0 Ω
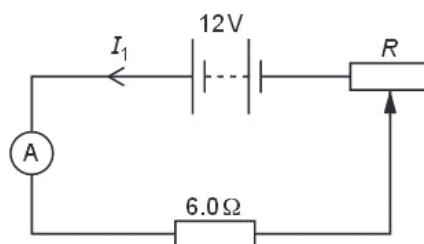
Fig. 5.1

The variable resistor is connected in series with a 12V power supply of negligible internal resistance, an ammeter and a 6.0 Ω resistor. The resistance R of the variable resistor can be varied between 0 and 12 Ω.

(i) The maximum possible current in the circuit is 2.0A. Calculate the minimum possible current.

minimum current = ... A [2]

(ii) On Fig. 5.2, sketch the variation with R of current I_1 in the circuit.

2.0

I_1/A

1.0

0
  0   4   8   12 R/Ω

[2]
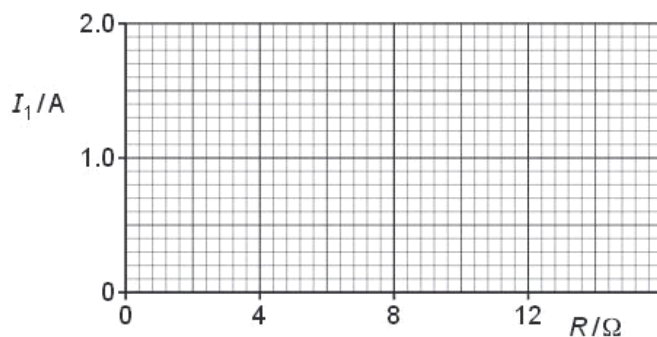
Fig. 5.2

(b) The variable resistor in **(a)** is now connected as a potential divider, as shown in Fig. 5.3.
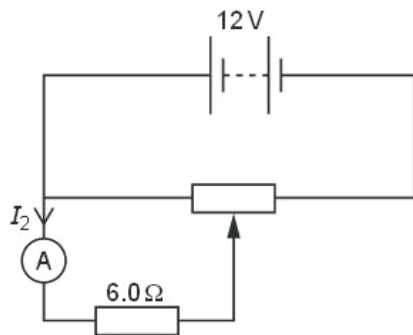
Fig. 5.3

Calculate the maximum possible and minimum possible current I_2 in the ammeter.

maximum I_2 = ... A

minimum I_2 = ... A

[2]

(c) (i) Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

[2]

Fig. 5.4

36

(ii) The resistor of resistance 6.0 Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

....

....

.... **[1]**

Q18.

5 **(a)** For a cell, explain the terms

(i) *electromotive force* (e.m.f.),

....

.... **[1]**

(ii) *internal resistance*.

....

.... **[1]**

(b) The circuit of Fig. 5.1 shows two batteries A and B and a resistor R connected in series.
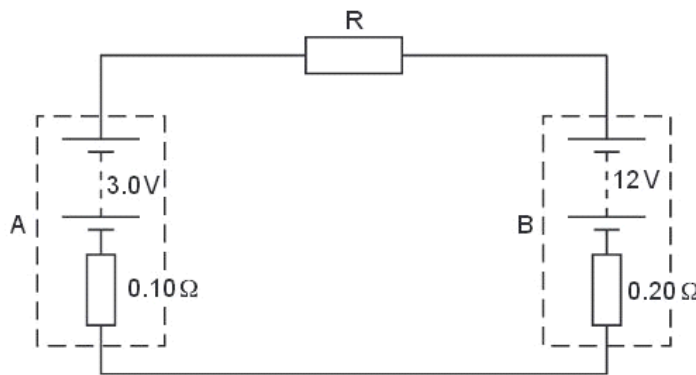
Fig. 5.1

Battery A has an e.m.f. of 3.0 V and an internal resistance of 0.10 Ω. Battery B has an e.m.f. of 12 V and an internal resistance of 0.20 Ω. Resistor R has a resistance of 3.3 Ω.

(i) Apply Kirchhoff's second law to calculate the current in the circuit.

current = ... A [2]

(ii) Calculate the power transformed by battery B.

power = ... W [2]

(iii) Calculate the total energy lost per second in resistor R and the internal resistances.

energy lost per second = ... Js^{-1} [2]

(c) The circuit of Fig. 5.1 may be used to store energy in battery A. Suggest how your answers in (b) support this statement.

....

....

.... [1]

Q19.

5 (a) (i) On Fig. 5.1, sketch the $I - V$ characteristic for a filament lamp.

I/A

0
0   V/V
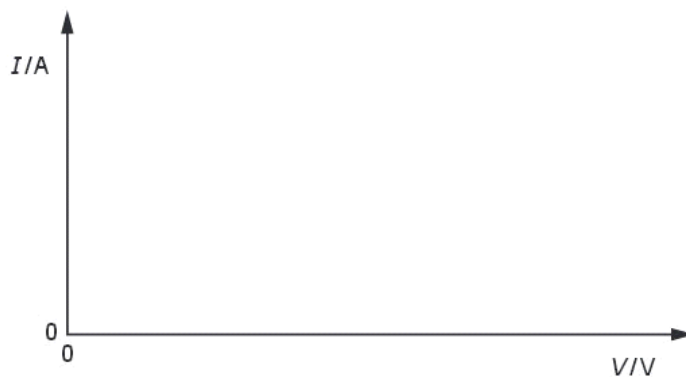
Fig. 5.1

[2]

(ii) Explain how the resistance of the lamp may be calculated for any voltage from its $I - V$ characteristic.

....

....[1]

(b) Two identical filament lamps are connected first in series, and then in parallel, to a 12V power supply that has negligible internal resistance. The circuits are shown in Fig. 5.2 and Fig. 5.3 respectively.

12V   12V
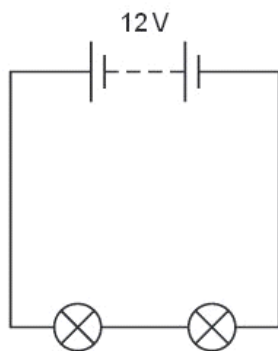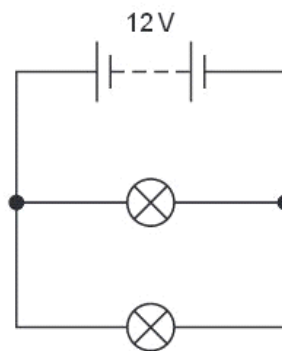
Fig. 5.2   **Fig. 5.3**

(i) State and explain why the resistance of each lamp when they are connected in series is different from the resistance of each lamp when they are connected in parallel.

....

....

....

....

.... [3]

(ii) Each lamp is marked with a rating '12V, 50W'. Calculate the total resistance of the circuit for the two lamps connected such that each lamp uses this power.

total resistance = ... Ω [3]

Q20.

4 **(a)** The output of a heater is 2.5 kW when connected to a 220V supply.

(i) Calculate the resistance of the heater.

resistance = ... Ω [2]

(ii) The heater is made from a wire of cross-sectional area $2.0 \times 10^{-7}\,\text{m}^2$ and resistivity $1.1 \times 10^{-6}\,\Omega\,\text{m}$.

Use your answer in **(i)** to calculate the length of the wire.

length = ... m [3]

(b) The supply voltage is changed to 110V.

(i) Calculate the power output of the heater at this voltage, assuming there is no change in the resistance of the wire.

power = ... W [1]

(ii) State and explain quantitatively **one** way that the wire of the heater could be changed to give the same power as in **(a)**.

....

....

....[2]

Q21.

5 **(a)** **(i)** State Kirchhoff's second law.

....

....[1]

(ii) Kirchhoff's second law is linked to the conservation of a certain quantity. State this quantity.

....[1]

(b) The circuit shown in Fig. 5.1 is used to compare potential differences.
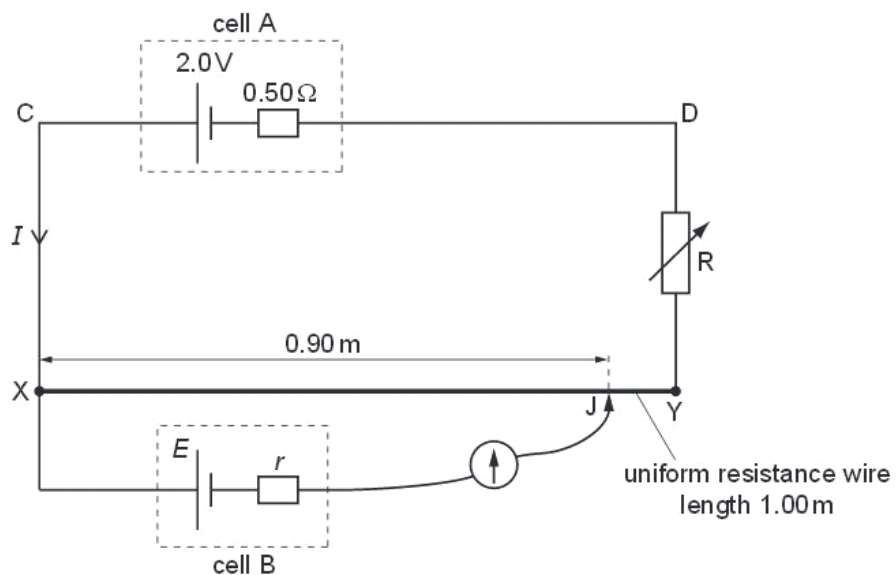
Fig. 5.1

The uniform resistance wire XY has length 1.00 m and resistance 4.0 Ω. Cell A has e.m.f. 2.0 V and internal resistance 0.50 Ω. The current through cell A is I. Cell B has e.m.f. E and internal resistance r.

