

PHYSICS



EXAM QUESTION PACK

9 ELECTRICITY

SCORE

/

PERCENTAGE

%

STEMUP

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S_1	switch		meter reading / Ω
	S_2	S_3	
open	open	open	∞
closed	open	open	$15\ \Omega$
open	closed	open	$30\ \Omega$
open	closed	closed	$15\ \Omega$

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.

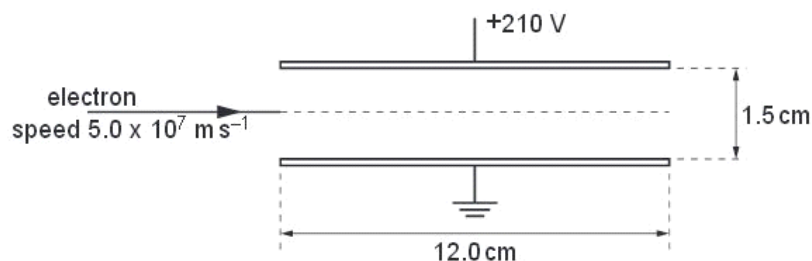


Fig. 2.1

The space between the plates is a vacuum.

The potential difference between the plates is 210V. 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 $5.0 \times 10^7 \text{ m s}^{-1}$.

U

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]

- (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.

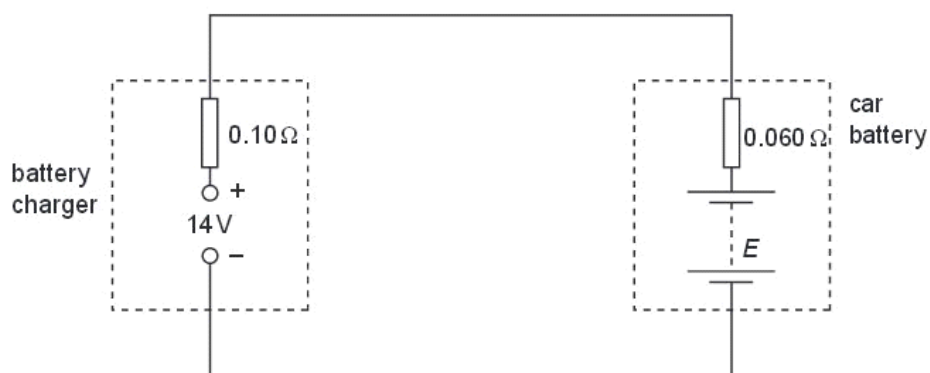


Fig. 6.1

- (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]

- (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.

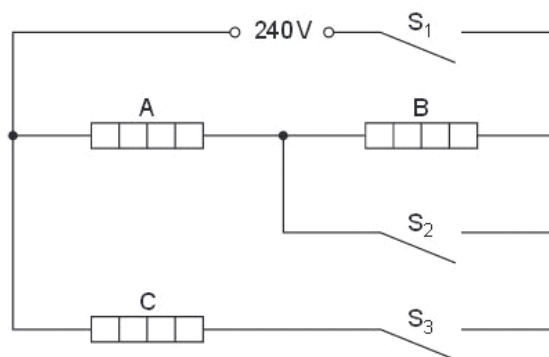


Fig. 6.1

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.

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(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.

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(

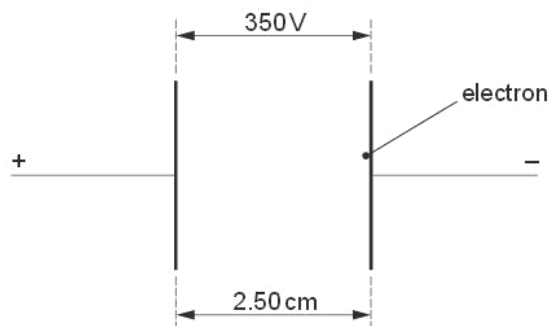


Fig. 6.1

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 = ... NC^{-1} [2]

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

[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.

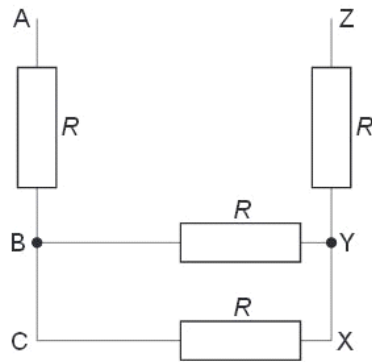


Fig. 7.1

(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]

- (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.

Ex

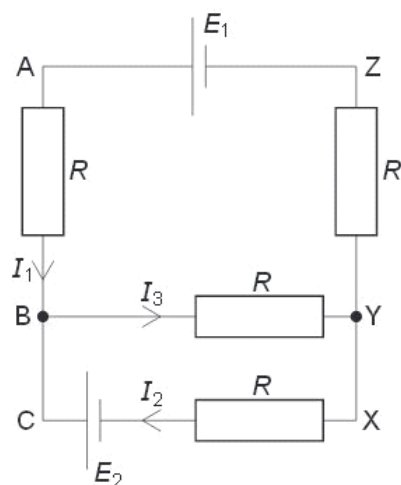


Fig. 7.2

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.

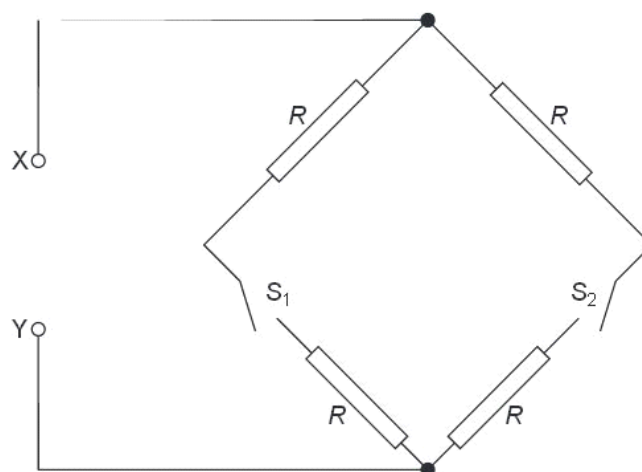


Fig. 7.1

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.

Ex6

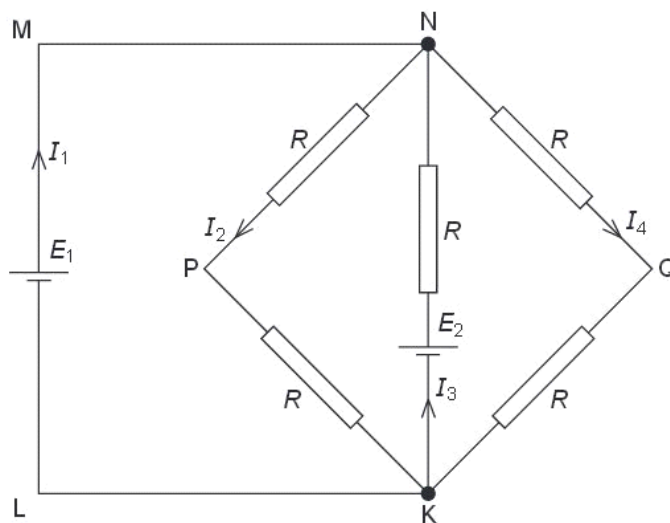


Fig. 7.3

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 NKL MN,

.....[1]

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

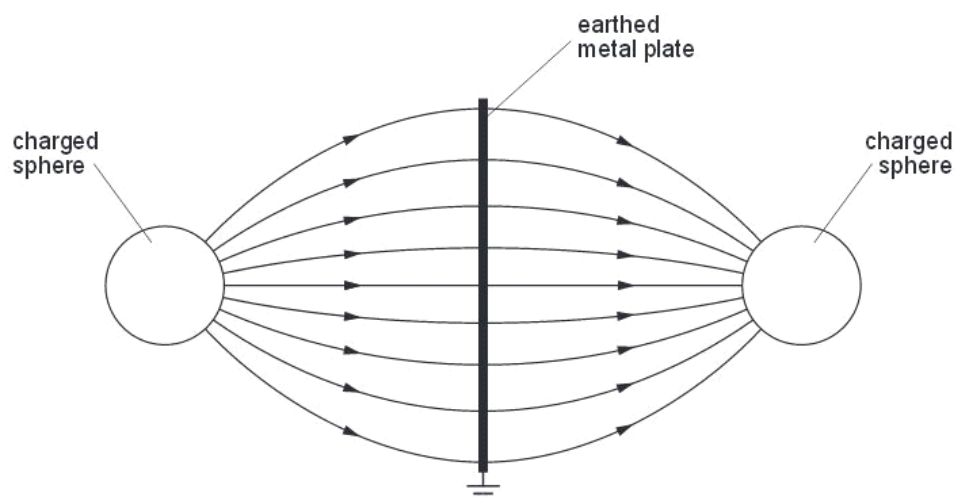
.....[1]

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.



- (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]

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

Ex 6

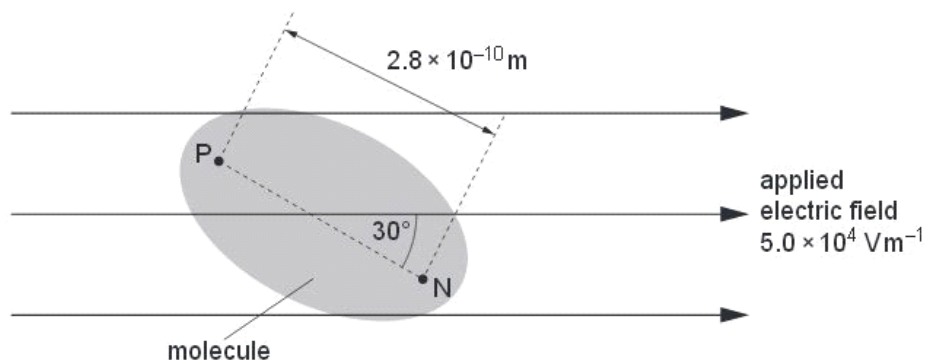


Fig. 5.2

The molecule is situated in a uniform electric field of field strength $5.0 \times 10^4 \text{ V m}^{-1}$. 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 $1.6 \times 10^{-19} \text{ C}$.

- (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 $1.0 \times 10^{-6} \Omega \text{m}$ at the operating temperature of the heater. The heater is to have a power dissipation of 60W when the potential difference across its terminals is 12V.

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(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 2.4Ω .

[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.

Ex a

.....

[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.

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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.

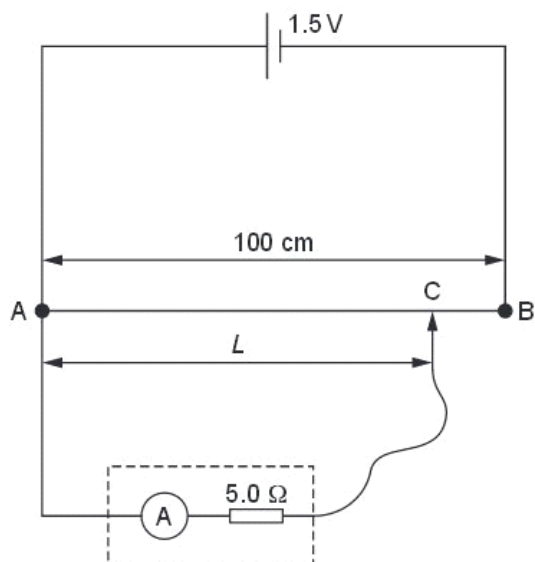


Fig. 6.1

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]

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- (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.

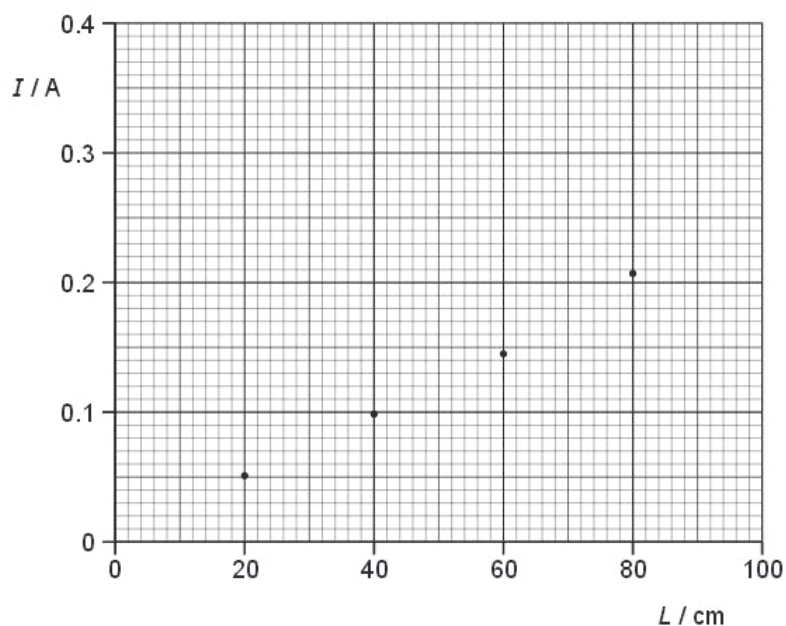


Fig. 6.2

- (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.

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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*.

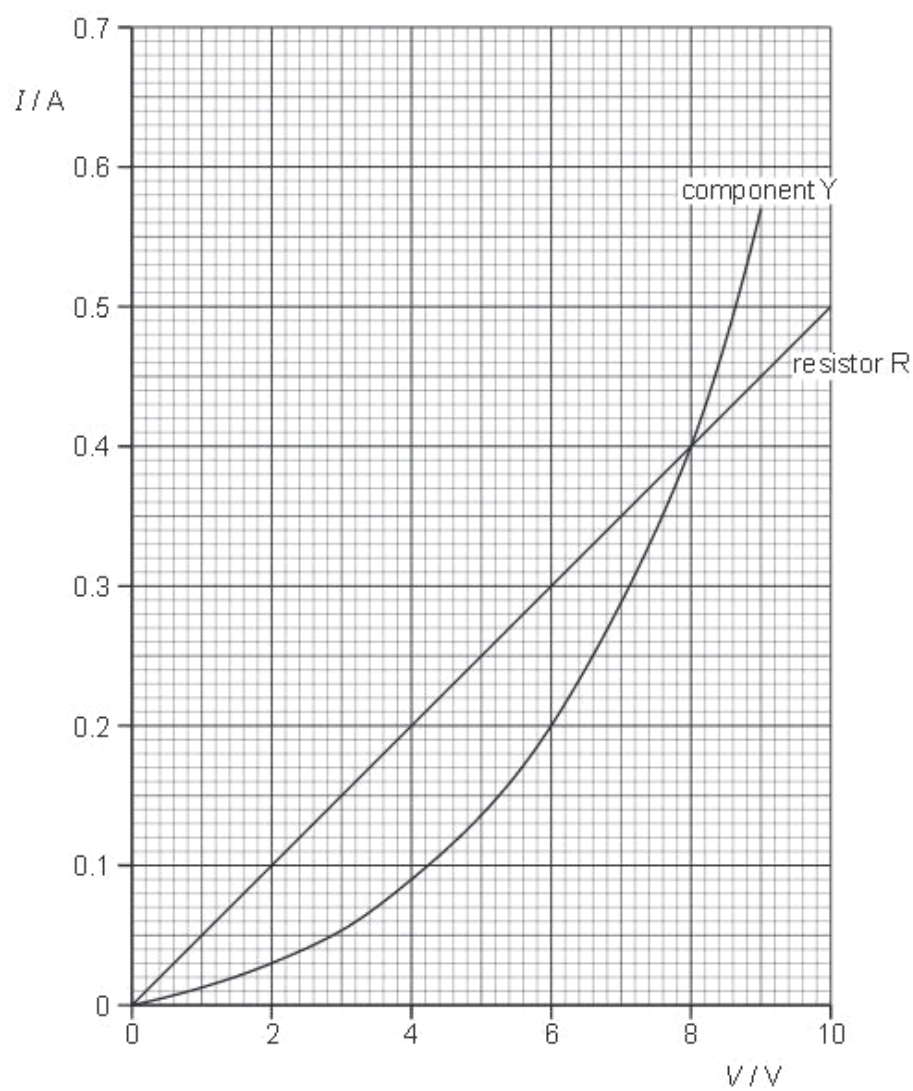
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.....
 [1]

- (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.