The current through cell B is made zero when the movable connection J is adjusted so that the length of XJ is 0.90 m. The variable resistor R has resistance 2.5 Ω.

(i) Apply Kirchhoff's second law to the circuit CXYDC to determine the current I.

I = ... A [2]

(ii) Calculate the potential difference across the length of wire XJ.

potential difference = ... V [2]

(iii) Use your answer in **(ii)** to state the value of *E*.

E = ... V [1]

(iv) State why the value of the internal resistance of cell B is not required for the determination of *E*.

....

....[1]

Q22.

4 A battery of electromotive force 12V and negligible internal resistance is connected to two resistors and a light-dependent resistor (LDR), as shown in Fig. 4.1.
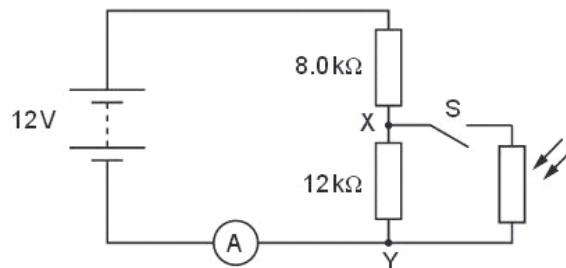
Fig. 4.1

An ammeter is connected in series with the battery. The LDR and switch S are connected across the points XY.

(a) The switch S is open. Calculate the potential difference (p.d.) across XY.

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

(b) The switch S is closed. The resistance of the LDR is 4.0 kΩ. Calculate the current in the ammeter.

current = ... A [3]

(c) The switch S remains closed. The intensity of the light on the LDR is increased. State and explain the change to

(i) the ammeter reading,

....

....

....[2]

(ii) the p.d. across XY.

....

....

....[2]

Q23.

4 (a) Define *electric field strength*.

....

....[1]

(b) A uniform electric field is produced by applying a potential difference of 1200V across two parallel metal plates in a vacuum, as shown in Fig. 4.1.
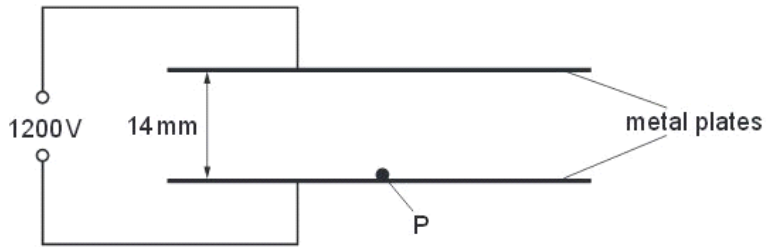

Fig. 4.1

The separation of the plates is 14mm. A particle P with charge 3.2×10^{-19} C and mass 6.6×10^{-27} kg starts from rest at the lower plate and is moved vertically to the top plate by the electric field.

Calculate

(i) the electric field strength between the plates,

electric field strength = ... $V\,m^{-1}$ [2]

(ii) the work done on P by the electric field,

work done = ... J [2]

45

(iii) the gain in gravitational potential energy of P,

gain in potential energy = ... J [2]

(iv) the gain in kinetic energy of P,

gain in kinetic energy = ... J [1]

(v) the speed of P when it reaches the top plate.

speed = ... m s^{-1} [2]

Q24.

5 **(a)** **(i)** State Kirchhoff's first law.

....

....[1]

(ii) Kirchhoff's first law is linked to the conservation of a certain quantity. State this quantity.

....[1]

(b) A variable resistor of resistance *R* is used to control the current in a circuit, as shown in Fig. 5.1.
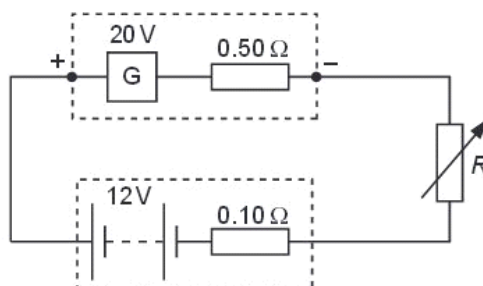
Fig. 5.1

The generator G has e.m.f. 20V and internal resistance 0.50 Ω. The battery has e.m.f. 12V and internal resistance 0.10 Ω. The current in the circuit is 2.0A.

(i) Apply Kirchhoff's second law to the circuit to determine the resistance *R*.

R = ... Ω [2]

(ii) Calculate the total power generated by G.

power = ... W [2]

47

(iii) Calculate the power loss in the total resistance of the circuit.

power = ... W [2]

(iv) The circuit is used to supply energy to the battery from the generator. Determine the efficiency of the circuit.

efficiency = ... [2]

Q25.

6   Two resistors A and B have resistances R_1 and R_2 respectively. The resistors are connected in series with a battery, as shown in Fig. 6.1.
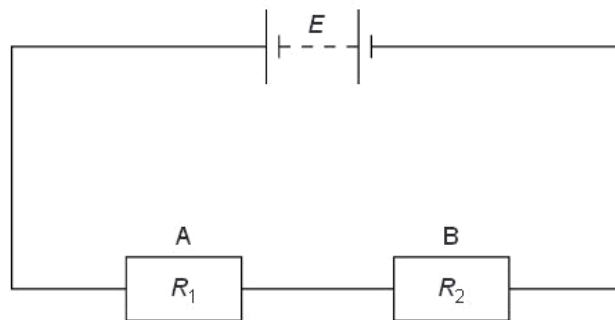
Fig. 6.1

The battery has electromotive force (e.m.f.) E and zero internal resistance.

(a)   State the energy transformation that occurs in

   (i)   the battery,

   ....

   .... [1]

(ii) the resistors.

....

.... [1]

(b) The current in the circuit is I.

State the rate of energy transformation in

(i) the battery,

.... [1]

(ii) the resistor A.

.... [1]

(c) The resistors are made from metal wires. Data for the resistors are given in Fig. 6.2.

resistor	A	B
resistivity of metal	ρ	$\rho/2$
length of wire	l	l
diameter of wire	d	$2d$

Fig. 6.2

Use information from Fig. 6.2 to determine the ratio

$$\frac{\text{power dissipated in A}}{\text{power dissipated in B}}.$$

ratio = ... [3]

(d) The resistors A and B are connected in parallel across the same battery of e.m.f. *E*. Determine the ratio

$$\frac{\text{power dissipated in A}}{\text{power dissipated in B}}.$$

ratio = ... [2]

Q26.

6 **(a)** Define *charge*.

....[1]

(b) A heater is made from a wire of resistance $18.0\,\Omega$ and is connected to a power supply of 240V. The heater is switched on for 2.60Ms.

Calculate

(i) the power transformed in the heater,

power = ... W [2]

(ii) the current in the heater,

current = ... A [1]

(iii) the charge passing through the heater in this time,

charge = ... C [2]

(iv) the number of electrons per second passing a given point in the heater.

number = ... s^{-1} [2]

Q27.

6   **(a)** Define *potential difference* (p.d.).

....[1]

(b) A battery of electromotive force 20V and zero internal resistance is connected in series with two resistors R_1 and R_2, as shown in Fig. 6.1.
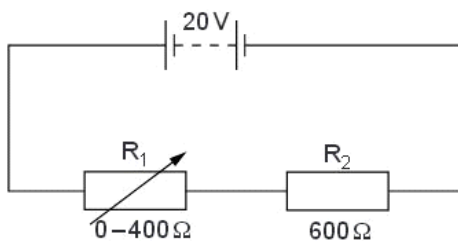

Fig. 6.1

The resistance of R_2 is 600 Ω. The resistance of R_1 is varied from 0 to 400 Ω.

Calculate

(i) the maximum p.d. across R_2,

maximum p.d. = ... V [1]

(ii) the minimum p.d. across R_2.

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

(c) A light-dependent resistor (LDR) is connected in parallel with R_2, as shown in Fig. 6.2.
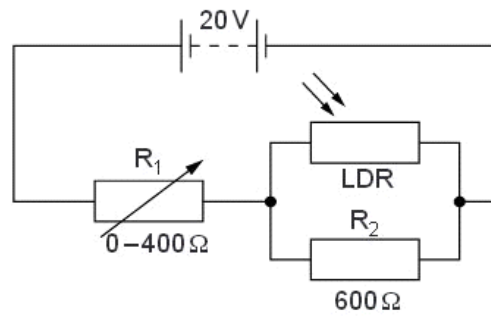

Fig. 6.2

When the light intensity is varied, the resistance of the LDR changes from $5.0\,k\Omega$ to $1.2\,k\Omega$.

(i) For the **maximum** light intensity, calculate the total resistance of R_2 and the LDR.

total resistance = ... Ω [2]

52

(ii) The resistance of R_1 is varied from 0 to 400 Ω in the circuits of Fig. 6.1 and Fig. 6.2. State and explain the difference, if any, between the minimum p.d. across R_2 in each circuit. Numerical values are not required.

....

....

....[2]

Q28.

6 An electron travelling horizontally in a vacuum enters the region between two horizontal metal plates, as shown in Fig. 6.1.

$\bigcirc$ + 400 V

electron
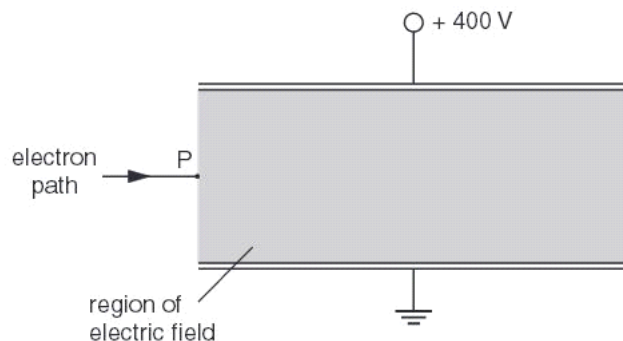path → P

region of
electric field

Fig. 6.1

The lower plate is earthed and the upper plate is at a potential of + 400 V. The separation of the plates is 0.80 cm.

The electric field between the plates may be assumed to be uniform and outside the plates to be zero.

(a) On Fig. 6.1,

    (i) draw an arrow at P to show the direction of the force on the electron due to the electric field between the plates,

    (ii) sketch the path of the electron as it passes between the plates and beyond them.

                                                                        [3]

(b) Determine the electric field strength E between the plates.

$E = $ .... V m^{-1} [2]

(c) Calculate, for the electron between the plates, the magnitude of

    (i) the force on the electron,

force = ... N

(ii) its acceleration.

acceleration = ... m s^{-2}

[4]

(d) State and explain the effect, if any, of this electric field on the horizontal component of the motion of the electron.

....

....

....[2]

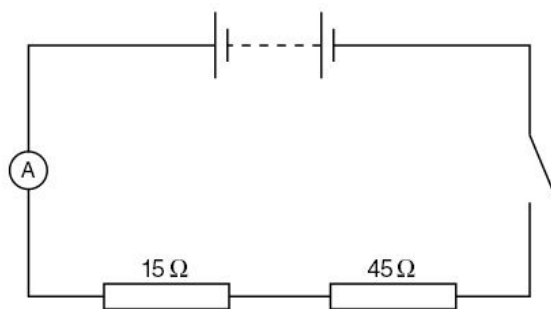**Q29.**

7   A student set up the circuit shown in Fig. 7.1.

Fig. 7.1

The resistors are of resistance 15 Ω and 45 Ω. The battery is found to provide 1.6×10^5 J of electrical energy when a charge of 1.8×10^4 C passes through the ammeter in a time of 1.3×10^5 s.

(a) Determine

    (i)   the electromotive force (e.m.f.) of the battery,

e.m.f. = ... V

    (ii)   the average current in the circuit.

current = ... A

[4]

(b) During the time for which the charge is moving, 1.1×10^5 J of energy is dissipated in the $45\,\Omega$ resistor.

    (i) Determine the energy dissipated in the $15\,\Omega$ resistor during the same time.

energy = ... J

    (ii) Suggest why the total energy provided is greater than that dissipated in the two resistors.

....

....

[4]

Q30.

5 Two large flat metal plates A and B are placed 9.0 cm apart in a vacuum, as illustrated in Fig. 5.1.
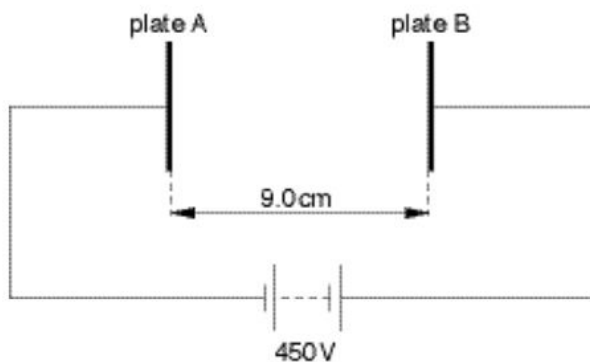

Fig. 5.1

A potential difference of 450 V is maintained between the plates by means of a battery.

(a) **(i)** On Fig. 5.1, draw an arrow to indicate the direction of the electric field between plates A and B.

(ii) Calculate the electric field strength between A and B.

field strength = ………………………………… N C^{-1}

[3]

(b) An electron is released from rest at the surface of plate A.

(i) Show that the change in electric potential energy in moving from plate A to plate B is 7.2×10^{-17} J.

(ii) Determine the speed of the electron on reaching plate B.

speed = ... m s^{-1}
[4]

(c) On the axes of Fig. 5.2, sketch a graph to show the variation with distance d from plate A of the speed v of the electron. [1]
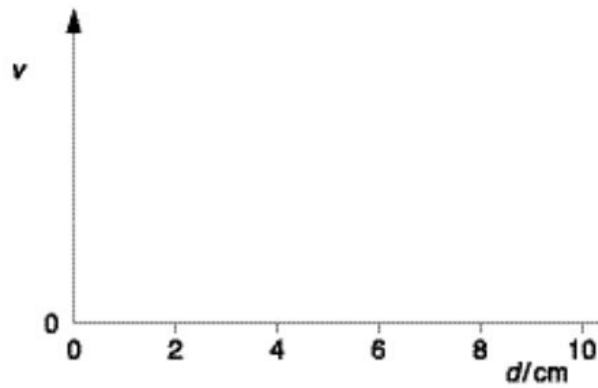

Fig. 5.2

Q31.

7   An electric heater is rated as 240 V, 1.2 kW and has constant resistance.

(a) For the heater operating at 240 V,

(i) show that the current in the heater is 5.0 A,

(ii) calculate its resistance.

resistance = ... Ω

[4]

60

(b) The heater in **(a)** is connected to a mains supply by means of two long cables, as illustrated in Fig. 7.1.

mains
supply

cables,
total resistance 4.0 Ω

heater
240 V
1.2 kW

Fig. 7.1

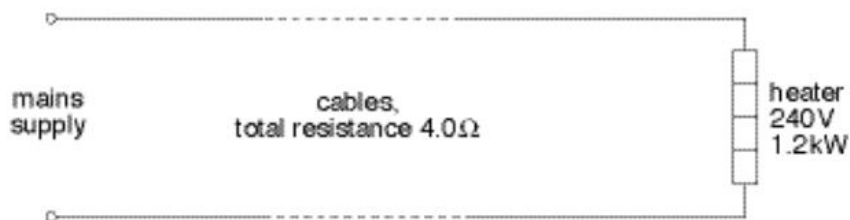The cables have a total resistance of 4.0 Ω. The voltage of the mains supply is adjusted so that the heater operates normally at 240 V. Using your answers in **(a)**, where appropriate, calculate

(i) the potential difference across the cables,

potential difference = ... V

(ii) the voltage of the mains supply,

voltage = ... V

61

(iii) the power dissipated in the cables.

power dissipated = ………………………………… W

[3]

(c) Using information from **(b)**, determine the efficiency ε at which power is transferred from the supply to the heater. That is, calculate

$$\varepsilon = \frac{\text{power dissipated in heater}}{\text{power input from supply}} \, .$$

efficiency = ……………………………………[2]

Q32.

6 Fig. 6.1 shows the variation with applied potential difference V of the current I in an electrical component C.
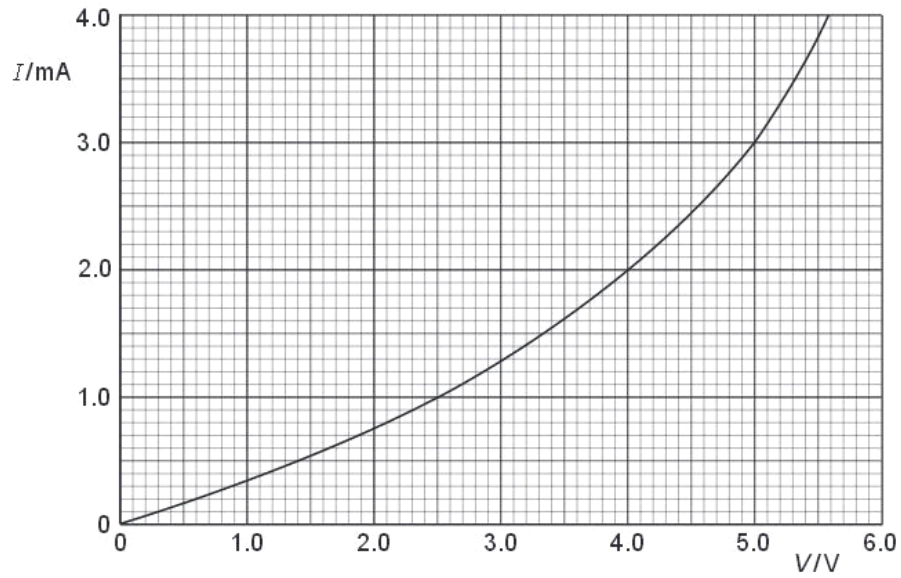
Fig. 6.1

(a) (i) State, with a reason, whether the resistance of component C increases or decreases with increasing potential difference.

....

.... [2]

(ii) Determine the resistance of component C at a potential difference of 4.0 V.

resistance = ... Ω [2]

(b) Component C is connected in parallel with a resistor R of resistance 1500 Ω and a battery of e.m.f. E and negligible internal resistance, as shown in Fig. 6.2.
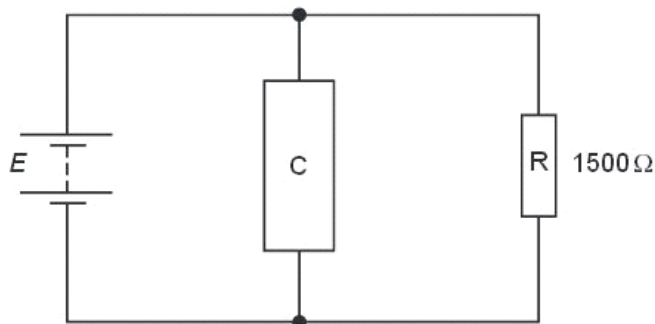
Fig. 6.2

(i) On Fig. 6.1, draw a line to show the variation with potential difference V of the current I in resistor R. **[2]**

(ii) Hence, or otherwise, use Fig. 6.1 to determine the current in the battery for an e.m.f. of 2.0 V.

current = ……………………… A **[2]**

(c) The resistor R of resistance 1500 Ω and the component C are now connected in series across a supply of e.m.f. 7.0 V and negligible internal resistance.