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

Exa

.....

[2]

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

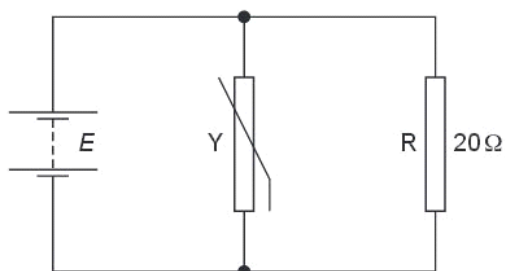


Fig. 6.2

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 6.0V ,

current = ...A [1]

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

resistance = ... Ω [2]

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

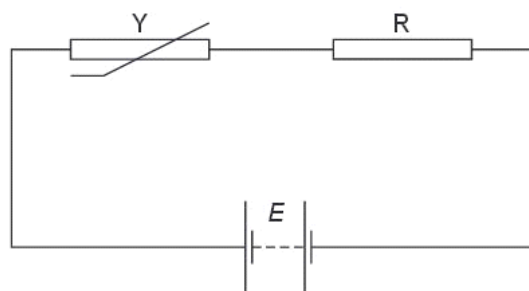


Fig. 6.3

The current in the circuit is 0.20 A.

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

$E = \dots\dots\dots$ V [1]

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

power = $\dots\dots\dots$ W [2]

Q17.

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

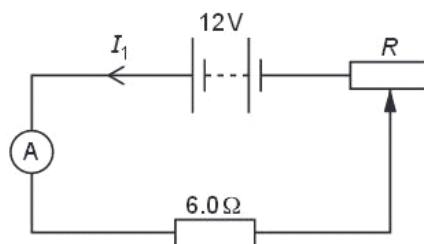


Fig. 5.1

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

- (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.

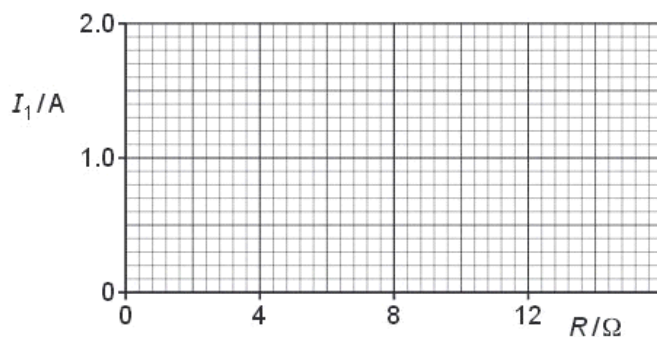


Fig. 5.2

[2]

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

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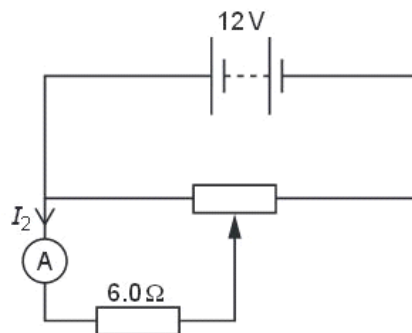


Fig. 5.3

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

maximum $I_2 = \dots\dots\dots$ A

minimum $I_2 = \dots\dots\dots$ A

[2]

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

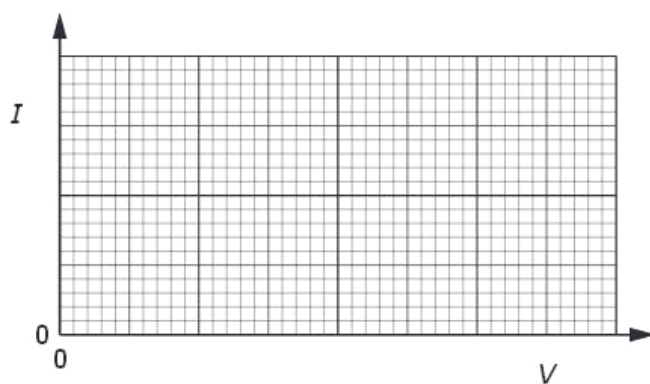


Fig. 5.4

[2]

- (ii) The resistor of resistance 6.0Ω 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.

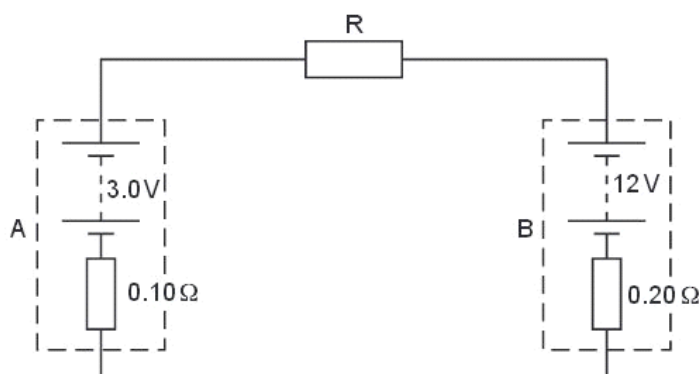


Fig. 5.1

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

- (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.

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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.

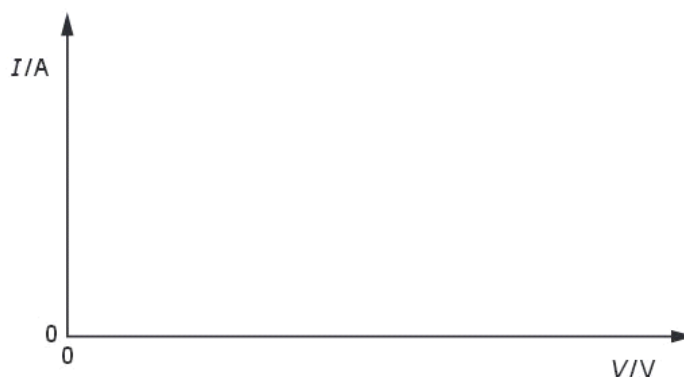


Fig. 5.1

[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.

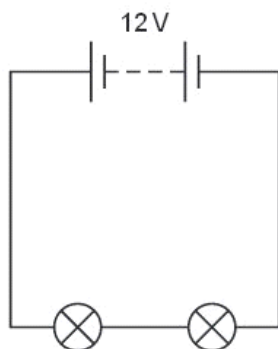


Fig. 5.2

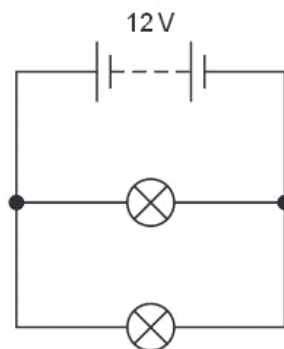


Fig. 5.3

- (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.

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[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 2.5kW when connected to a 220V supply.

- (i) Calculate the resistance of the heater.

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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]

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

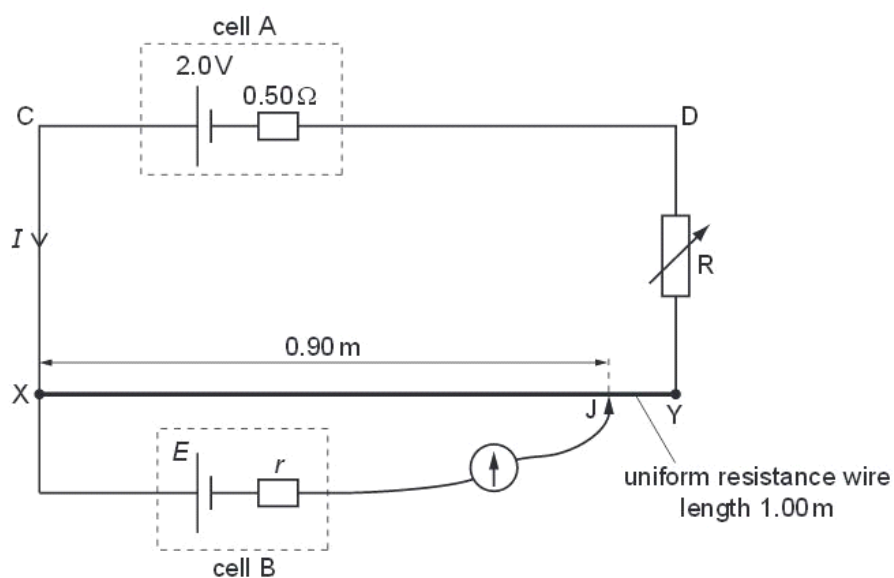


Fig. 5.1

The uniform resistance wire XY has length 1.00m and resistance 4.0Ω . Cell A has e.m.f. 2.0V and internal resistance 0.50Ω . 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 0.90m. The variable resistor R has resistance 2.5Ω .

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

$I = \dots\dots\dots$ A [2]

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

Exa
(

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.

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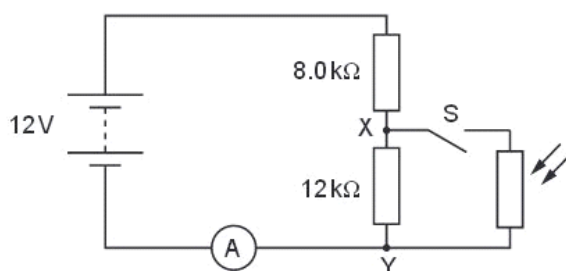


Fig. 4.1

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 $4.0\text{ k}\Omega$. 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

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- (i) the ammeter reading,

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

- (ii) the p.d. across XY.

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

Q23.

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

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.....
 [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.

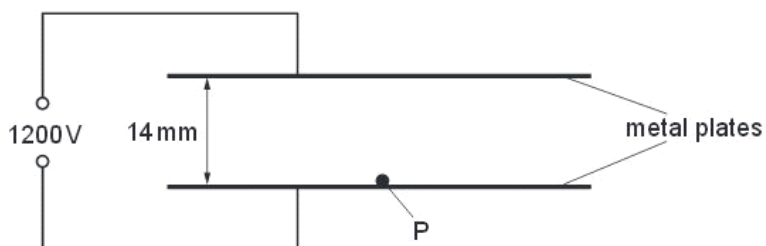


Fig. 4.1

The separation of the plates is 14 mm. 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]

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

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

(iv) the gain in kinetic energy of P,

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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.

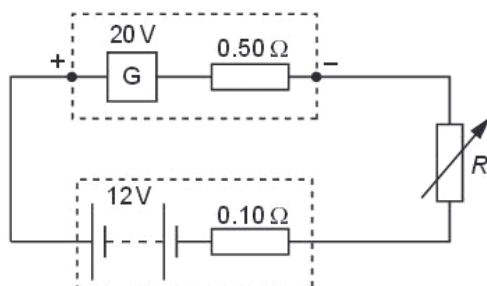


Fig. 5.1

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

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

$$R = \dots\dots\dots \Omega [2]$$

- (ii) Calculate the total power generated by G .

$$\text{power} = \dots\dots\dots \text{W} [2]$$

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

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Use

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.

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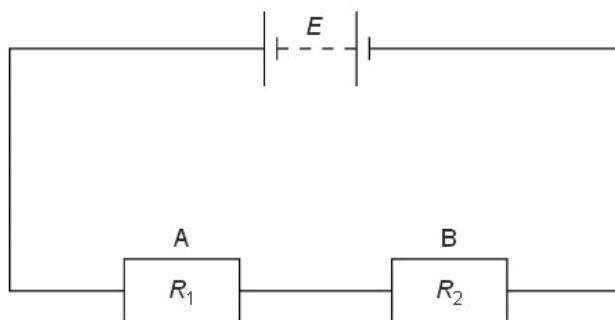


Fig. 6.1

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]

For
Exami-
Us

- (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.

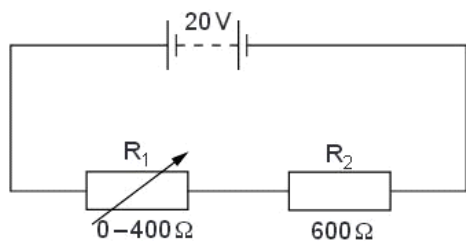


Fig. 6.1

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

For
Examine
Use

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.

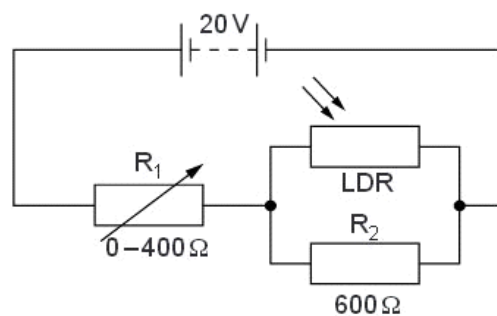


Fig. 6.2

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

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

total resistance = ... Ω [2]

- (ii) The resistance of R_1 is varied from 0 to 400Ω 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.

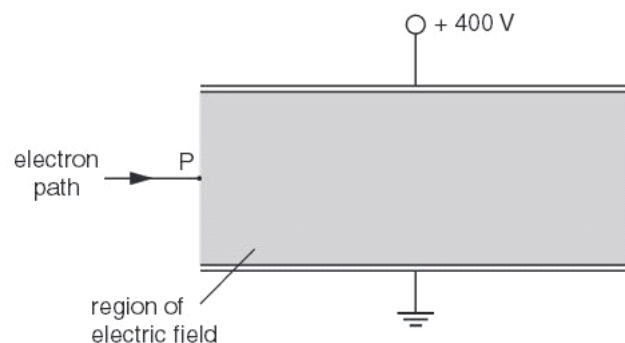


Fig. 6.1

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.

$$E = \dots\dots\dots \text{ V m}^{-1} \quad [2]$$

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

- (i) the force on the electron,

$$\text{force} = \dots\dots\dots \text{ N}$$

(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.

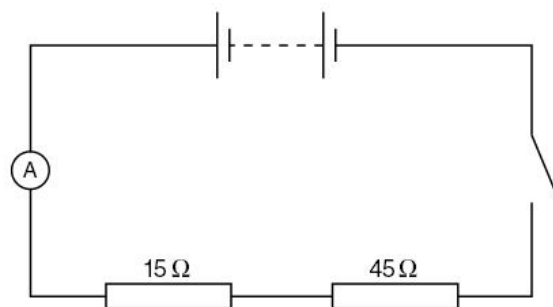


Fig. 7.1

The resistors are of resistance $15\ \Omega$ and $45\ \Omega$. The battery is found to provide $1.6 \times 10^5\ \text{J}$ of electrical energy when a charge of $1.8 \times 10^4\ \text{C}$ passes through the ammeter in a time of $1.3 \times 10^5\ \text{s}$.