Using information from Fig. 6.1, state and explain which component, R or C, will dissipate thermal energy at a greater rate.

……

……

……

…… **[3]**

Q33.

64

6 Two horizontal metal plates X and Y are at a distance 0.75 cm apart. A positively charged particle of mass 9.6×10^{-15} kg is situated in a vacuum between the plates, as illustrated in Fig. 6.1.
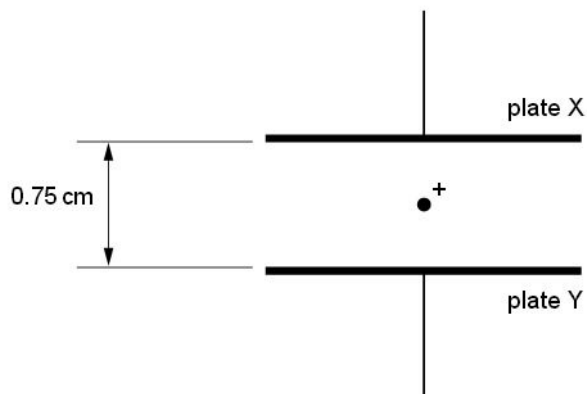
Fig. 6.1

The potential difference between the plates is adjusted until the particle remains stationary.

(a) State, with a reason, which plate, X or Y, is positively charged.

....

....

.... [2]

(b) The potential difference required for the particle to be stationary between the plates is found to be 630 V. Calculate

(i) the electric field strength between the plates,

field strength = ... N C^{-1} [2]

(ii) the charge on the particle.

charge = ... C [3]

Q34.

7   A battery of e.m.f. 4.50 V and negligible internal resistance is connected in series with a fixed resistor of resistance 1200 Ω and a thermistor, as shown in Fig. 7.1.

E
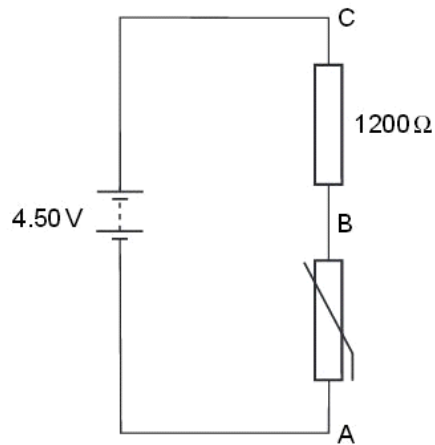
Fig. 7.1

(a)   At room temperature, the thermistor has a resistance of 1800 Ω. Deduce that the potential difference across the thermistor (across AB) is 2.70 V.

[2]

66

(b) A uniform resistance wire PQ of length 1.00m is now connected in parallel with the resistor and the thermistor, as shown in Fig. 7.2.
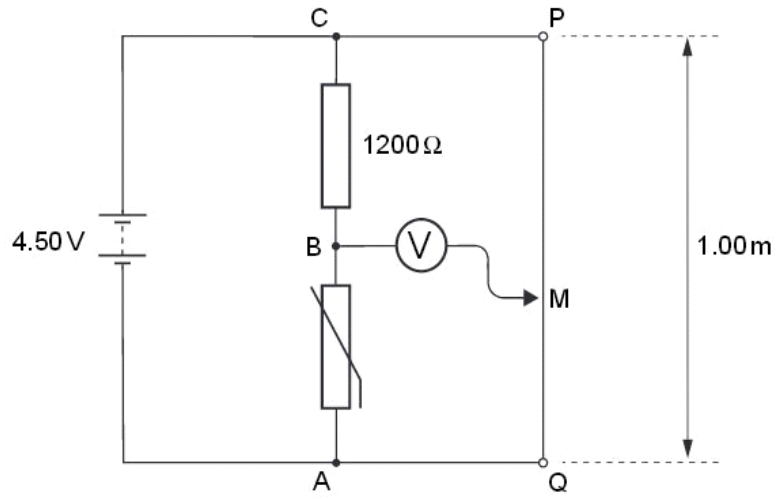
Fig. 7.2

A sensitive voltmeter is connected between point B and a moveable contact M on the wire.

(i) Explain why, for constant current in the wire, the potential difference between any two points on the wire is proportional to the distance between the points.

....

....

....[2]

67

(ii) The contact M is moved along PQ until the voltmeter shows zero reading.

1. State the potential difference between the contact at M and the point Q.

potential difference = ... V [1]

2. Calculate the length of wire between M and Q.

length = ... cm [2]

(iii) The thermistor is warmed slightly. State and explain the effect on the length of wire between M and Q for the voltmeter to remain at zero deflection.

....

....

....[2]

Q35.

7 **(a)** Distinguish between the electromotive force (e.m.f.) of a cell and the potential difference (p.d.) across a resistor.

....

....

....

.... [3]

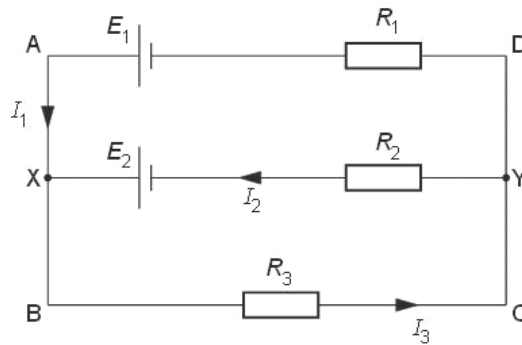**(b)** Fig. 7.1. is an electrical circuit containing two cells of e.m.f. E_1 and E_2.

Fig. 7.1

The cells are connected to resistors of resistance R_1, R_2 and R_3 and the currents in the branches of the circuit are I_1, I_2 and I_3, as shown.

(i) Use Kirchhoff's first law to write down an expression relating I_1, I_2 and I_3.

.... [1]

(ii) Use Kirchhoff's second law to write down an expression relating

1. E_2, R_2, R_3, I_2 and I_3 in the loop XBCYX,

.... [1]

2. E_1, E_2, R_1, R_2, I_1 and I_2 in the loop AXYDA.

.... [1]

Q36.

69

6 An electric shower unit is to be fitted in a house. The shower is rated as 10.5 kW, 230V. The shower unit is connected to the 230V mains supply by a cable of length 16 m, as shown in Fig. 6.1.
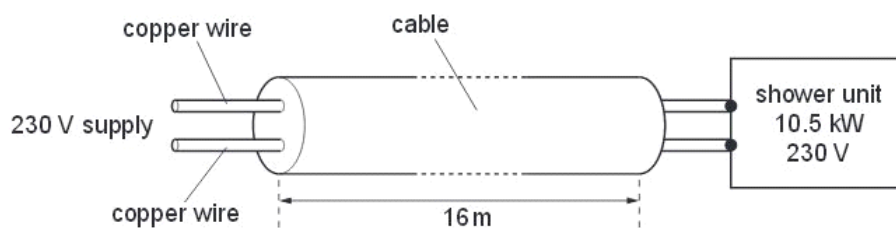
Fig. 6.1

(a) Show that, for normal operation of the shower unit, the current is approximately 46 A.

[2]

(b) The resistance of the two wires in the cable causes the potential difference across the shower unit to be reduced. The potential difference across the shower unit must not be less than 225V.
The wires in the cable are made of copper of resistivity $1.8 \times 10^{-8} \, \Omega \, m$.
Assuming that the current in the wires is 46 A, calculate

(i) the maximum resistance of the cable,

resistance = ... Ω [3]

(ii) the minimum area of cross-section of each wire in the cable.

area = ... m^2 [3]

(c) Connecting the shower unit to the mains supply by means of a cable having wires with too small a cross-sectional area would significantly reduce the power output of the shower unit.

    (i) Assuming that the shower is operating at 210V, rather than 230V, and that its resistance is unchanged, determine the ratio

$$\frac{\text{power dissipated by shower unit at 210V}}{\text{power dissipated by shower unit at 230V}}.$$

ratio = ... [2]

    (ii) Suggest and explain one further disadvantage of using wires of small cross-sectional area in the cable.

....

....

.... [2]

Q37.

4 Two parallel plates P and Q are separated by a distance of 7.6 mm in a vacuum. There is a potential difference of 250V between the plates, as illustrated in Fig. 4.1.

Fig. 4.1

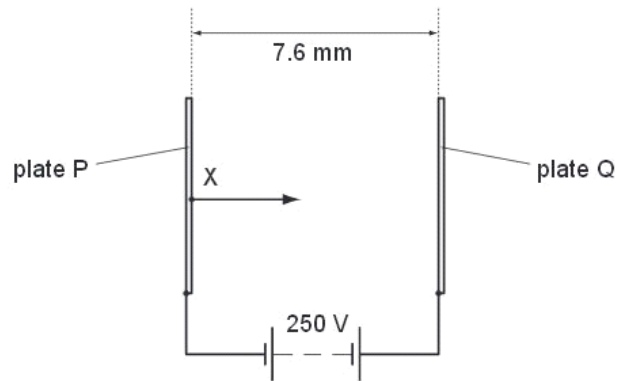Electrons are produced at X on plate P. These electrons accelerate from rest and travel to plate Q.
The electric field between the plates may be assumed to be uniform.

(a) (i) Determine the force on an electron due to the electric field.

force = ... N [3]

(ii) Show that the change in kinetic energy of an electron as it moves from plate P to plate Q is 4.0×10^{-17} J.

[2]

(iii) Determine the speed of an electron as it reaches plate Q.

speed = ...m s^{-1} [2]

(b) The positions of the plates are adjusted so that the electric field between them is not uniform. The potential difference remains unchanged.
State and explain the effect, if any, of this adjustment on the speed of an electron as it reaches plate Q.

....

....

....

.... [3]

Q38.

7 A potential divider circuit consists of two resistors of resistances P and Q, as shown in Fig. 7.1.

E
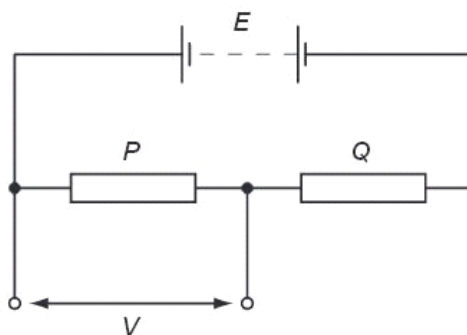
Fig. 7.1

The battery has e.m.f. E and negligible internal resistance.

(a) Deduce that the potential difference V across the resistor of resistance P is given by the expression

$$V = \frac{P}{P + Q} E.$$

[2]

(b) The resistances P and Q are $2000\,\Omega$ and $5000\,\Omega$ respectively.
A voltmeter is connected in parallel with the $2000\,\Omega$ resistor and a thermistor is connected in parallel with the $5000\,\Omega$ resistor, as shown in Fig. 7.2.

Fig. 7.2

The battery has e.m.f. 6.0V. The voltmeter has infinite resistance.

(i) State and explain qualitatively the change in the reading of the voltmeter as the temperature of the thermistor is raised.

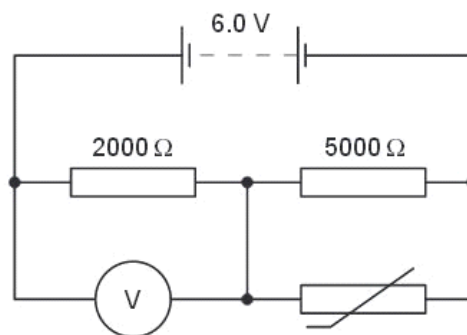...

....

....

.... [3]

(ii) The voltmeter reads 3.6V when the temperature of the thermistor is 19°C. Calculate the resistance of the thermistor at 19°C.

resistance = ... Ω [4]

Q39.

6 A cell has electromotive force (e.m.f.) *E* and internal resistance *r*. It is connected in series with a variable resistor R, as shown in Fig. 6.1.
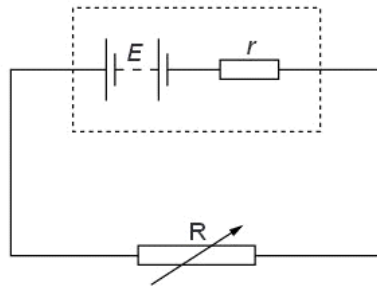
Fig. 6.1

(a) Define electromotive force (e.m.f.).

....

....

.... [2]

(b) The variable resistor R has resistance X. Show that

$$\frac{\text{power dissipated in resistor R}}{\text{power produced in cell}} = \frac{X}{X + r}.$$

[3]

(c) The variation with resistance X of the power P_R dissipated in R is shown in Fig. 6.2.
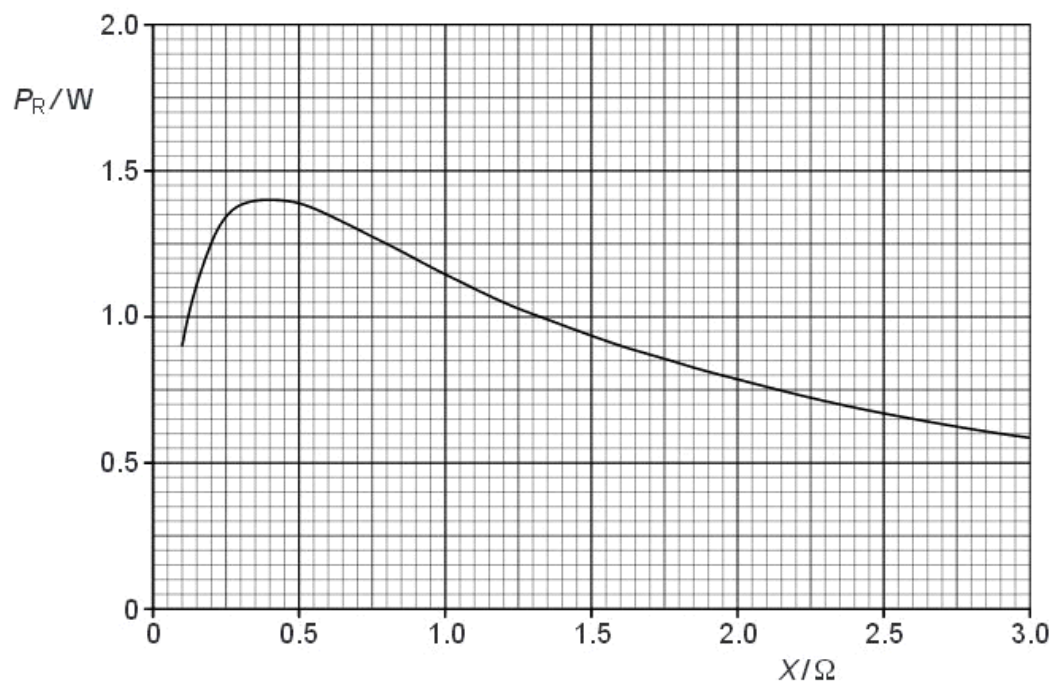

Fig. 6.2

77

(i) Use Fig. 6.2 to state, for maximum power dissipation in resistor R, the magnitude of this power and the resistance of R.

maximum power = ... W

resistance = ... Ω

[2]

(ii) The cell has e.m.f. 1.5V.
Use your answers in **(i)** to calculate the internal resistance of the cell.

internal resistance = ... Ω [3]

(d) In Fig. 6.2, it can be seen that, for larger values of X, the power dissipation decreases. Use the relationship in **(b)** to suggest one advantage, despite the lower power output, of using the cell in a circuit where the resistance X is larger than the internal resistance of the cell.

....

.... [1]

Q40.

6 **(a)** Two resistors, each of resistance R, are connected first in series and then in parallel.
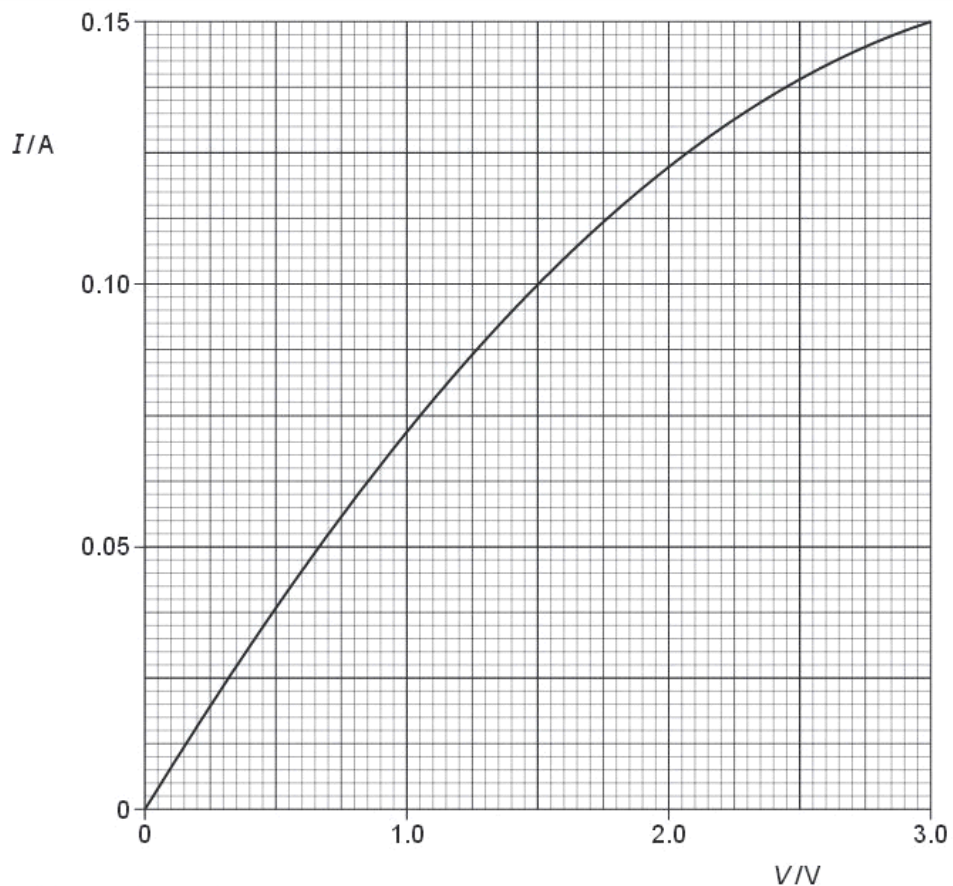
Show that the ratio

$$\frac{\text{combined resistance of resistors connected in series}}{\text{combined resistance of resistors connected in parallel}}$$

is equal to 4.

[1]

(b) The variation with potential difference V of the current I in a lamp is shown in Fig. 6.1.

Calculate the resistance of the lamp for a potential difference across the lamp of 1.5V.

Ex a

resistance = ... Ω [2]

(c) Two lamps, each having the *I-V* characteristic shown in Fig. 6.1, are connected first in series and then in parallel with a battery of e.m.f. 3.0V and negligible internal resistance.

Complete the table of Fig. 6.2 for the lamps connected to the battery.

	p.d. across each lamp/V	resistance of each lamp/Ω	combined resistance of lamps/Ω
lamps connected in series	....	....	....
lamps connected in parallel	....	....	....