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Use

(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, $1.1 \times 10^5 \text{ J}$ of energy is dissipated in the 45Ω resistor.

- (i) Determine the energy dissipated in the 15Ω 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.

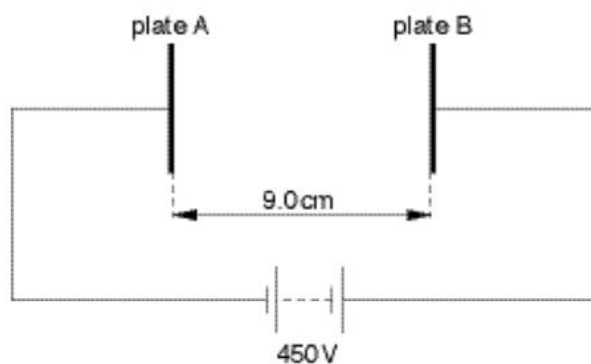


Fig. 5.1

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 $7.2 \times 10^{-17} \text{ J}$.

- (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]

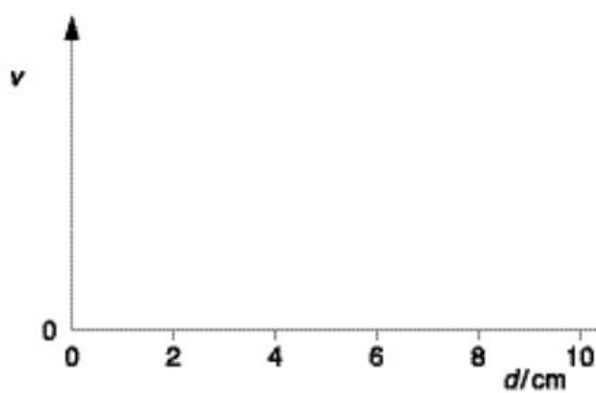


Fig. 5.2

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]

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

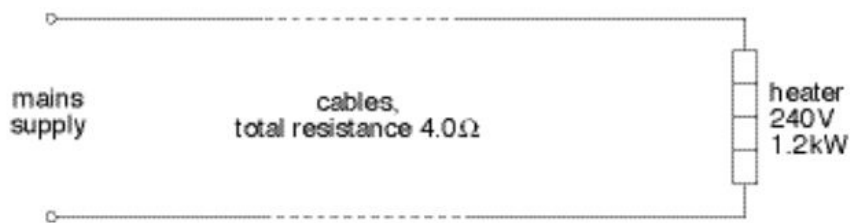


Fig. 7.1

The cables have a total resistance of $4.0\ \Omega$. 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

(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.

Ex 1

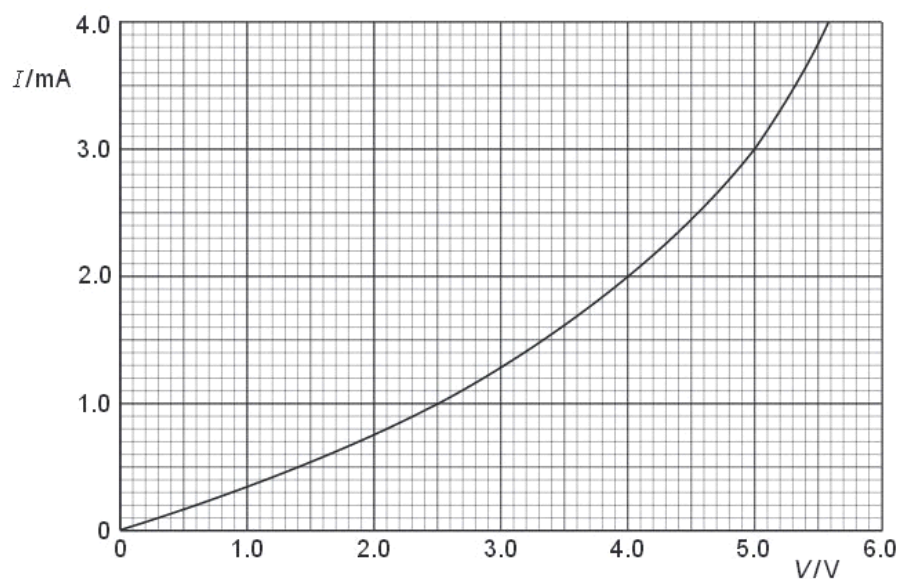


Fig. 6.1

- (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 $1500\ \Omega$ and a battery of e.m.f. E and negligible internal resistance, as shown in Fig. 6.2.

Exa

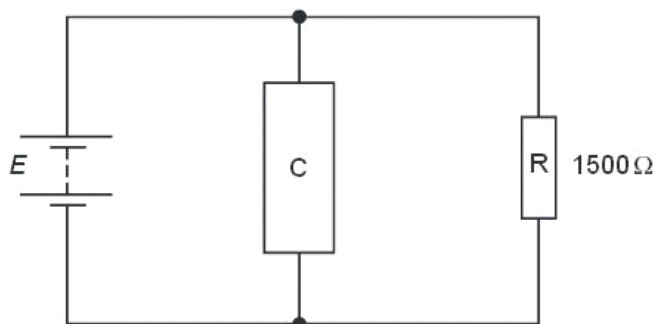


Fig. 6.2

- (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 $1500\ \Omega$ 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.

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

Exa

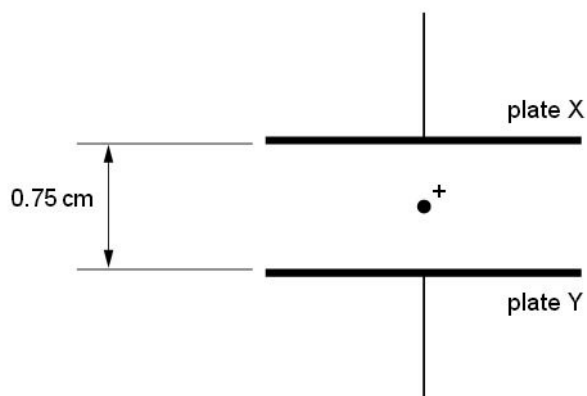


Fig. 6.1

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 $1200\ \Omega$ and a thermistor, as shown in Fig. 7.1.

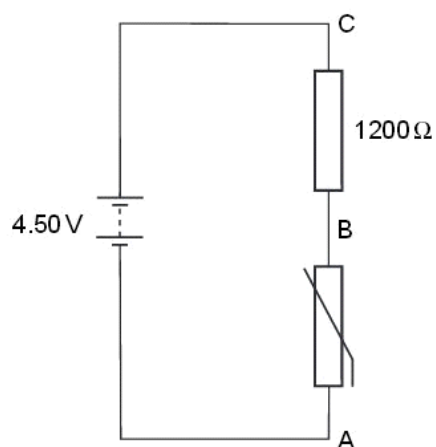


Fig. 7.1

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

[2]

- (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.

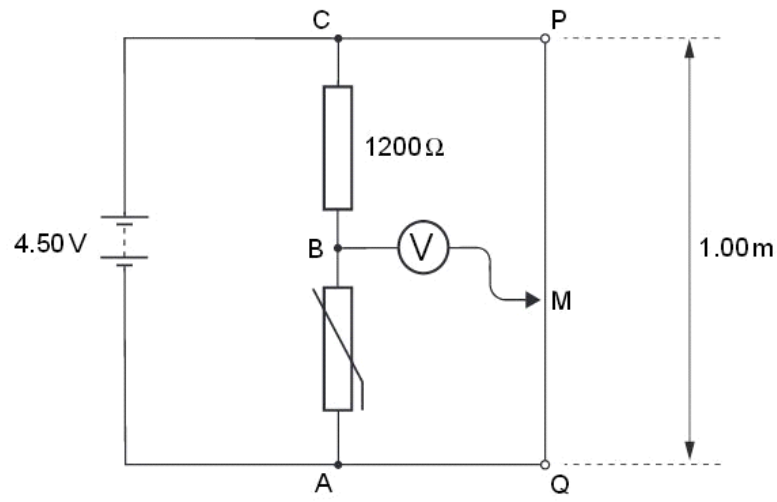


Fig. 7.2

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]

(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 .

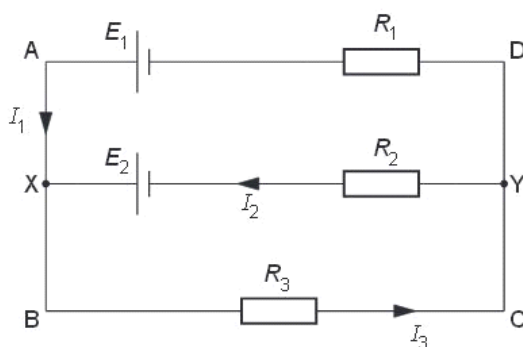


Fig. 7.1

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.

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

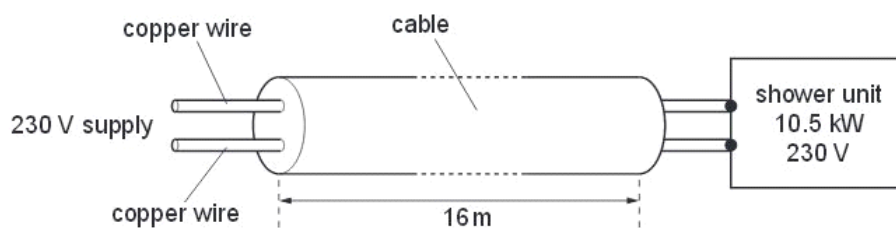


Fig. 6.1

- (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 225 V.
The wires in the cable are made of copper of resistivity $1.8 \times 10^{-8} \Omega \text{ m}$.
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 250 V between the plates, as illustrated in Fig. 4.1.

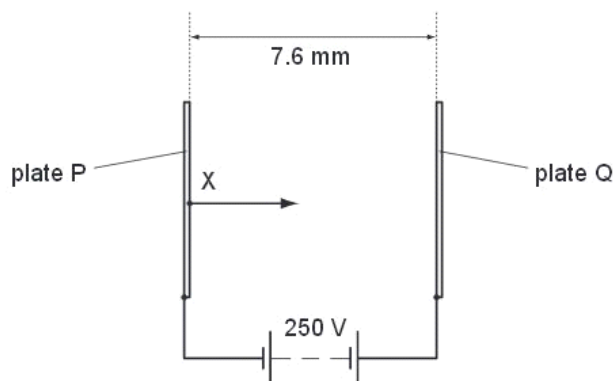


Fig. 4.1

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.

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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

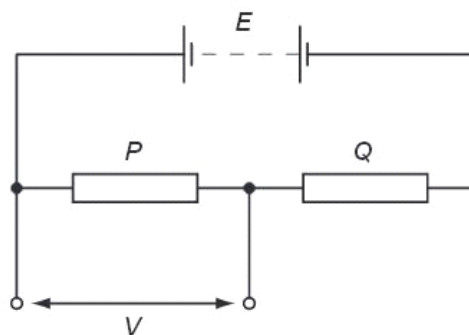


Fig. 7.1

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.

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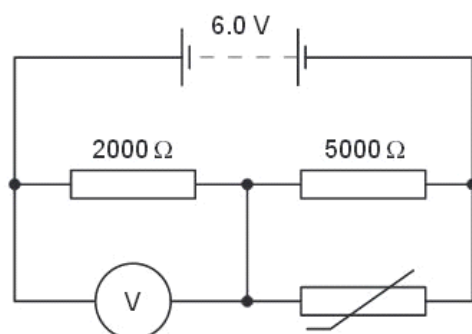


Fig. 7.2

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.

For
Examiner's
Use

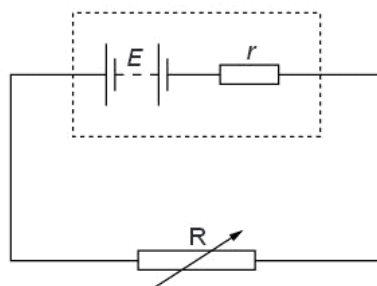


Fig. 6.1

- (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.

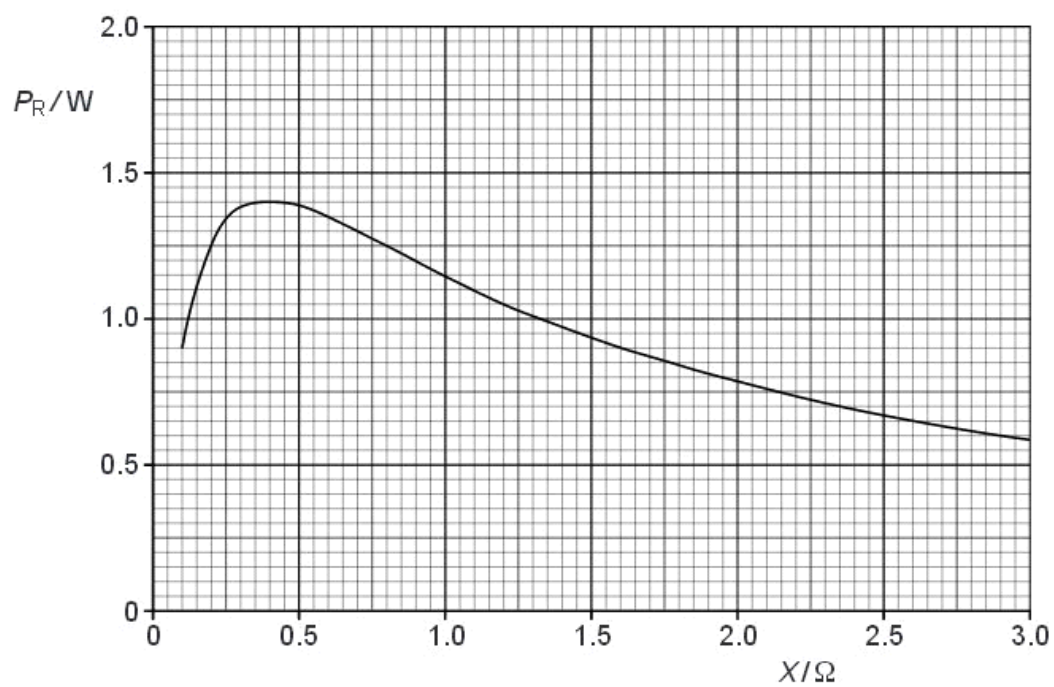


Fig. 6.2

- (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

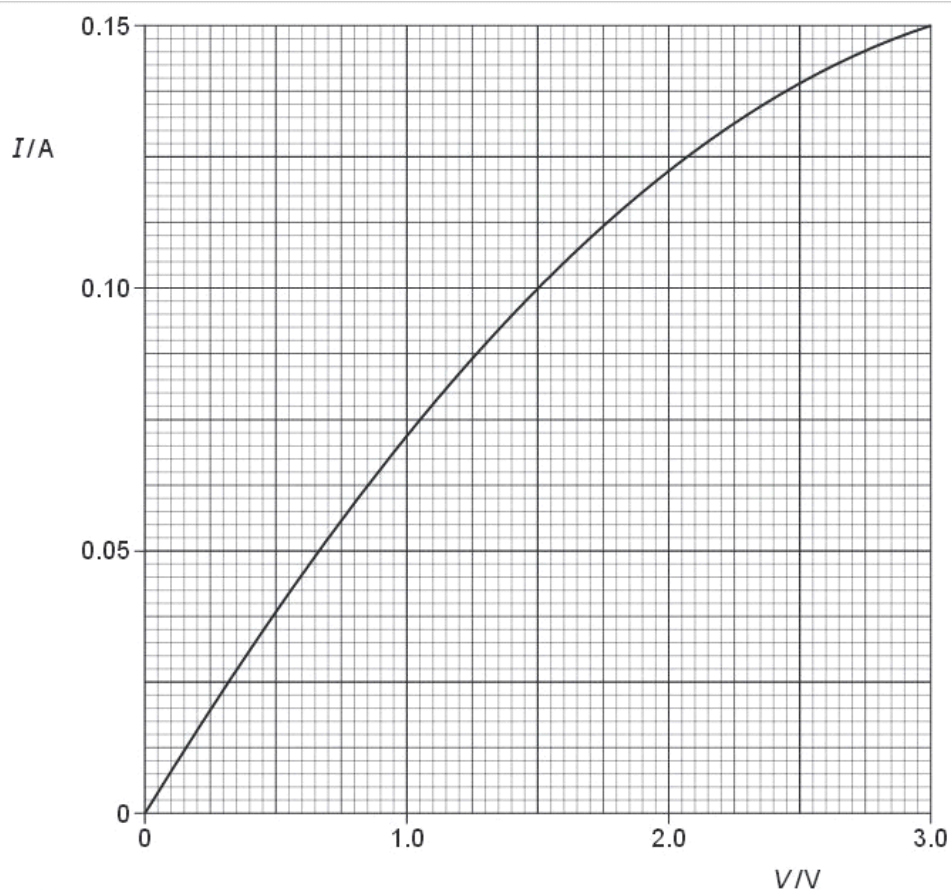
$$\frac{\text{combined resistance of resistors connected in series}}{\text{combined resistance of resistors connected in parallel}}$$

is equal to 4.

F
Ex am
U

[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:

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.

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

resistance = ... Ω [2]

Ex.

- (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.

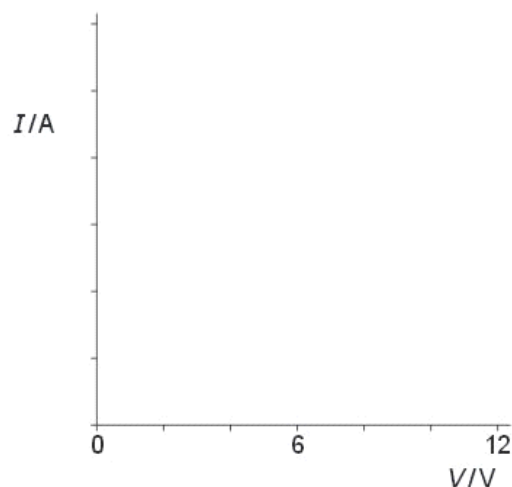


Fig. 6.1

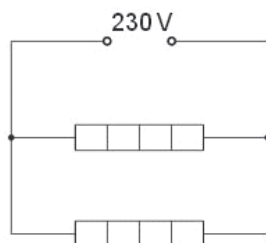
[3]

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

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

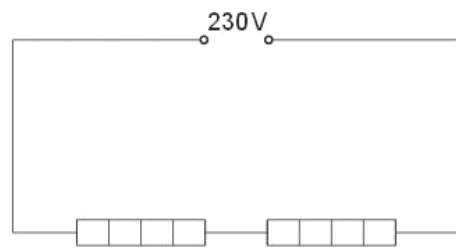
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- (i)



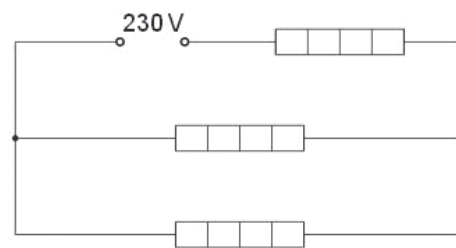
power = ... kW [1]

(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.

Ex 1

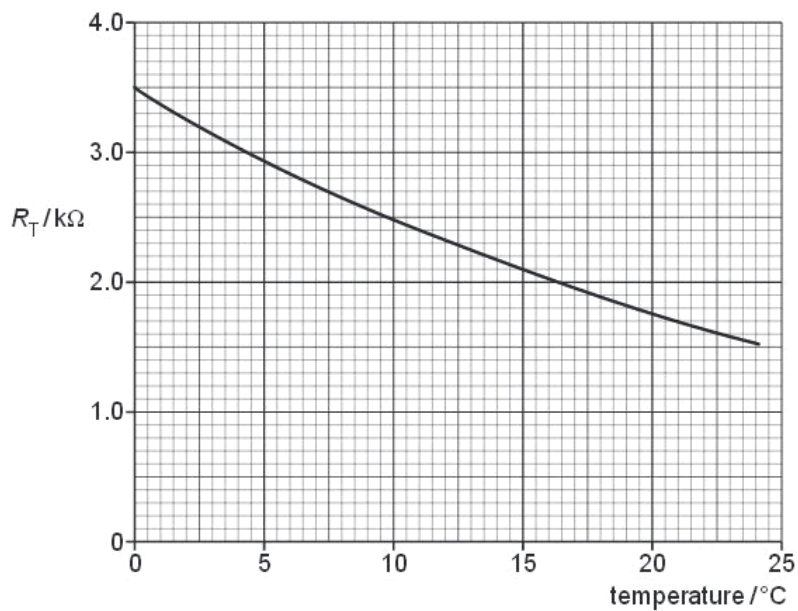


Fig. 6.1

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

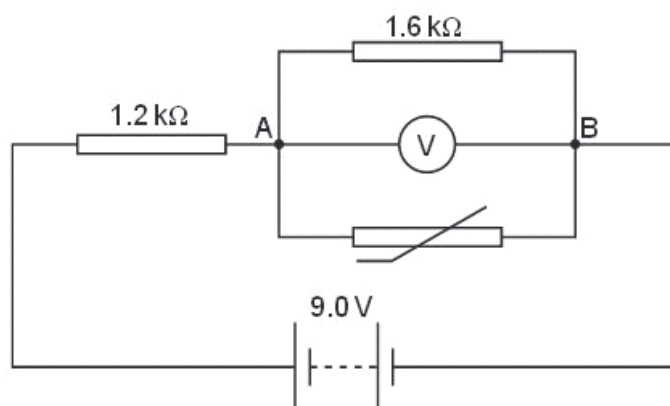


Fig. 6.2

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

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Use

(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 4.0V.
Determine

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

resistance = ... Ω [2]

(ii) the temperature of the thermistor.

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Use

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.

For
Examiner's
Use

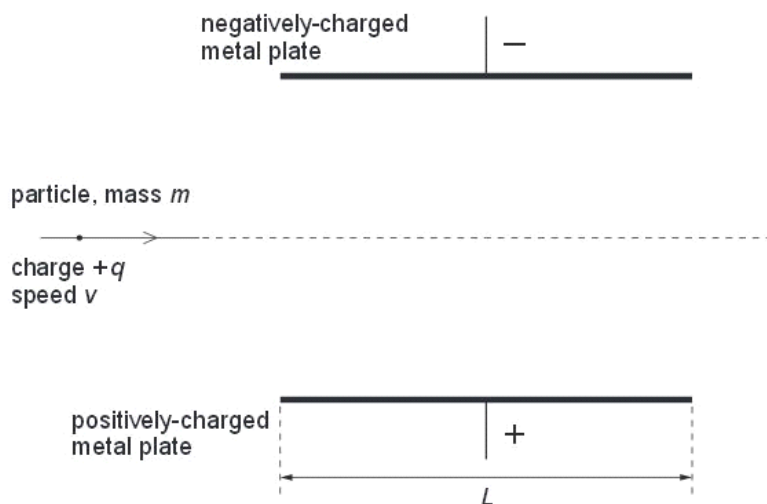


Fig. 7.1

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]

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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.

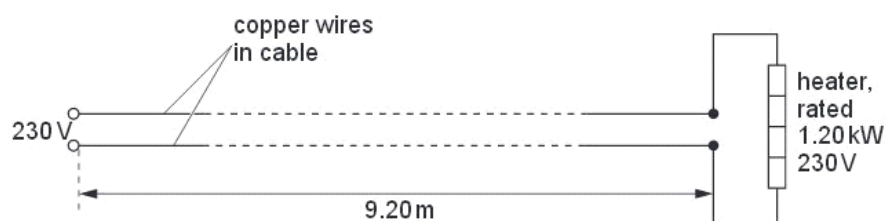


Fig. 8.1

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 $1.70 \times 10^{-8} \Omega \text{ m}$.

(a) Show that

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

[2]

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

[2]

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

Ex a

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]

Fc
Ex am
Us

- (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.

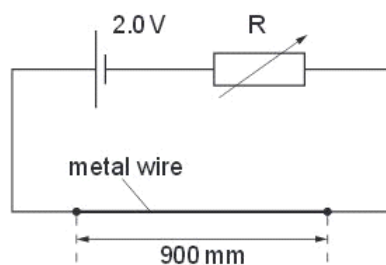


Fig. 5.1

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

- (i) Calculate the resistivity of the metal wire.

resistivity = ... [2]

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

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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.

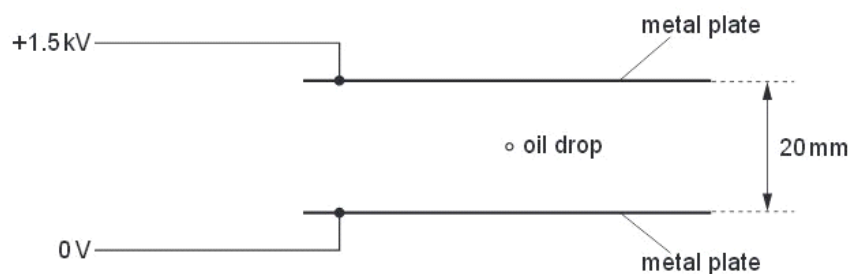


Fig. 4.1

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.

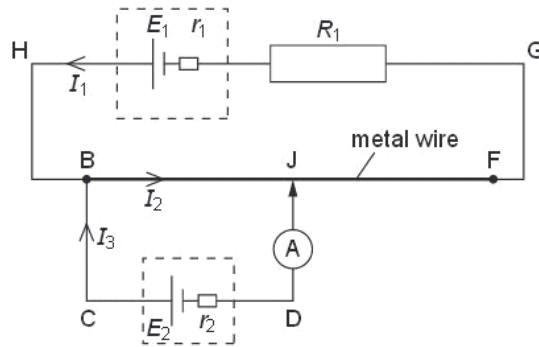


Fig. 5.1

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 5.5Ω , as shown in Fig. 4.1.

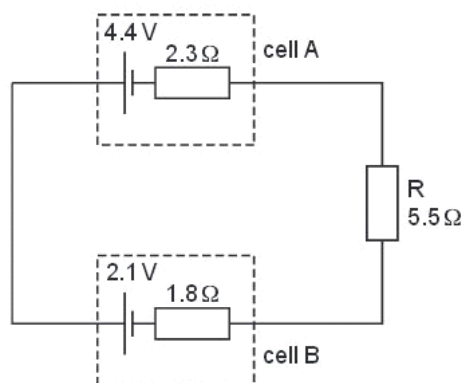


Fig. 4.1

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

- (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]

(iv) Calculate

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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.

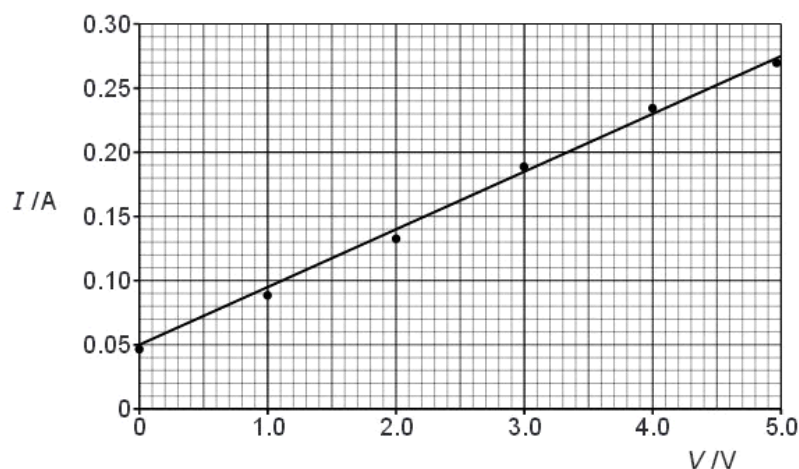


Fig. 2.1

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.

$R = \dots\dots\dots \Omega$ [3]

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

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

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

$R = \dots\dots\dots \pm \dots\dots\dots \Omega$ [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 1.00 m and resistance $10\ \Omega$. Two resistors of resistance $4.0\ \Omega$ and $2.0\ \Omega$ are connected in series across the wire.

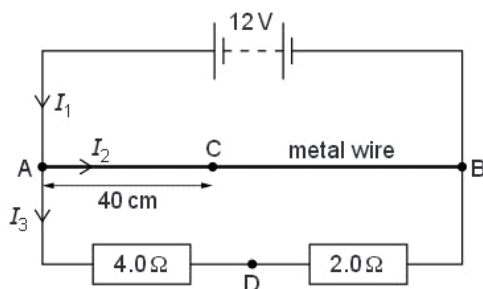


Fig. 5.1

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 .

$I_1 = \dots\dots\dots$ A [3]

- (iii) Calculate the ratio x , where

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

$x = \dots\dots\dots$ [3]

- (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 .

Ex

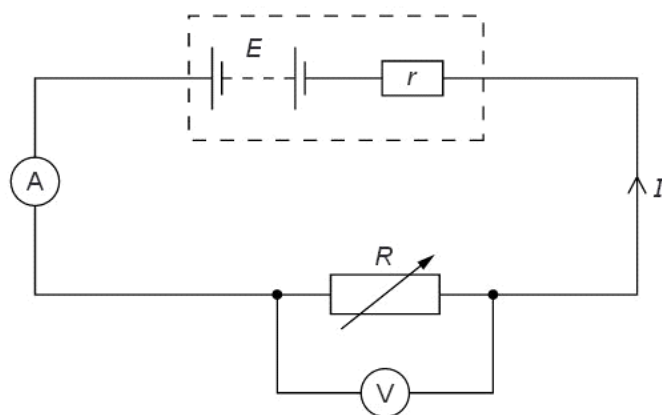


Fig. 4.1

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.

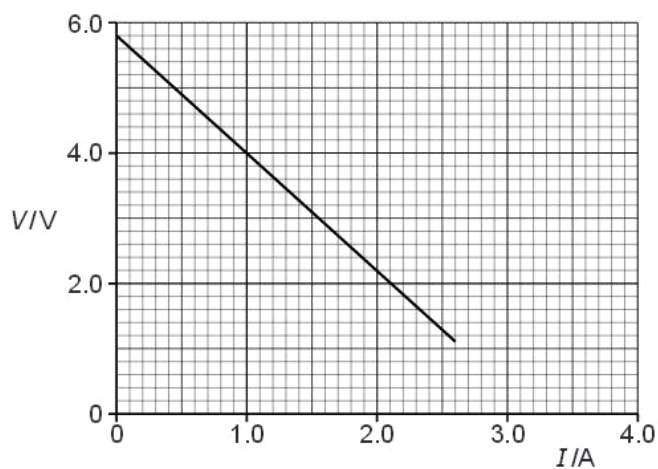


Fig. 4.2

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6

Use Fig. 4.2 to determine

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

$E = \dots\dots\dots$ V [1]

(ii) the internal resistance r .