Fig. 6.2

[4]

(d) (i) Use data from the completed Fig. 6.2 to calculate the ratio

$$\frac{\text{combined resistance of lamps connected in series}}{\text{combined resistance of lamps connected in parallel}}.$$

ratio = ... [1]

(ii) The ratios in **(a)** and **(d)(i)** are not equal.

By reference to Fig. 6.1, state and explain qualitatively the change in the resistance of a lamp as the potential difference is changed.

....

....

....

.... [3]

Q41.

6 (a) A lamp is rated as 12V, 36W.

Ex.

(i) Calculate the resistance of the lamp at its working temperature.

resistance = ... Ω [2]

(ii) On the axes of Fig. 6.1, sketch a graph to show the current-voltage (*I–V*) characteristic of the lamp. Mark an appropriate scale for current on the *y*-axis.

I / A

0   6   12

V / V
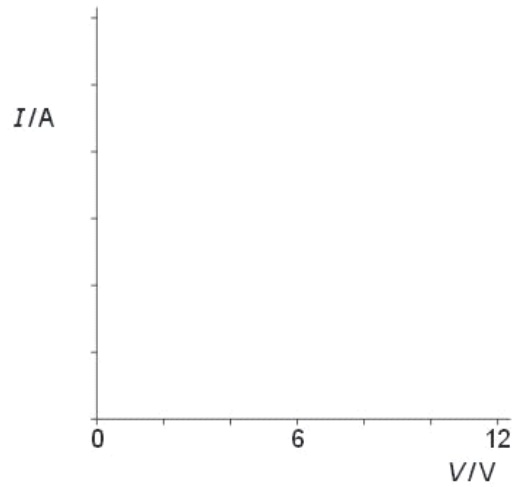
Fig. 6.1

[3]

(b) Some heaters are each labelled 230 V, 1.0 kW. The heaters have constant resistance.

Determine the total power dissipation for the heaters connected as shown in each of the diagrams shown below.

(i)

230 V

power = ... kW [1]

82
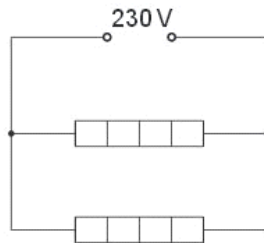
(ii)
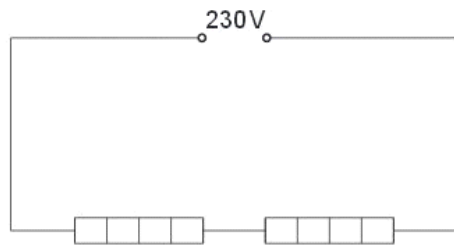
power = ...….......... kW [1]

(iii)
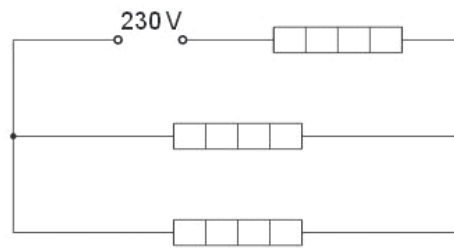
power = ...….......... kW [2]

Q42.

6   The variation with temperature of the resistance R_T of a thermistor is shown in Fig. 6.1.
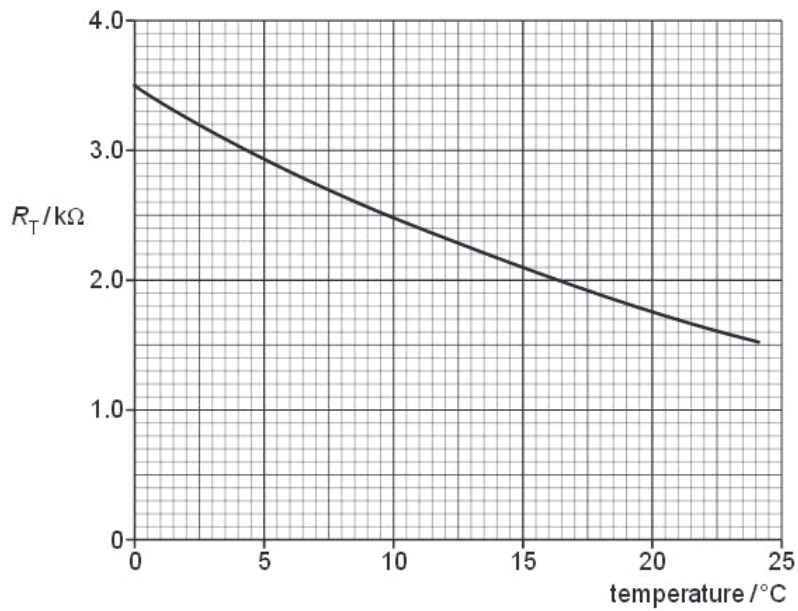
Fig. 6.1

The thermistor is connected into the circuit of Fig. 6.2.

Fig. 6.2

84
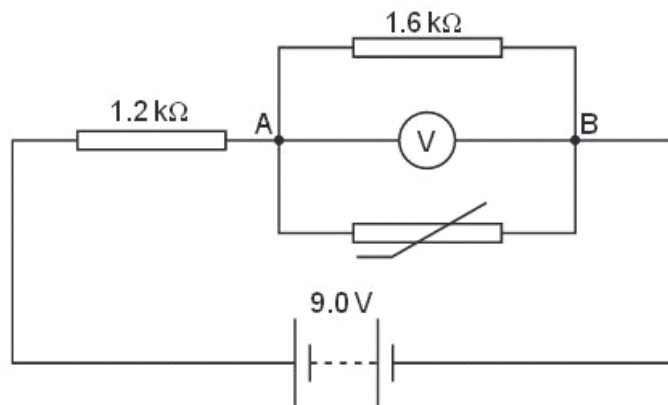
The battery has e.m.f. 9.0 V and negligible internal resistance. The voltmeter has infinite resistance.

(a) For the thermistor at 22.5 °C, calculate

 (i) the total resistance between points A and B on Fig. 6.2,

resistance = ... Ω [2]

 (ii) the reading on the voltmeter.

voltmeter reading = ... V [2]

(b) The temperature of the thermistor is changed. The voltmeter now reads 4.0 V. Determine

 (i) the total resistance between points A and B on Fig. 6.2,

resistance = ... Ω [2]

(ii) the temperature of the thermistor.

temperature = ...°C [2]

(c) A student suggests that the voltmeter, reading up to 10V, could be calibrated to measure temperature.

Suggest two disadvantages of using the circuit of Fig. 6.2 with this voltmeter for the measurement of temperature in the range 0°C to 25°C.

1. ....

....

2. ....

....

[2]

Q43.

7 Two oppositely-charged parallel metal plates are situated in a vacuum, as shown in Fig. 7.1.

Fig. 7.1

The plates have length *L*.
The uniform electric field between the plates has magnitude *E*. The electric field outside the plates is zero.

A positively-charged particle has mass *m* and charge +*q*. Before the particle reaches the region between the plates, it is travelling with speed *v* parallel to the plates.
The particle passes between the plates and into the region beyond them.

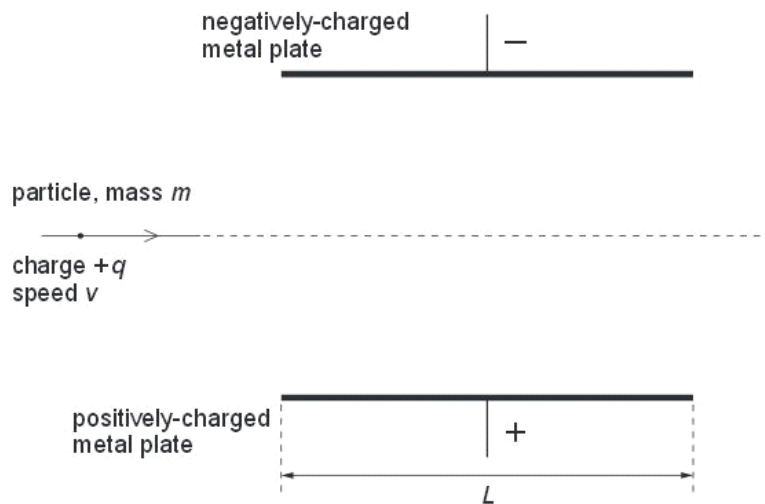**(a)** **(i)** On Fig. 7.1, draw the path of the particle between the plates and beyond them. [2]

     (ii) For the particle in the region between the plates, state expressions, in terms of *E*, *m*, *q*, *v* and *L*, as appropriate, for

        1. the force *F* on the particle,

        .... [1]

        2. the time *t* for the particle to cross the region between the plates.

        .... [1]

(b) **(i)** State the law of conservation of linear momentum.

     ....

     ....

     .... [2]

     (ii) Use your answers in **(a)(ii)** to state an expression for the change in momentum of the particle.

     .... [1]

     (iii) Suggest and explain whether the law of conservation of linear momentum applies to the particle moving between the plates.

     ....

     ....

     .... [2]

For Examiner Use

Q44.

8 An electric heater has a constant resistance and is rated as 1.20 kW, 230 V.

The heater is connected to a 230 V supply by means of a cable that is 9.20 m long, as illustrated in Fig. 8.1.

copper wires
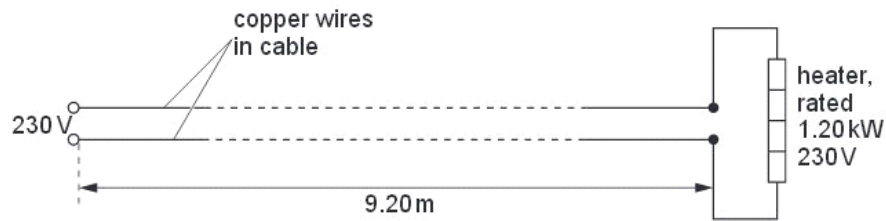in cable

230 V

heater,
rated
1.20 kW
230 V

9.20 m

Fig. 8.1

The two copper wires that make up the cable each have a circular cross-section of diameter 0.900 mm. The resistivity of copper is $1.70 \times 10^{-8}\,\Omega\,m$.

(a) Show that

(i) the resistance of the heater is 44.1 Ω,

[2]

(ii) the total resistance of the cable is 0.492 Ω.

[2]

(b) The current in the cable and heater is switched on. Determine, to three significant figures, the power dissipated in the heater.

power = ... W [3]

(c) Suggest two disadvantages of connecting the heater to the 230V supply using a cable consisting of two thinner copper wires.

1. ....

....

2. ....

....

[2]

Q45.

5 **(a)** Define the *ohm*.

.... [1]

(b) Determine the SI base units of **resistivity**.

base units of resistivity = ... [3]

(c) A cell of e.m.f. 2.0V and negligible internal resistance is connected to a variable resistor R and a metal wire, as shown in Fig. 5.1.

Fig. 5.1

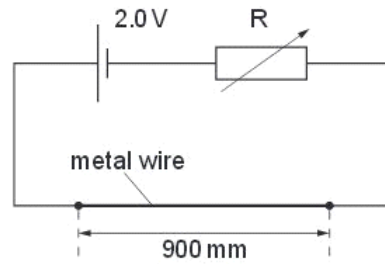The wire is 900mm long and has an area of cross-section of $1.3 \times 10^{-7}\,m^2$. The resistance of the wire is $3.4\,\Omega$.

(i) Calculate the resistivity of the metal wire.

resistivity = ... [2]

(ii) The resistance of R may be varied between 0 and 1500 Ω.
Calculate the maximum potential difference (p.d.) and minimum p.d. possible across
the wire.

maximum p.d. = ... V

minimum p.d. = ...V

[2]

(iii) Calculate the power transformed in the wire when the potential difference across
the wire is 2.0 V.

power = ... W [2]

(d) Resistance R in **(c)** is now replaced with a different variable resistor Q. State the power
transformed in Q, for Q having

(i) zero resistance,

power = ... W [1]

(ii) infinite resistance.

power = ... W [1]

Q46.

4 **(a)** Define *electric field strength*.

....

....[1]

(b) Two horizontal metal plates are 20 mm apart in a vacuum. A potential difference of 1.5 kV is applied across the plates, as shown in Fig. 4.1.
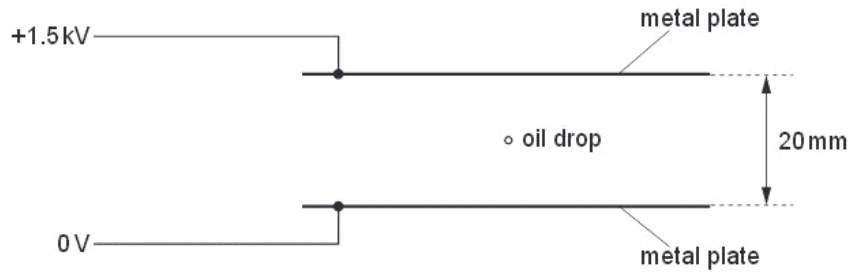

Fig. 4.1

A charged oil drop of mass 5.0×10^{-15} kg is held stationary by the electric field.

(i) On Fig. 4.1, draw lines to represent the electric field between the plates. [2]

(ii) Calculate the electric field strength between the plates.

electric field strength = ... V m^{-1} [1]

(iii) Calculate the charge on the drop.

charge = ... C [4]

(iv) The potential of the upper plate is increased. Describe and explain the subsequent motion of the drop.

....

....

....[2]

Q47.

5 A potentiometer circuit that is used as a means of comparing potential differences is shown in Fig. 5.1.
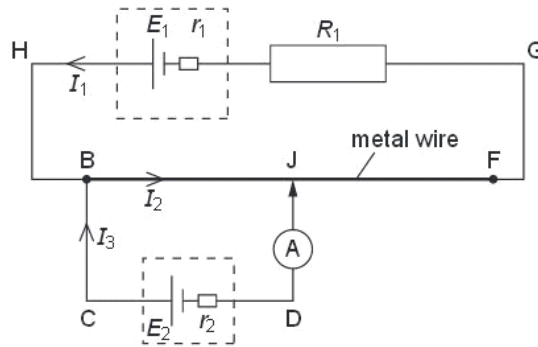
Fig. 5.1

A cell of e.m.f. E_1 and internal resistance r_1 is connected in series with a resistor of resistance R_1 and a uniform metal wire of total resistance R_2.
A second cell of e.m.f. E_2 and internal resistance r_2 is connected in series with a sensitive ammeter and is then connected across the wire at BJ. The connection at J is halfway along the wire. The current directions are shown on Fig. 5.1.

(a) Use Kirchhoff's laws to obtain the relation

(i) between the currents I_1, I_2 and I_3,

....[1]

(ii) between E_1, R_1, R_2, r_1, I_1 and I_2 in loop HBJFGH,

....[1]

(iii) between E_1, E_2, r_1, r_2, R_1, R_2, I_1 and I_3 in the loop HBCDJFGH.

....[2]

(b) The connection at J is moved along the wire. Explain why the reading on the ammeter changes.

....

....

....

....[2]

Q48.

4 **(a)** Distinguish between *potential difference* (p.d.) and *electromotive force* (e.m.f.) in terms of energy transformations.

....

....

....

....[2]

(b) Two cells A and B are connected in series with a resistor R of resistance 5.5 Ω, as shown in Fig. 4.1.

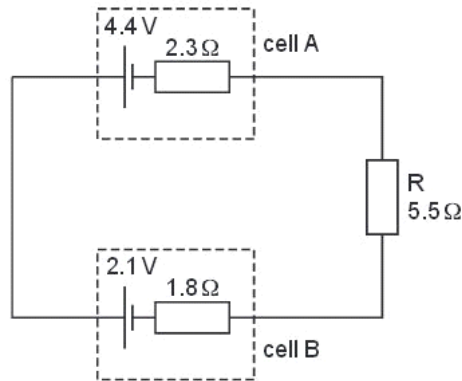**Fig. 4.1**

Cell A has e.m.f. 4.4 V and internal resistance 2.3 Ω. Cell B has e.m.f. 2.1 V and internal resistance 1.8 Ω.

(i) State Kirchhoff's second law.

....

....[1]

(ii) Calculate the current in the circuit.

current = ... A [2]

(iii) On Fig. 4.1, draw an arrow to show the direction of the current in the circuit. Label this arrow *I*. [1]

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(iv) Calculate

    1. the p.d. across resistor R,

p.d. = ... V [1]

    2. the terminal p.d. across cell A,

p.d. = ... V [1]

  3. the terminal p.d. across cell B.

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

Q49.

2 **(a)** Define electrical *resistance*.

....

.... [1]

(b) A circuit is set up to measure the resistance R of a metal wire. The potential difference (p.d.) V across the wire and the current I in the wire are to be measured.

(i) Draw a circuit diagram of the apparatus that could be used to make these measurements.

[3]

(ii) Readings for p.d. V and the corresponding current I are obtained. These are shown in Fig. 2.1.
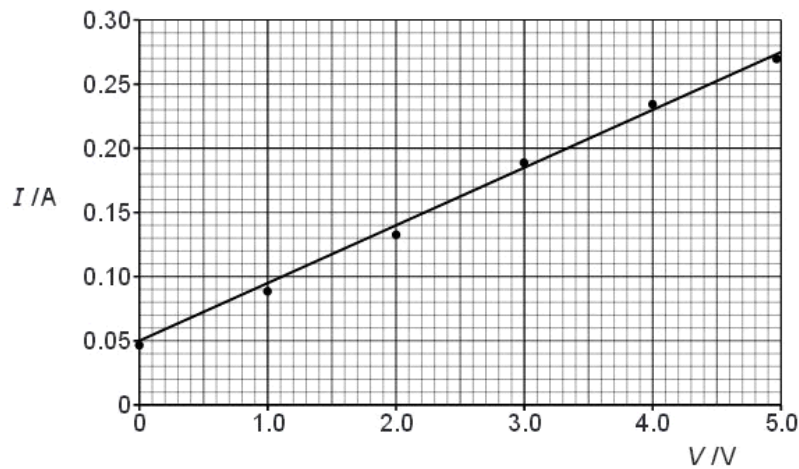

Fig. 2.1

Explain how Fig. 2.1 indicates that the readings are subject to

1. a systematic uncertainty,

....

.... [1]

2. random uncertainties.

....

.... [1]

(iii) Use data from Fig. 2.1 to determine R. Explain your working.

$R =$ .... Ω [3]

(c) In another experiment, a value of R is determined from the following data:

Current $I = 0.64 \pm 0.01\,A$ and p.d. $V = 6.8 \pm 0.1\,V$.

Calculate the value of R, together with its uncertainty. Give your answer to an appropriate number of significant figures.

$R =$ .... ± ....Ω [3]

Q50.

5 Fig. 5.1 shows a 12V power supply with negligible internal resistance connected to a uniform metal wire AB. The wire has length 1.00m and resistance 10 Ω. Two resistors of resistance 4.0 Ω and 2.0 Ω are connected in series across the wire.
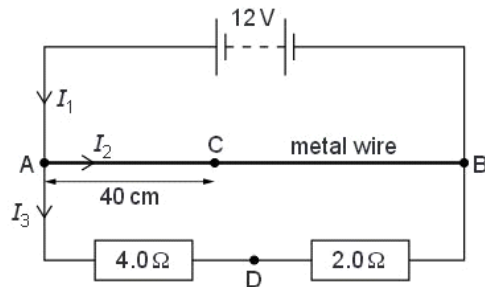
Fig. 5.1

Currents I_1, I_2 and I_3 in the circuit are as shown in Fig. 5.1.