$r = \dots\dots\dots$ Ω [2]

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

power = $\dots\dots\dots$ 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 = $\dots\dots\dots$ % [2]

Q52.

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

.....[1]

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



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 2.5 mm^2 and resistivity $18\text{ n}\Omega\text{ m}$. The heater has a constant resistance of 38Ω .

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

[3]

- (ii) Calculate the current in the wires.

current = ... A [3]

- (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.

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.....

 [2]

Q53.

- 6 A battery connected in series with a resistor R of resistance 5.0Ω is shown in Fig. 6.1.

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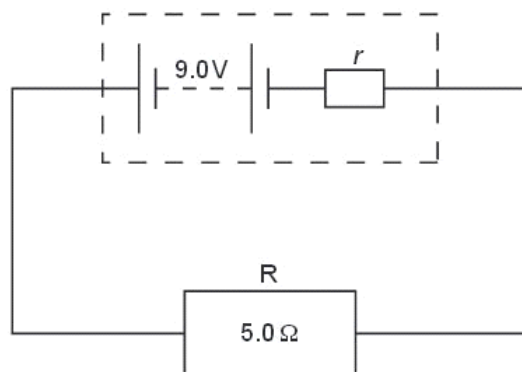


Fig. 6.1

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 9.0V and the internal resistance is r .
The potential difference (p.d.) across the battery terminals is 6.9V .

- (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]

0150 3343

0700 000000

(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.

Ex

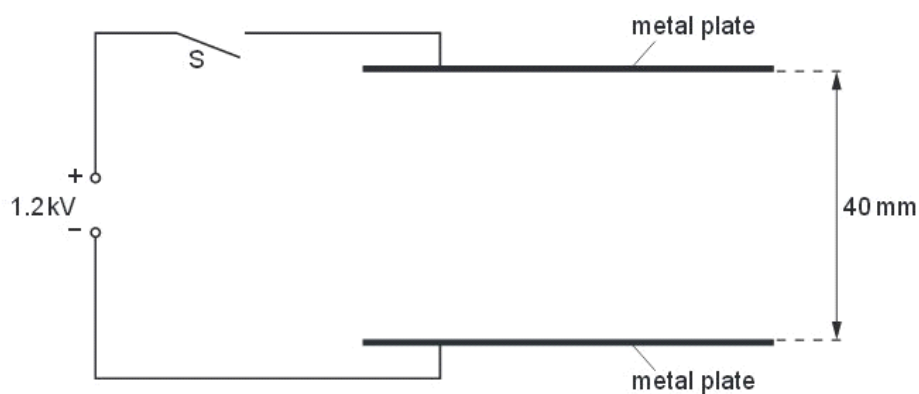


Fig. 7.1

The separation of the plates is 40 mm.

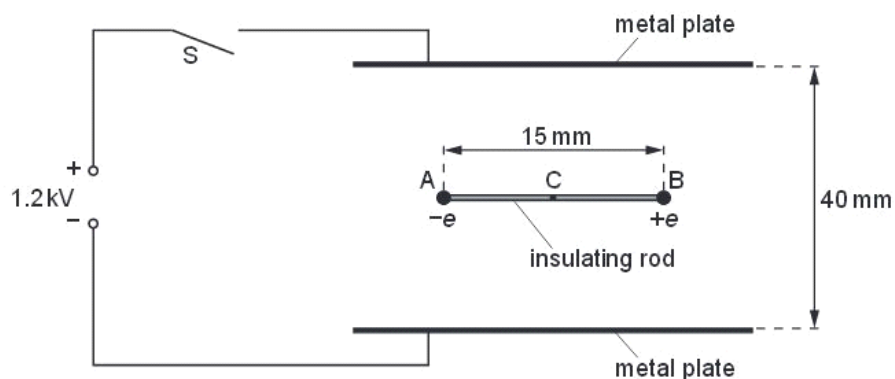
The switch S is then closed so that a potential difference of 1.2 kV is applied across the plates.

(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.

$$E = \dots\dots\dots \text{ V m}^{-1} \quad [2]$$

- (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.

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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 $4.8 \times 10^{-15} \text{ N}$.

[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]

Q1

5 (a)	(i)	resistance = V/I C1	
		= $6.0/(40 \times 10^{-3})$ A1	
		= 150Ω A1	
		(no marks for use of gradient)	
	(ii)	at 8.0 V, resistance = $8.0/(50 \times 10^{-3}) = 160 \Omega$ C1	
		change = 10Ω A1	[4]
(b)	(i)	straight line through origin M1	
		passes through $I = 40 \text{ mA}$, $V = 8.0 \text{ V}$ A1	
	(ii)	current in both must be 40 mA C1	
		e.m.f. = $8.0 + 6.0 = 14.0 \text{ V}$ A1	[4]

Q2.

7 (a)	(i)	$P = VI$ current = $60/240 = 0.25 \text{ A}$	C1 A1	
	(ii)	$R (= V/I) = 240/0.25$ $= 960 \Omega$	M1 A0	[3]
(b)		$R = \rho L/A$ (wrong formula, 0/3)	C1	
		$960 = (7.9 \times 10^{-7} \times L)/(\pi \times \{6.0 \times 10^{-6}\}^2)$	C1	
		$L = 0.137 \text{ m}$	A1	[3]
		(use of $A = 2\pi r$, then allow 1/3 marks only for resistivity formula)		
(c)		e.g. the filament must be coiled/it is long for a lamp	B1	[1]
		(allow any sensible comment based on candidate's answer for L)		
Total				[7]

Q3.

8 (a)	$V/E = R/R_{\text{tot}}$	or	$0.5 = I \times 3900$	C1	
	$1.0/1.5 = R/(R + 3900)$	or	$1.0 = 0.5R/3900$	M1	
	$R = 7800\Omega$.	or	$R = 7800\Omega$	A0	[2]
(b)	$V = 1.5 \times (7800/(7800 + 1250))$	or	$I = 1.5/(7800 + 1250)$	C1	
	$= 1.29 \text{ V}.$	or	$V = IR = 1.29 \text{ V}$	A1	[2]
(c)	Combined resistance of R and voltmeter is 3900 Ω			C1	
	reading at 0 °C is 0.75 V			A1	[2]
				Total	[6]

Q4.

6	(a) (i) lines normal to plate and equal spacing (at least 4 lines) direction from (+) to earthed plate	B1 B1	[2]
	(ii) $E = 160/0.08$ $= 2.0 \times 10^3 \text{ V m}^{-1}$	M1 A0	[1]
	(b) (i) correct directions with line of action of arrows passing through charges	B1	[1]
	(ii) force $= Eq$ $= 2.0 \times 10^3 \times 1.2 \times 10^{-15}$ $= 2.4 \times 10^{-12} \text{ N}$	C1 A1	[2]
	(iii) couple = force $\times$ perpendicular separation $= 2.4 \times 10^{-12} \times 2.5 \times 10^{-3} \times \sin 35^\circ$ $= 3.4(4) \times 10^{-15} \text{ N m}$	M1 A1	[2]
	(iv) <u>either</u> rotates to align with the field or oscillates (about a position) with the positive charge nearer to the earthed plate/clockwise	M1 A1	[2]
Q5.			
7	(a) potential difference/current	B1	[1]
	(b) (i) 1) 1.13 W 2) 1.50 V	B1	[1]
	(ii) power $= V^2 / R$ or power $= VI$ and $V = IR$ $R = 1.50^2 / 1.13$ $= 1.99 \Omega$	C1 A1	[2]
	(iii) <u>either</u> $E = IR + Ir$ or voltage divided between R and r $I = 1.5 / 2.0 (=0.75 \text{ A})$ p.d. across $R =$ p.d. across $r = 1.5$ $3.0 = 1.5 + 0.75r$ $r = 2.0 \Omega$ so $R = r = 1.99 \Omega$	C1 C1 A1	[3]
	(c) larger p.d. across R means smaller p.d. across r smaller power dissipation at larger value of V since power is VI and I is same for R and r	M1 A1 A1	[3]

Q6.

7	(a) lamp C lamp is shorted	M1 A1	[2]
	(b) shorted lamp A would cause damage to the supply/lamps /blow fuse in supply	B1	[1]
	(c) 15 Ω	B1	[1]
	(d) (i) $V = IR$ $R = 30 \Omega$	C1 A1	[2]
	(ii) $P = VI$ or I^2R or V^2/R $P = 1.2 \text{ W}$	C1 A1	[2]
	(e) filament is cold when measuring with ohm-meter in (b) resistance of filament rises as temperature rises	B1 B1	[2]

Q7.

2	(a) force per unit positive charge (on a small test charge)	B1	[1]
	(b) field strength = $(210 / \{1.5 \times 10^{-2}\}) = 1.4 \times 10^4 \text{ N C}^{-1}$	A1	[1]
	(c) (i) acceleration = Eq / m $= (1.4 \times 10^4 \times 1.6 \times 10^{-19}) / (9.1 \times 10^{-31})$ $= 2.5 \times 10^{15} \text{ m s}^{-2}$ (2.46 $\times 10^{15}$) towards positive plate / upwards (and normal to plate)	C1 C1 A1 B1	[4]
	(ii) time = $2.4 \times 10^{-9} \text{ s}$	A1	[1]
	(d) either vertical displacement after acceleration for $2.4 \times 10^{-9} \text{ s}$ $= \frac{1}{2} \times 2.46 \times 10^{15} \times (2.4 \times 10^{-9})^2$ $= 7.1 \times 10^{-3} \text{ m}$ (0.71 cm < 0.75 cm and) so will pass between plates i.e. valid conclusion based on a numerical value or $0.75 \times 10^{-2} = \frac{1}{2} \times 2.46 \times 10^{15} \times t^2$ t is time to travel 'half-way across' plates = $2.47 \times 10^{-9} \text{ s}$ (2.4 ns < 2.47 ns) so will pass between plates i.e. valid conclusion based on a numerical value	C1 A1 A1	[3]

Q8.

6	(a) (i) 1	total resistance = 0.16Ω	A1	
	2	e.m.f. = <i>either</i> $(14 - E)$ <i>or</i> $(E - 14)$	A1	[2]
	(ii)	<i>either</i> $14 - E = 42 \times 0.16$ <i>or</i> $(E - 14) = -42 \times 0.16$ $E = 7.3 \text{ V}$	C1 A1	[2]
	(b) (i)	charge = It $= 12.5 \times 4 \times 60 \times 60$ $= 1.8 \times 10^5 \text{ C}$	C1 A1	[2]
	(ii)	<i>either</i> energy = EQ <i>or</i> energy = Et <i>either</i> energy = $14 \times 1.8 \times 10^5$ <i>or</i> energy = $14 \times 12.5 \times 4 \times 3600$ $= 2.52 \times 10^6 \text{ J}$	C1 A1	[2]
	(iii)	energy = I^2Rt <i>or</i> Vit <i>and</i> $V = IR$ $= 12.5^2 \times 0.16 \times 4 \times 3600$ $= 3.6 \times 10^5 \text{ J}$	C1 A1	[2]
	(c)	efficiency = $(2.52 \times 10^6 - 3.6 \times 10^5) / (2.52 \times 10^6)$ $= 86\%$	C1 A1	[2]

Q9.

6	(a)	<i>either</i> $P = VI$ <i>and</i> $V = IR$ <i>or</i> $P = V^2 / R$ resistance = 38.4Ω	C1 A1	[2]
	(b)	zero 1.5 kW 3.0 kW 0.75 kW 2.25 kW	B1 B1 B1 B1 B1	[5]

Q10.

- 6 (a) (i) $E = V/d$ C1
 $= 350 / (2.5 \times 10^{-2})$
 $= 1.4 \times 10^4 \text{ N C}^{-1}$ A1 [2]
- (ii) force = Eq C1
 $= 1.4 \times 10^4 \times 1.6 \times 10^{-19}$ M1
 $= 2.24 \times 10^{-15}$ A0 [2]
- (b) (i) $F = ma$ C1
 $a = (2.24 \times 10^{-15}) / (9.1 \times 10^{-31})$
 $= 2.46 \times 10^{15} \text{ m s}^{-2}$... (allow 2.5×10^5) A1 [2]
- (ii) $s = \frac{1}{2}at^2$ C1
 $2.5 \times 10^{-2} = \frac{1}{2} \times 2.46 \times 10^{15} \times t^2$
 $t = 4.5 \times 10^{-9} \text{ s}$ A1 [2]
- (c) *either* gravitational force is normal to electric force
or electric force horizontal, gravitational force vertical B2 [2]
special case: force/acceleration due to electric field $\gg$ force/acceleration
due to gravitational field, allow 1 mark

Q11.

- 7 (a) (i) R B1 [1]
(ii) $0.5R$ B1 [1]
(iii) $2.5R$... (allow e.c.f. from (ii)) B1 [1]
- (b) (i) $I_1 + I_2 = I_3$ B1 [1]
(ii) $E_2 = I_3R + I_2R$ B1 [1]
(iii) $E_1 - E_2 = 2I_1R - I_2R$ B1 [1]

Q12.

- 7 (a) ∞ A1
 $2R$ A1
 R A1 [3]
- (b) (i) $I_1 + I_3 = I_2 + I_4$ A1 [1]
(ii) $E_2 - E_1 = I_3R$ A1 [1]
(iii) $E_2 = I_3R + 2I_4R$ A1 [1]

Q13.

- 5 (a) region/area where a charge experiences a force B1 [1]
- (b) (i) left-hand sphere (+), right-hand sphere (–) B1 [1]
- (ii) 1 correct region labelled C within 10 mm of central part of plate
otherwise within 5 mm of plate B1 [1]
- 2 correct region labelled D area of field not included for (b)(ii)1 B1 [1]
- (c) (i) arrows through P and N in correct directions B1 [1]
- (ii) torque = force $\times$ perpendicular distance (between forces) C1
 $= 1.6 \times 10^{-19} \times 5.0 \times 10^4 \times 2.8 \times 10^{-10} \times \sin 30$
 $= 1.1 \times 10^{-24} \text{ N m}$ A1 [2]

Q14.

- 6 (a) (i) $P = VI$ C1
 $60 = 12 \times I$
 $I = 5.0 \text{ A}$ A1 [2]
- (ii) either $V = IR$ or $P = I^2 R$ or $P = V^2 / R$ C1
either $12 = 5 \times R$ or $60 = 5^2 \times R$ or $60 = 12^2 / R$ M1
 $R = 2.4 \Omega$ A0 [2]
- (b) $R = \rho L / A$ C1
 $A = \pi \times (0.4 \times 10^{-3})^2 (= 5.03 \times 10^{-7})$ C1
 $L = (2.4 \times 5.03 \times 10^{-7}) / (1.0 \times 10^{-6})$
 $= 1.2 \text{ m}$ A1 [3]
- (c) resistance is halved M1
either current is doubled or power $\propto 1/R$ M1
power is doubled A1 [3]

Q15.

6	(a)	either $P \propto V^2$ or $P = V^2/R$	C1	
		reduction = $(230^2 - 220^2)/230^2$ = 8.5 %	A1	[2]
(b)	(i)	zero	A1	[1]
	(ii)	0.3(0)A	A1	[1]
(c)	(i)	correct plots to within ± 1 mm	B1	[1]
		reasonable line/curve through points giving current as 0.12 A allow ± 0.005 A)	B1	[1]
	(iii)	$V = IR$	C1	
		$V = 0.12 \times 5.0$ = 0.6(0)V	A1	[2]
(d)		circuit acts as a potential divider/current divides/current in AC not the same as current in BC	B1	
		resistance between A and C not equal to resistance between C and B	B1	
		or current in wire AC $\times R$ is not equal to current in wire BC $\times R$	B1	
		any 2 statements		[2]

Q16.

6	(a)	(i) movement/flow of charged particles	B1	[1]
		(ii) work done per unit charge (transferred)	B1	[1]
(b)		straight line through origin	B1	
		resistance = V/I , with values for V and I shown = 20Ω (using the gradient loses the last mark)	M1 A0	[2]
(c)	(i)	0.5A	A1	[1]
	(ii)	either resistance of each resistor is 20Ω or total current = 0.8 A either combined resistance = 10Ω or $R = E/I = 10 \Omega$	C1 A1	[2]
(d)	(i)	10V	A1	[1]
	(ii)	power = EI = $10 \times 0.2 = 2.0$ W	C1 A1	[2]

Q17.

- 5 (a) (i) $I = 12 / (6 + 12)$
minimum current = 0.67 A C1
A1 [2]
- (ii) correct start and finish points M1
correct shape for curve with decreasing gradient A1 [2]
- (b) maximum current = 2.0 A A1
minimum current = 0 A1 [2]
- (c) (i) smooth curve starting at (0,0) with decreasing gradient M1
end section not horizontal A1 [2]
- (ii) full range of current / p.d. possible
or currents / p.d. down to zero
or brightness ranging from off to full brightness B1 [1]

Q18.

- 5 (a) (i) energy converted from chemical to electrical when charge flows through cell
or round complete circuit B1
- (ii) (resistance of the cell) causing loss of voltage or energy loss in cell B1 [2]
- (b) (i) $E_B - E_A = I(R + r_B + r_A)$
 $12 - 3 = I(3.3 + 0.1 + 0.2)$
 $I = 2.5 \text{ A}$ C1
A1 [2]
- (ii) Power = $E \times I$
 $= 12 \times 2.5$
 $= 30 \text{ W}$ C1
A1 [2]
- (iii) $P = I^2 \times R$ or $P = V^2 / R$ or $P = VI$
 $= (2.5)^2 \times 3$ $= 9^2 / 3.6$ $= 9 \times 2.5$
 $= 22.5 \text{ J s}^{-1}$ C1
A1 [2]
- (c) power supplied from cell B is greater than energy lost per second in circuit B1 [1]

Q19.

- 5 (a) (i) Start from (0,0) and smooth curve in correct direction B1
Curve correct for end section never horizontal B1 [2]
- (ii) $R = V / I$ hence take co-ords of V and I from graph and calculate V / I B1 [1]
- (b) (i) each lamp in parallel has a greater p.d. / greater current M1
lamp hotter M1
resistance of lamps in parallel greater A1 [3]
- (ii) $P = V^2 / R$ or $P = VI$ and $V = IR$
 $R = 144 / 50 = 2.88$ for each lamp C1
total $R = 1.44 \Omega$ C1
A1 [3]

Q20.

- 4 (a) (i) $R = V^2 / P$ or $P = IV$ and $V = IR$
 $= (220)^2 / 2500$
 $= 19.4 \Omega$ (allow 2 s.f.) C1
A1 [2]
- (ii) $R = \rho l / A$ C1
 $l = [19.4 \times 2.0 \times 10^{-7}] / 1.1 \times 10^{-6}$ C1
 $= 3.53 \text{ m}$ (allow 2 s.f.) A1 [3]
- (b) (i) $P = 625, 620$ or 630 W A1 [1]
- (ii) R needs to be reduced C1
Either length $\frac{1}{4}$ of original length
or area $4\times$ greater
or diameter $2\times$ greater A1 [2]

Q21.

- 5 (a) (i) sum of e.m.f.'s = sum of p.d.'s around a loop/circuit B1 [1]
- (ii) energy B1 [1]
- (b) (i) $2.0 = I \times (4.0 + 2.5 + 0.5)$ C1
 $I = 0.286 \text{ A}$ (allow 2 s.f.) A1 [2]
(If total resistance is not 7Ω , 0/2 marks)
- (ii) $R = [0.90 / 1.0] \times 4 (= 3.6)$ C1
 $V = I R = 0.286 \times 3.6 = 1.03 \text{ V}$ A1 [2]
(If factor of 0.9 not used, then 0/2 marks)
- (iii) $E = 1.03 \text{ V}$ A1 [1]
- (iv) *either* no current through cell B
or p.d. across r is zero B1 [1]

Q22.

- 4 (a) total resistance = $20 \text{ (k}\Omega\text{)}$ C1
current = $12 / 20 \text{ (mA)}$ or potential divider formula C1
p.d. = $[12 / 20] \times 12 = 7.2 \text{ V}$ A1 [3]
- (b) parallel resistance = $3 \text{ (k}\Omega\text{)}$ C1
total resistance $8 + 3 = 11 \text{ (k}\Omega\text{)}$ C1
current = $12 / 11 \times 10^3 = 1.09 \times 10^{-3}$ or $1.1 \times 10^{-3} \text{ A}$ A1 [3]
- (c) (i) LDR resistance decreases M1
total resistance (of circuit) is less hence current increases A1 [2]
- (ii) resistance across XY is less M1
less proportion of 12 V across XY hence p.d. is less A1 [2]

Q23.

- 4 (a) electric field strength is the force per unit positive charge (acting on a stationary charge) B1 [1]
- (b) (i) $E = V / d$ C1
 $= 1200 / 14 \times 10^{-3}$
 $= 8.57 \times 10^4 \text{ V m}^{-1}$ A1 [2]
- (ii) $W = QV$ or $W = F \times d$ and therefore $W = E \times Q \times d$ C1
 $= 3.2 \times 10^{-19} \times 1200$
 $= 3.84 \times 10^{-16} \text{ J}$ A1 [2]
- (iii) $\Delta U = mgh$ C1
 $= 6.6 \times 10^{-27} \times 9.8 \times 14 \times 10^{-3}$
 $= 9.06 \times 10^{-28} \text{ J}$ A1 [2]
- (iv) $\Delta K = 3.84 \times 10^{-16} - \Delta U$
 $= 3.84 \times 10^{-16} \text{ J}$ A1 [1]
- (v) $K = \frac{1}{2}mv^2$ C1
 $v = [(2 \times 3.8 \times 10^{-16}) / 6.6 \times 10^{-27}]^{1/2}$
 $= 3.4 \times 10^5 \text{ ms}^{-1}$ A1 [2]

Q24.

- 5 (a) (i) sum of currents into a junction = sum of currents out of junction B1 [1]
- (ii) charge B1 [1]
- (b) (i) $\Sigma E = \Sigma IR$ C1
 $20 - 12 = 2.0(0.6 + R)$ (not used 3 resistors 0/2)
 $R = 3.4 \Omega$ A1 [2]
- (ii) $P = EI$ C1
 $= 20 \times 2$
 $= 40 \text{ W}$ A1 [2]
- (iii) $P = I^2 R$ C1
 $P = (2)^2 \times (0.1 + 0.5 + 3.4)$
 $= 16 \text{ W}$ A1 [2]
- (iv) efficiency = useful power / output power C1
 $24 / 40 = 0.6$ or $12 \times 2 / 20 \times 2$ or 60% A1 [2]

Q25.

- 6 (a) (i) chemical to electrical B1 [1]
(ii) electrical to thermal / heat or heat and light B1 [1]
- (b) (i) $(P_B =) EI$ or $I^2(R_1 + R_2)$ A1 [1]
(ii) $(P_R =) I^2 R_1$ A1 [1]
- (c) $R = \rho l / A$ or clear from the following equation B1
ratio = $I^2 R_1 / I^2 R_2 = \frac{\rho l / \pi d^2}{\rho(2l) / \pi(2d)^2}$ or R_1 has 8× resistance of R_2 C1
= 8 or 8:1 A1 [3]
- (d) $P = V^2 / R$ or E^2 / R C1
(V or E the same) hence ratio is 1/8 or 1:8 = 0.125 (allow ecf from (c)) A1 [2]

Q26.

- 6 (a) charge = current × time B1 [1]
- (b) (i) $P = V^2 / R$ C1
 $= (240)^2 / 18 = 3200 \text{ W}$ A1 [2]
- (ii) $I = V / R = 240 / 18 = 13.3 \text{ A}$ A1 [1]
- (iii) charge = $It = 13.3 \times 2.6 \times 10^6$ C1
 $= 3.47 \times 10^7 \text{ C}$ A1 [2]
- (iv) number of electrons = $3.47 \times 10^7 / 1.6 \times 10^{-19} (= 2.17 \times 10^{26})$ C1
number of electrons per second = $2.17 \times 10^{26} / 2.6 \times 10^6 = 8.35 \times 10^{19}$ A1 [2]

Q27.

- 6 (a) p.d. = $\frac{\text{work done} / \text{energy transformed}}{\text{charge}}$ (from electrical to other forms) B1 [1]
- (b) (i) maximum 20 V A1 [1]
(ii) minimum = $(600 / 1000) \times 20$ C1
= 12 V A1 [2]
- (c) (i) use of 1.2 kΩ M1
 $1/1200 + 1/600 = 1/R, R = 400 \Omega$ A1 [2]
- (ii) total parallel resistance ($R_2 + \text{LDR}$) is less than R_2 M1
(minimum) p.d. is reduced A1 [2]

Q28.

- 6 (a) (i) arrow in upward direction, foot near P B1
- (ii) curved path consistent with (i) between plates B1
then straight (with no kink at change-over) B1 [3]
- (b) $E = V/d$ C1
 $= 400 / (0.8 \times 10^{-2})$
 $= 5.0 \times 10^4 \text{ V m}^{-1}$ (allow 1 sig fig) A1 [2]
- (c) (i) $F = Eq$ C1
 $= 5.0 \times 10^4 \times 1.6 \times 10^{-19}$
 $= 8.0 \times 10^{-15} \text{ N}$ (allow 1 sig fig and e.c.f.) A1
- (ii) $a = F/m$ C1
 $= (8.0 \times 10^{-15}) / (9.1 \times 10^{-31})$
 $= 8.8 \times 10^{15} \text{ m s}^{-2}$ (allow 1 sig fig and e.c.f.) A1 [4]
- (d) because F_E is normal to horizontal motion M1
no effect A1 [2]

Q29.

- 7 (a) (i) e.m.f. = energy / charge C1
 $= (1.6 \times 10^5) / (1.8 \times 10^4)$
 $= 8.9 \text{ V}$ A1
- (ii) current = $\Delta Q / \Delta t$ C1
 $= (1.80 \times 10^4) / (1.3 \times 10^5)$
 $= 0.14 \text{ A}$ A1 [4]
- (b) (i) energy $\propto R$ (or formula) C1
energy = $(15 / 45) \times 1.14 \times 10^5$ C1
 $= 3.7 \times 10^4 \text{ J}$ A1
- (ii) energy dissipated in internal resistance (of battery) B1 [4]
OR in extra resistance in circuit

Q30.

- 5 (a) (i) arrow from B towards A..... B1
- (ii) $E = V/d$ C1
 $= 450/(9.0 \times 10^{-2})$ C1
 $= 5.0 \times 10^3 \text{ N C}^{-1}$ (accept 1 sig. fig) A1 [3]
- (b) (i) energy = qV or Eqd C1
 $= 1.6 \times 10^{-19} \times 450$ A1
 $= 7.2 \times 10^{-17} \text{ J}$ A0
- (ii) $E_k = \frac{1}{2}mv^2$ C1
 $7.2 \times 10^{-17} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$ C1
 $v = 1.26 \times 10^7 \text{ m s}^{-1}$ A1 [4]
- (c) line from origin, curved in correct direction but not 'level out' B1 [1]

Q31.

- 7 (a) (i) $P = Vi$ C1
 $1200 = 240 \times i$ M1
 $i = 5.0 \text{ A}$ A0
- (ii) $V = iR$ C1
 $240 = 5.0 \times R$ C1
 $R = 48\Omega$ A1 [4]
- (b) (i) p.d. = $(5.0 \times 4.0) = 20 \text{ V}$ A1
- (ii) mains voltage = $(240 + 20) = 260 \text{ V}$ A1
- (iii) $P = (20 \times 5.0) = 100 \text{ W}$ A1 [3]
- (c) power input = $1200 + 100 = 1300 \text{ W}$ C1
efficiency = $1200/1300 = 0.92$ A1 [2]

Q32.

- 6 (a) (i) resistance is ratio V/I (at a point) B1
either gradient increases or I increases more rapidly than V B1 [2]
(If states $R = \text{reciprocal of gradient}$, then 0/2 marks here)
- (ii) current = 2.00 mA C1
 resistance = 2 000 Ω A1 [2]
- (b) (i) straight line from origin M1
 passing through (6.0 V, 4.0 mA) (allow $\frac{1}{2}$ square tolerance) A1 [2]
- (ii) individual currents are 0.75 mA and 1/33 mA C1
 current in battery = 2.1 mA A1 [2]
(allow argument in terms of $P = I^2 R$ or IV)
- (c) same current in R and in C M1
 p.d. across C is larger than that across R M1
 so since power = VI , greater in C A1 [3]
(allow argument in terms of $P = I^2 R$ or IV)

Q33.

- 6 (a) force must be upwards (on positive charge)
 so plate Y is positive M1
A1 [2]
- (b) (i) $E = V / d$ C1
 $= 630 / (0.75 \times 10^{-2})$
 $= 8.4 \times 10^4 \text{ N C}^{-1}$ A1 [2]
- (ii) $qE = mg$ C1
 $q = (9.6 \times 10^{-15} \times 9.8) / (8.4 \times 10^4)$ C1
 $= 1.12 \times 10^{-18} \text{ C}$ A1 [3]

Q34.

- 7 (a) *either* $V = E R_1 / (R_1 + R_2)$ *or* $I = E / (R_1 + R_2)$ C1
 $= \frac{1800}{3000} \times 4.50$ $V = \frac{1800}{3000} \times 4.50$ M1
 $= 2.70 \text{ V}$ $= 2.70 \text{ V}$ A0 [2]
- (b) (i) for a wire, $V = I \times (\rho L / A)$ M1
 I, ρ and A are constant A1
 so $V \propto L$ A0 [2]

- (ii) 1 2.70 V A1 [1]
- 2 $\frac{L}{100} = \frac{2.70}{4.50}$ C1
- $L = 60.0 \text{ cm}$ A1 [2]
- (iii) thermistor resistance decreases as temperature rises M1
so QM is shorter A1 [2]

Q35.

- 7 (a) both measure (energy / work) / charge B1
for e.m.f., transfer of chemical energy to electrical energy B1
for p.d., transfer of electrical energy to thermal energy / other forms B1 [3]
- (b) (i) $I_1 + I_2 = I_3$ B1 [1]
(ii) 1. $E_2 = I_2 R_2 + I_3 R_3$ B1 [1]
2. $E_1 - E_2 = I_1 R_1 - I_2 R_2$ B1 [1]

Q36.