(a) (i) Use Kirchhoff's first law to state a relationship between I_1, I_2 and I_3.

....[1]

(ii) Calculate I_1.

$I_1 =$ .... A [3]

(iii) Calculate the ratio x, where

$$x = \frac{\text{power in metal wire}}{\text{power in series resistors}}.$$

$x =$ .... [3]

98

(b) Calculate the potential difference (p.d.) between the points C and D, as shown in Fig. 5.1. The distance AC is 40 cm and D is the point between the two series resistors.

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

Q51.

4 A circuit used to measure the power transfer from a battery is shown in Fig. 4.1. The power is transferred to a variable resistor of resistance R.
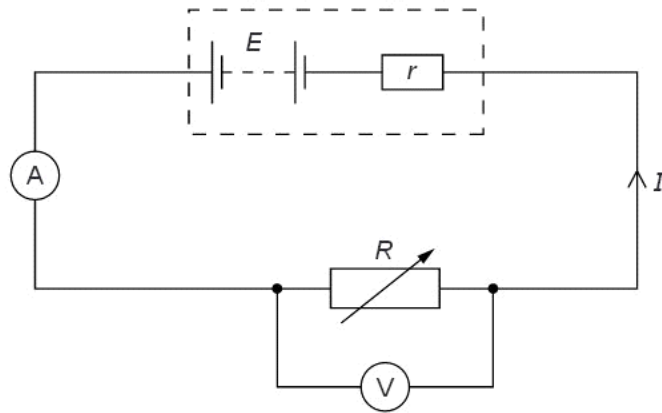
Fig. 4.1

The battery has an electromotive force (e.m.f.) E and an internal resistance r. There is a potential difference (p.d.) V across R. The current in the circuit is I.

(a) By reference to the circuit shown in Fig. 4.1, distinguish between the definitions of e.m.f. and p.d.

....

....

....

.... [3]

(b) Using Kirchhoff's second law, determine an expression for the current I in the circuit.

[1]

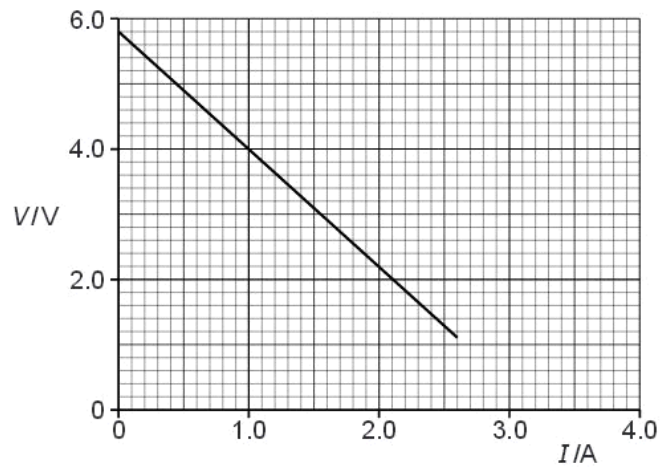**(c)** The variation with current I of the p.d. V across R is shown in Fig. 4.2.

Fig. 4.2

100

Use Fig. 4.2 to determine

(i) the e.m.f. *E*,

$E =$ .... V [1]

(ii) the internal resistance *r*.

$r =$ .... Ω [2]

(d) (i) Using data from Fig. 4.2, calculate the power transferred to *R* for a current of 1.6A.

power = ... W [2]

(ii) Use your answers from **(c)(i)** and **(d)(i)** to calculate the efficiency of the battery for a current of 1.6A.

efficiency = ... % [2]

Q52.

6 **(a)** Define *potential difference* (p.d.).

....[1]

(b) A power supply of e.m.f. 240V and zero internal resistance is connected to a heater as shown in Fig. 6.1.

240 V

Fig. 6.1

The wires used to connect the heater to the power supply each have length 75m. The wires have a cross-sectional area 2.5mm^2 and resistivity 18 nΩ m. The heater has a constant resistance of 38 Ω.

(i) Show that the resistance of each wire is 0.54 Ω.

[3]

(ii) Calculate the current in the wires.

current = ... A [3]

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(iii) Calculate the power loss in the wires.

power = ... W [3]

(c) The wires to the heater are replaced by wires of the same length and material but having a cross-sectional area of $0.50\,mm^2$. Without further calculation, state and explain the effect on the power loss in the wires.

....

....

....[2]

Q53.

6 A battery connected in series with a resistor R of resistance $5.0\,\Omega$ is shown in Fig. 6.1.
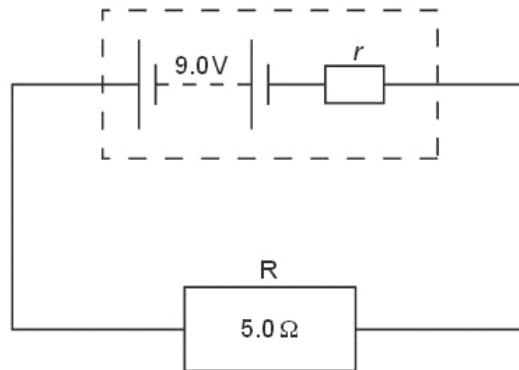
Fig. 6.1

The electromotive force (e.m.f.) of the battery is 9.0 V and the internal resistance is *r*.
The potential difference (p.d.) across the battery terminals is 6.9 V.

The electromotive force (e.m.f.) of the battery is 9.0 V and the internal resistance is r. The potential difference (p.d.) across the battery terminals is 6.9 V.

(a) Use energy considerations to explain why the p.d. across the battery is not equal to the e.m.f. of the battery.

....

....

.... [2]

(b) Calculate

    (i) the current in the circuit,

current = ... A [2]

    (ii) the internal resistance r.

$r =$ .... Ω [2]

(c) Calculate, for the battery in the circuit,

(i) the total power produced,

power = ... W [2]

(ii) the efficiency.

efficiency = ... [2]

Q54.

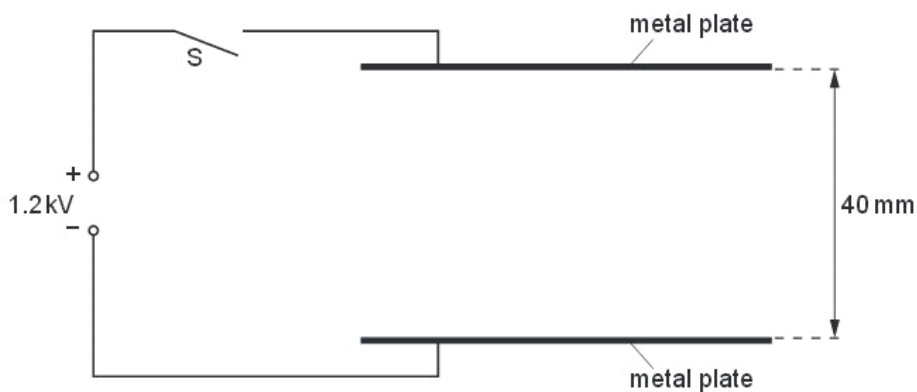7 **(a)** Two horizontal metal plates are connected to a power supply, as shown in Fig. 7.1.

Fig. 7.1

The separation of the plates is 40 mm.

The switch S is then closed so that a potential difference of 1.2 kV is applied across the plates.

(i) On Fig. 7.1, draw six field lines to represent the electric field between the metal plates. [2]

(ii) Calculate the electric field strength E between the plates.

$E =$ .... $V m^{-1}$ [2]

(b) The switch S is opened and the plates lose their charge. Two very small metal spheres A and B joined by an insulating rod are placed between the metal plates as shown in Fig. 7.2.
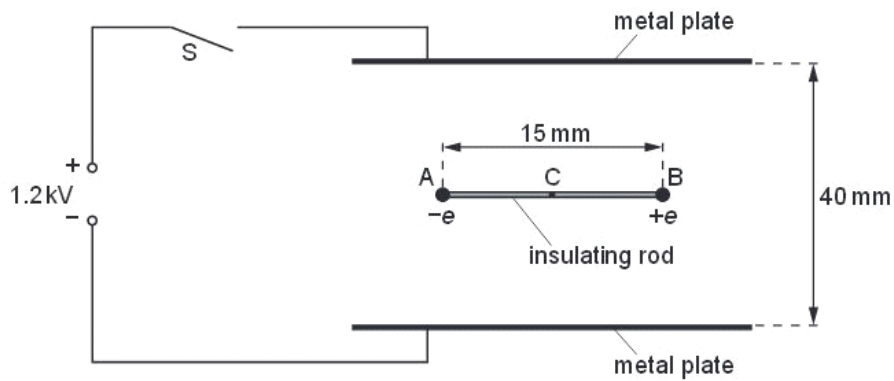
Sphere A has charge $-e$ and sphere B has charge $+e$, where e is the charge of a proton. The length AB is 15 mm. The rod is supported at its centre C so that the rod is horizontal and in equilibrium.

The switch S is then closed so that the potential difference of 1.2 kV is applied across the plates.

(i) There is a force acting on A due to the electric field between the plates.
Show that this force is 4.8×10^{-15} N.

[2]

(ii) The insulating rod joining A and B is fixed in the position shown in Fig. 7.2. Calculate the torque of the couple acting on the rod.

torque = ... unit .... [3]

(iii) The insulating rod is now released so that it is free to rotate about C. State and explain the position of the rod when it comes to rest.

....

....

....

....[2]