- 6 (a) power = VI C1
current = $10.5 \times 103 / 230$ M1
= 45.7 A A0 [2]
- (b) (i) p.d. across cable = 5.0 V C1
 $R = 5.0 / 46$ C1
= 0.11 Ω A1 [3]
- (ii) $R = \rho L / A$ C1
 $0.11 = (1.8 \times 10^{-8} \times 16 \times 2) / A$ C1
 $A = 5.3 \times 10^{-6} \text{ m}^2$ A1 [3]
(wires in parallel, not series, allow max 1/3 marks)
- (c) (i) either power = V^2 / R or power $\propto V^2$ C1
ratio = $(210 / 230)^2 = 0.83$ A1 [2]
- (ii) resistance of cable is greater M1
greater power loss/fire hazard/insulation may melt
wire may melt/cable gets hot A1 [2]

Q37.

- 4 (a) (i) either force = $e \times (V / d)$ or $E = V/d$ C1
= $1.6 \times 10^{-19} \times (250 / 7.6 \times 10^{-3})$ C1
= $5.3 \times 10^{-15} \text{ N}$ A1 [3]
- (ii) either $\Delta E_K = eV$ or $\Delta E_K = Fd$ C1
= $1.6 \times 10^{-19} \times 250$ = $5.3 \times 10^{-15} \times 7.6 \times 10^{-3}$ M1
= $4.0 \times 10^{-17} \text{ J}$ A0 [2]
(allow full credit for correct working via calculation of a and v)

- (iii) either $\Delta E_K = \frac{1}{2}mv^2$
 $4.0 \times 10^{-17} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$ C1
 $v = 9.4 \times 10^6 \text{ m s}^{-1}$ A1 [2]
- or $v^2 = 2as$ and $a = F/m$
 $v^2 = (2 \times 5.3 \times 10^{-15} \times 7.6 \times 10^{-3}) / (9.11 \times 10^{-31})$ (C1)
 $v = 9.4 \times 10^6 \text{ m s}^{-1}$ (A1)
- (b) speed depends on (electric) potential difference M2
(If states ΔE_K does not depend on uniformity of field, then
award 1 mark, treated as an M mark)
 so speed always the same A1 [3]

Q38.

- 7 (a) either $V = IP$ B1
 current in circuit = $E / (P + Q)$ B1
 hence $V = EP / (P + Q)$ A0 [2]
- or current is the same throughout the circuit (M1)
 $V / P = E / (P + Q)$ (A1)
 hence $V = EP / (P + Q)$ (A0)
- (b) (i) (as temperature rises), resistance of (thermistor) decreases M1
 either resistance of parallel combination decreases
 or p.d. across 5 k Ω resistor / thermistor decreases M1
 p.d. across 2000 Ω resistor / voltmeter reading increases A1 [3]
- (ii) if R is the resistance of the parallel combination,
 either $3.6 = (2 \times 6) / (2 + R)$ or current in 2 k Ω resistor = 1.8 mA C1
 $R = 1.33 \text{ k}\Omega$ current in 5 k Ω resistor = 0.48 mA C1
 $\frac{1}{1.33} = \frac{1}{5} + \frac{1}{T}$ current in thermistor = 1.32 mA C1
 $T = 1.82 \text{ k}\Omega$ $T = 2.4 / 1.32 = 1.82 \text{ k}\Omega$ A1 [4]

Q39.

- 6 (a) energy transferred from source / changed from some form to electrical M1
 per unit charge (to drive charge round a complete circuit) A1 [2]
- (b) and power in $R = I^2X$ M1
 $E = I(X + r)$ M1
 power in cell = EI and algebra clear leading to ratio = $X / (X + r)$ A1 [3]

- (c) (i) 1.4 W A1
 0.40 Ω (allow $\pm 0.05 \Omega$) A1 [2]
- (ii) current in circuit = $\sqrt{1.4/0.4} = 1.87 \text{ A}$ C1
 1.5 = 1.87 ($r + 0.40$) C1
 $r = 0.40 \Omega$ A1 [3]
- (d) either less power lost / energy wasted / lost
 or greater efficiency (of energy transfer) B1 [1]

[Total: 11]

Q40.

- 6 (a) total resistance in series = $2R$
 total resistance in parallel = $\frac{1}{2}R$ M1
 ratio is $2R / \frac{1}{2}R = 4$ (allow mark if clear numbers in the ratio) A0 [1]
- (b) at 1.5 V, current is 0.10 A C1
 resistance = $V/I = \frac{1.5}{0.1}$
 = 15 Ω A1 [2]
 (use of tangent or any other current scores no marks)

(c)

	p.d. across each lamp / V	resistance of each lamp / Ω	combined resistance / Ω
series	1.5	15	30
parallel	3.0	20	10

column 1 A1
 columns 2 and 3: max 3 marks with -1 mark for each error or omission A3 [4]

- (d) (i) ratio is 3(allow e.c.f.) A1 [1]
- (ii) resistance increases as potential difference increases B1
 increasing p.d. increases current B1
 current increases non-linearly so resistance increases B1 [3]

[Total: 11]

Q41.

- 6 (a) (i) either $P = V^2 / R$ or $P = VI$ and $V = IR$
 $R = 4.0 \Omega$ C1
A1 [2]
- (ii) sketch vertical axis labelled appropriately B1
(straight) line from origin then curved in correct direction B1
line passes through 12 V, 3.0 A B1 [3]
- (b) (i) 2.0 kW A1 [1]
- (ii) 0.5 kW A1 [1]
- (iii) total resistance = $3R / 2$ C1
power = 0.67 kW A1 [2]

Q42.

- 6 (a) (i) at 22.5 °C, $R_T = 1600 \Omega$ or 1.6 k Ω C1
total resistance = 800 Ω A1 [2]
- (ii) either use of potential divider formula or current = 9 / 2000 (4.5 mA) C1
 $V = (0.8/2.0) \times 9$ $V = (9/2000) \times 800$
= 3.6V = 3.6V A1 [2]
- (b) (i) total resistance = $4/5 \times 1200$ C1
= 960 Ω A1 [2]
- (ii) for parallel combination, $1/960 = 1/1600 + 1/R_T$ C1
 $R_T = 2400 \Omega$ / 2.4 k Ω A1 [2]
temperature = 11 °C
- (c) e.g. only small part of scale used / small sensitivity B1
non-linear B1 [2]
(any two sensible suggestions, 1 each, max 2)

Q43.

- 7 (a) (i) path: reasonable curve upwards between plates
straight and at a tangent to the curve beyond the plates
B1
B1 [2]
- (ii) 1. $(F =) E.q$ B1 [1]
2. $(t =) L / v$ B1 [1]
- (b) (i) total momentum of a system remains constant **or** total momentum of a system before a collision equals total momentum after collision
provided no external force acts on the system
(do not accept 'conserved' but otherwise correct statement gets 1/2)
M1
A1 [2]
- (ii) $(\Delta p =) EqL / v$ allow ecf from (a)(ii) B1 [1]
- (iii) *either* charged particle is not an isolated system
so law does not apply
or system is particle and 'plates'
equal and opposite Δp on plates / so law applies
M1
A1 [2]
(M1)
(A1)

Q44.

- 8 (a) (i) *either* $P = V^2 / R$ *or* $I = 1200 / 230$ *or* 5.22 C1
 $R = 230^2 / 1200$ *or* $R = (230 \times 230) / 1200$ M1
 $= 44.1 \Omega$ *or* $R = 230 / 5.22$ A0 [2]
 $= 44.1 \Omega$
- (ii) $R = \rho L / A$ C1
 $= (1.7 \times 10^{-8} \times 9.2 \times 2) / (\pi \times \{0.45 \times 10^{-3}\}^2)$ M1
 $= 0.492 \Omega$ A0 [2]
- (b) current = $230 / 44.6$ C1
power = $(230 / 44.6)^2 \times 44.1$ C1
 $= 1170 \text{ W}$ A1 [3]
(allow full credit for solution based on potential divider)
- (c) e.g. less power dissipated in the heater / smaller p.d. across heater /
more power loss in cable / current lower
cable becomes heated / melts
(any two sensible suggestions, 1 each, max 2)
B1
B1 [2]

Q45.

- 5 (a) ohm = volt / ampere B1 [1]
- (b) $\rho = RA / l$ or unit is Ωm C1
 units: $VA^{-1}m^2m^{-1} = NmC^{-1}A^{-1}m^2m^{-1}$ C1
 $= kgm^2s^{-2}A^{-1}s^{-1}A^{-1}m^2m^{-1}$
 $= kgm^3s^{-3}A^{-2}$ A1 [3]
- (c) (i) $\rho = [3.4 \times 1.3 \times 10^{-7}] / 0.9$ C1
 $= 4.9 \times 10^{-7} (\Omega m)$ A1 [2]
- (ii) max = 2.0 V A1
 min = $2 \times (3.4 / 1503.4) = 4.5 \times 10^{-3} V$ A1 [2]
- (iii) $P = V^2 / R$ or $P = VI$ and $V = IR$ C1
 $= (2)^2 / 3.4$
 $= 1.18$ (allow 1.2) W A1 [2]
- (d) (i) power in Q is zero when $R = 0$ B1 [1]
- (ii) power in Q = 0 / tends to zero as $R = \text{infinity}$ B1 [1]

Q46.

- 4 (a) electric field strength = force / positive charge B1 [1]
- (b) (i) at least three equally spaced parallel vertical lines B1
 direction down B1 [2]
- (ii) $E = 1500 / 20 \times 10^{-3} = 75000 V m^{-1}$ A1 [1]
- (iii) $F = qE$ C1
 $(W = mg \text{ and } qE = mg)$ C1
 $q = mg / E = 5 \times 10^{-15} \times 9.81 / 75000$
 $= 6.5 \times 10^{-19} C$ A1
 negative charge A1 [4]
- (iv) $F > mg$ or F now greater B1
 drop will move upwards B1 [2]

Q47.

- 5 (a) (i) $I_1 + I_3 = I_2$ A1 [1]
- (ii) $E_1 = \frac{I_2 R_2}{2} + \frac{I_1 R_2}{2} + I_1 R_1 + I_1 r_1$ A1 [1]
- (iii) $E_1 - E_2$ B1
 $= -I_3 r_2 + I_1 (R_1 + r_1 + R_2 / 2)$ B1 [2]
- (b) p.d. across BJ of wire changes / resistance of BJ changes B1
 there is a difference in p.d across wire and p.d. across cell E_2 B1 [2]

Q48.

- 4 (a) p.d. = $\frac{\text{energy transformed from electrical to other forms}}{\text{unit charge}}$ B1
- e.m.f. = $\frac{\text{energy transformed from other forms to electrical}}{\text{unit charge}}$ B1 [2]
- (b) (i) sum of e.m.f.s (in a closed circuit) = sum of potential differences B1 [1]
- (ii) $4.4 - 2.1 = I \times (1.8 + 5.5 + 2.3)$ M1
 $I = 0.24 \text{ A}$ A1 [2]
- (iii) arrow (labelled) I shown anticlockwise A1 [1]
- (iv) 1. $V = I \times R = 0.24 \times 5.5 = 1.3(2) \text{ V}$ A1 [1]
2. $V_A = 4.4 - (I \times 2.3) = 3.8(5) \text{ V}$ A1 [1]
3. either $V_B = 2.1 + (I \times 1.8)$ or $V_B = 3.8 - 1.3$ C1
 $= 2.5(3) \text{ V}$ A1 [2]

Q49.

- 2 (a) resistance = potential difference / current B1 [1]
- (b) (i) metal wire in series with power supply and ammeter B1
 voltmeter in parallel with metal wire B1
 rheostat in series with power supply or potential divider arrangement or variable power supply B1 [3]
- (ii) 1. intercept on graph B1 [1]
2. scatter of readings about the best fit line B1 [1]
- (iii) correction for zero error explained B1
 use of V and corrected I values from graph C1
 resistance = $V / I = 22.(2) \Omega$ [e.g. $4.0 / 0.18$] A1 [3]
- (c) $R = 6.8 / 0.64 = 10.625$ C1
- $\%R = \%V + \%I$
 $= (0.1 / 6.8) \times 100 + (0.01 / 0.64) \times 100$ C1
 $= 1.47\% + 1.56\%$
 $\Delta R = 0.0303 \times 10.625 = 0.32 \Omega$
 $R = 10.6 \pm 0.3 \Omega$ A1 [3]

Q50.

- 5 (a) (i) $I_1 = I_2 + I_3$ B1 [1]
- (ii) $I = V / R$ or $I_2 = 12 / 10$ (= 1.2 A) C1
 $R = [1/6 + 1 / 10]^{-1}$ [total $R = 3.75 \Omega$] or $I_3 = 12 / 6$ (= 2.0 A) C1
 $I_1 = 12 / 3.75 = 3.2 \text{ A}$ or $I_1 = 1.2 + 2.0 = 3.2 \text{ A}$ A1 [3]
- (iii) power = VI or $I^2 R$ or V^2 / R C1
- $x = \frac{\text{power in wire}}{\text{power in series resistors}} = \frac{I_2^2 R_w}{I_3^2 R_s}$ or $\frac{V_2}{V_3}$ or $\frac{V^2 / R_w}{V^2 / R_s}$ C1
- $x = 12 \times 1.2 / 12 \times 2.0 = 0.6(0)$ allow 3 / 5 or 3:5 A1 [3]
- (b) p.d. BC: $12 - 12 \times 0.4 = 7.2 \text{ (V)}$ / p.d. AC = 4.8(V) C1
 p.d. BD: $12 - 12 \times 4 / 6 = 4.0 \text{ (V)}$ / p.d. AD = 8.0(V) C1
 p.d. = 3.2V A1 [3]

Q51.

- 4 (a) e.m.f. = chemical energy to electrical energy M1
 p.d. = electrical energy to thermal energy M1
 idea of per unit charge A1 [3]
- (b) $E = I(R + r)$ or $I = E / (R + r)$ (any subject) B1 [1]
- (c) (i) $E = 5.8 \text{ V}$ B1 [1]
- (ii) evidence of gradient calculation or calculation with values from graph
 e.g. $5.8 = 4 + 1.0 \times r$ C1
 $r = 1.8 \Omega$ A1 [2]
- (d) (i) $P = VI$ C1
 $P = 2.9 \times 1.6 = 4.6$ (4.64)W A1 [2]
- (ii) power from battery = $1.6 \times 5.8 = 9.28$ or efficiency = VI / EI C1
 efficiency = $(4.64 / 9.28) \times 100 = 50 \%$ or $(2.9 / 5.8) \times 100 = 50\%$ A1 [2]

Q52.

- 6 (a) p.d. = work (done) / charge OR energy transferred from (electrical to other forms) / (unit) charge B1 [1]
- (b) (i) $R = \rho l / A$ C1
 $\rho = 18 \times 10^{-9}$ C1
 $R = (18 \times 10^{-9} \times 75) / 2.5 \times 10^{-6} = 0.54 \Omega$ A1 [3]
- (ii) $V = IR$ C1
 $R = 38 + (2 \times 0.54)$ C1
 $I = 240 / 39.08 = 6.1$ (6.14) A A1 [3]

(iii) $P = I^2 R$ or $P = VI$ and $V = IR$ or $P = V^2/R$ and $V = IR$
 $= (6.14)^2 \times 2 \times 0.54$
 $= 41 \text{ (40.7) W}$

C1
C1
A1 [3]

- (c) area of wire is less (1/5) hence resistance greater ($\times 5$)
 OR $R \propto 1/A$ therefore R is greater
 p.d. across wires greater so power loss in cables increases
- M1
A1 [2]

Q53.

- 6 (a) e.m.f. = total energy available (per unit charge)
 some (of the available energy) is used/lost/wasted/given out in the internal resistance of the battery (hence p.d. available less than e.m.f.)
- B1
B1 [2]
- (b) (i) $V = IR$
 $I = 6.9 / 5.0 = 1.4 \text{ (1.38) A}$
- C1
A1 [2]
- (ii) $r = \text{lost volts} / \text{current}$
 $= (9 - 6.9) / 1.38 = 1.5(2) \Omega$
- C1
A1 [2]
- (c) (i) $P = EI$ (not $P = VI$ if only this line given or 9 V not used in second line)
 $= 9 \times 1.38 = 12 \text{ (12.4) W}$
- C1
A1 [2]
- (ii) efficiency = output power / total power
 $= VI / EI = 6.9 / 9 \text{ or } (9.52) / (12.4) = 0.767 / 76.7\%$
- C1
A1 [2]

Q54.

- 7 (a) (i) six vertical lines from plate to plate equally spaced across plates
 [only allow if greatest to least spacing is < 1.3 , condone slight curving on the two edges. There must be no area between the plates where an additional line(s) could be added.]
 arrow downwards on at least one line
- B1
B1 [2]
- (ii) $E = V/d$
 $= 1200 / 40 \times 10^{-3} = 3.0 \times 10^4 \text{ V m}^{-1}$ (allow 1 s.f.)
- C1
A1 [2]
- (b) (i) $F = Ee$
 $= 3 \times 10^4 \times 1.6 \times 10^{-19} = 4.8 \times 10^{-15} \text{ N}$
- C1
A1 [2]
- (ii) couple = $F \times \text{separation of charges}$
 $= 4.8 \times 10^{-15} \times 15 \times 10^{-3} = 7.2 \times 10^{-17}$
 unit: N m or unit consistent with unit used for the separation
- C1
A1
B1 [3]
- (iii) A at top/next to +ve plate B at bottom/next to -ve plate vertically aligned
 [could be shown on the diagram]
 forces are equal and opposite in same line / no resultant force and no resultant torque
- M1
A1 [2]

Current electricity - 2018

1. 9702/11/M/J/18/No.30

The current I in a metal wire is given by the expression shown.

$$I = Anvq$$

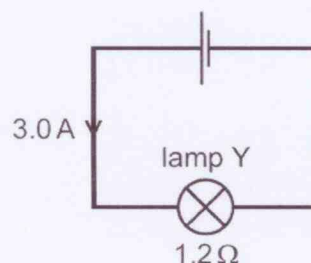
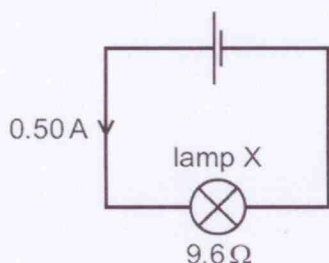
What does the symbol n represent?

- A the number of atoms per unit volume of the metal
- B the number of free electrons per atom in the metal
- ☒ C the number of free electrons per unit volume of the metal
- D the total number of electrons per unit volume of the metal

I - current
 A - cross-sectional area
 n - number of e^- per unit volume
 v - drift velocity
 q - charge in e^- 's.

2. 9702/11/M/J/18/No.31

The circuit diagrams show two lamps X and Y each connected to a cell. The current in lamp X is 0.50 A and its resistance is $9.6\ \Omega$. The current in lamp Y is 3.0 A and its resistance is $1.2\ \Omega$.



What is the ratio $\frac{\text{power in lamp X}}{\text{power in lamp Y}}$?

- ☒ A 0.22
- B 0.75
- C 1.3
- D 4.5

$$P = I^2 R$$

$$\frac{P_X}{P_Y} = \frac{0.5^2 \times 9.6}{3.0^2 \times 1.2} = 0.2222$$

3. 9702/11/M/J/18/No.32

A cylindrical piece of a soft, electrically-conducting material has resistance R . It is rolled out so that its length is doubled but its volume stays constant.

What is its new resistance?

- A $\frac{R}{2}$
- B R
- C $2R$
- ☒ D $4R$

$$V = \pi r^2 \times L$$

$$= \frac{\pi r^2}{2} \times 2L = V$$

$$R = \frac{\rho \times 2L}{\frac{A}{2}}$$

$$= \frac{4\rho L}{A} = 4R$$

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4. 9702/11/M/J/18/No.33

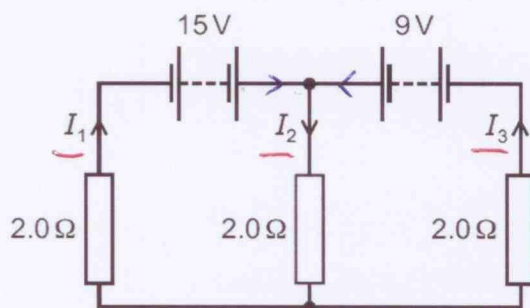
The sum of the electrical currents into a point in a circuit is equal to the sum of the currents out of the point.

Which statement is correct?

- ☒ A This is Kirchhoff's first law, which results from the conservation of charge.
- ☐ B This is Kirchhoff's first law, which results from the conservation of energy.
- ☐ C This is Kirchhoff's second law, which results from the conservation of charge.
- ☐ D This is Kirchhoff's second law, which results from the conservation of energy.

5. 9702/11/M/J/18/No.34

In the circuit shown, the batteries have negligible internal resistance.



What are the values of the currents I_1 , I_2 and I_3 ?

	I_1/A	I_2/A	I_3/A
A	-5.5	1.0	6.5
B	0.5	4.0	3.5
☒ C	3.5	4.0	0.5
D	6.5	1.0	-5.5

$$I_2 = I_1 + I_3$$

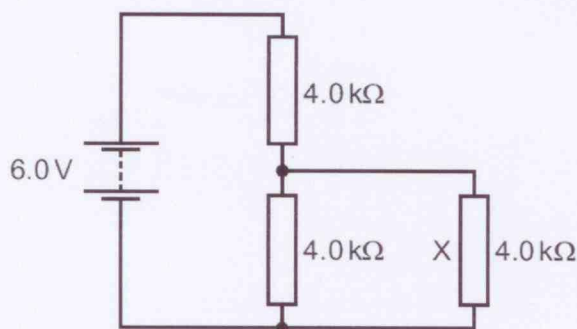
$$I_1 > I_3$$

$$I_2 > I_1$$

$$I_2 > I_3$$

6. 9702/11/M/J/18/No.35

A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors as shown.



$$R_{\text{parallel}} = \frac{4 \times 4}{4 + 4} = \frac{16}{8} = 2 \text{ k}\Omega$$

$$V_{\text{out}} = \frac{2 \text{ k}\Omega \times 6 \text{ V}}{(2 + 4) \text{ k}\Omega} = 2 \text{ V}$$

$$I_x = \frac{V}{R} = \frac{2 \text{ V}}{4000 \Omega} = 0.0005 = \underline{\underline{0.5 \text{ mA}}}$$

Each resistor has a resistance of 4.0 kΩ.

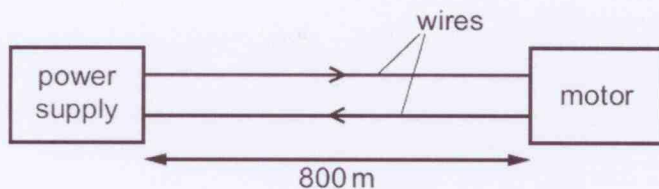
What is the current in resistor X?

- A 0.25 mA **B 0.50 mA** C 0.75 mA D 1.0 mA

7. 9702/11/M/J/18/No.37

A motor is required to operate at a distance of 800 m from its power supply. The motor requires a potential difference (p.d.) of 16.0 V and a current of 0.60 A to operate.

Two wires are used to supply power to the motor as shown.



$$\begin{aligned} \text{Total Resistance} &= (0.005 \times 800) \times 2 \\ &= 8 \Omega \end{aligned}$$

$$\begin{aligned} V &= IR \\ &= 0.6 \times 8 \\ &= 4.8 \text{ V (wasted)} \end{aligned}$$

$$\begin{aligned} V_{\text{Total}} &= 16 + 4.8 \text{ V} \\ &= \underline{\underline{20.8 \text{ V}}} \end{aligned}$$

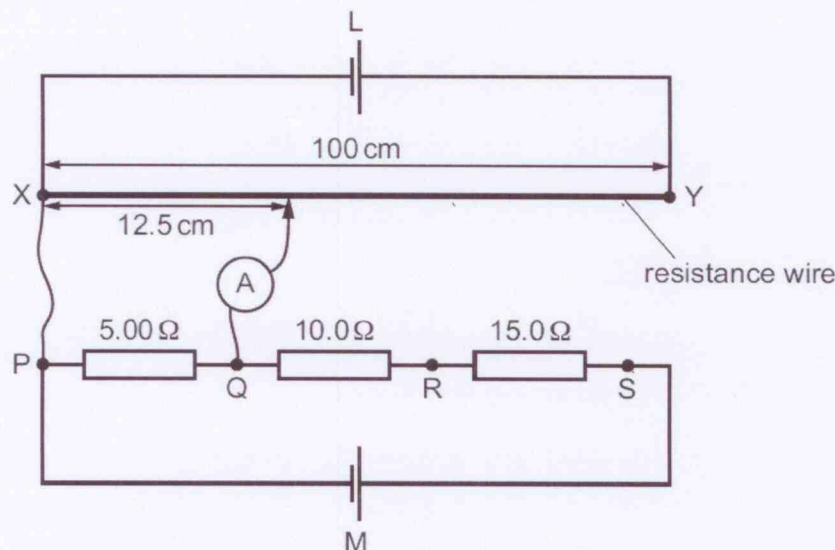
The resistance of each of these wires is 0.0050 Ω per metre.

What is the minimum output p.d. of the power supply?

- A 11.2 V B 16.0 V C 18.4 V **D 20.8 V**

8. 9702/11/M/J/18/No.36

A uniform resistance wire XY of length 100 cm is connected in series with a cell L. Another cell M is connected in series with resistors of resistances $5.00\ \Omega$, $10.0\ \Omega$ and $15.0\ \Omega$.



The potential difference (p.d.) between P and Q is balanced against 12.5 cm of the resistance wire, so that the ammeter reads zero.

The p.d. across the other resistors is then balanced against other lengths of the resistance wire.

Which balanced lengths of resistance wire correspond to the connection points given in the table?

connection points	balanced length / cm			
	A	B	C	D
Q and R	12.5	25.0	25.0	25.0
Q and S	62.5	62.5	75.0	62.5
P and R	37.5	37.5	37.5	12.5

$$\frac{L_2}{L_1} = \frac{R_2}{R_1}$$

$$QR: \frac{x}{12.5} = \frac{10}{5}$$

$$x = 25\text{ cm}$$

$$QS: \frac{x}{12.5} = \frac{25}{5}$$

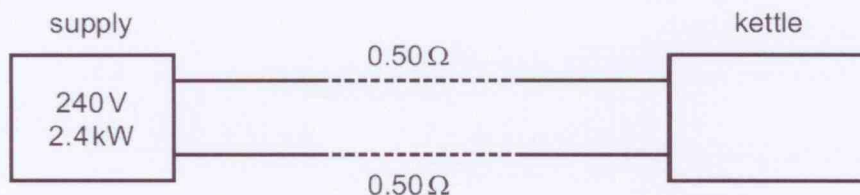
$$x = 62.5\text{ cm}$$

$$PR: \frac{x}{12.5} = \frac{15}{5}$$

$$x = 37.5\text{ cm}$$

9. 9702/12/M/J/18/No.32

The power output of an electrical supply is 2.4 kW at a potential difference (p.d.) of 240 V. The two wires between the supply and a kettle each have a resistance of 0.50Ω , as shown.



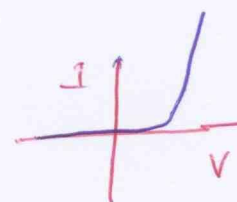
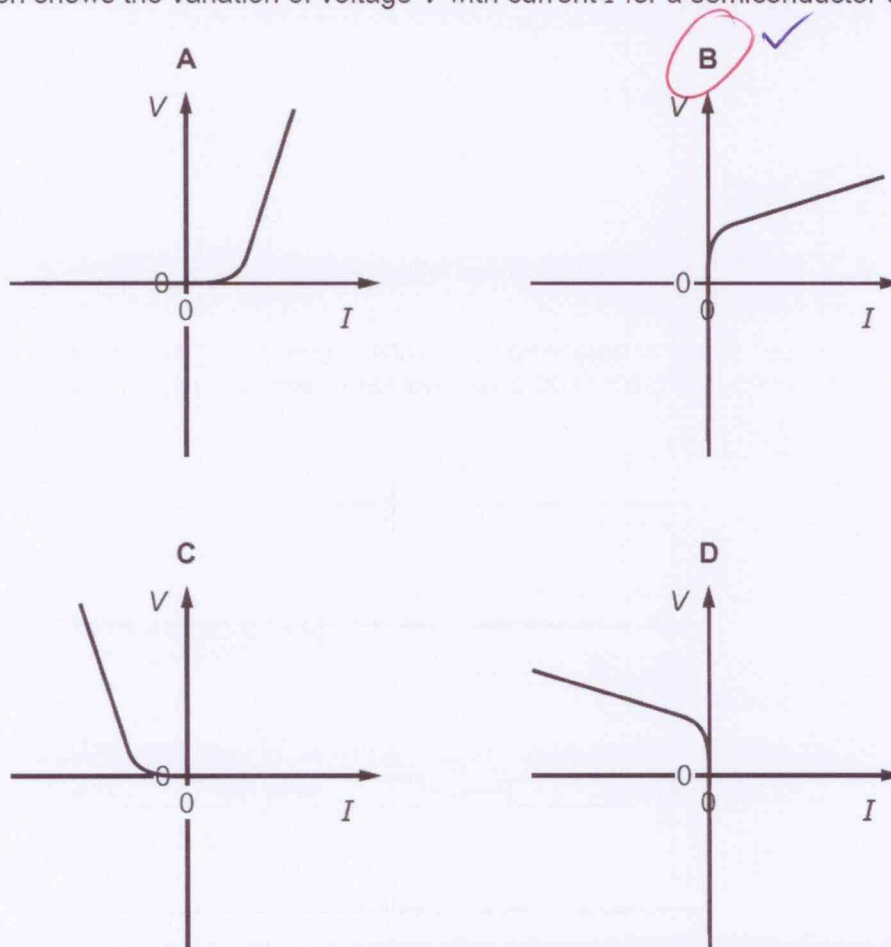
What is the power supplied to the kettle and what is the p.d. across the kettle?

	power / kW	p.d. / V
A ✓	2.3	230
B	2.3	235
C	2.4	230
D	2.4	235

$$\begin{aligned}
 P &= VI \\
 I &= \frac{P}{V} = \frac{2400 \text{ W}}{240 \text{ V}} \\
 I &= 10 \text{ A} \\
 V_{\text{drop}} &= 10 \text{ A} \times (0.5 \times 2) \Omega \\
 &= 10 \text{ V} \\
 V_{\text{kettle}} &= 240 - 10 \\
 &= 230 \text{ V} \\
 P_{\text{kettle}} &= 230 \times 10 \\
 &= 2300 \text{ W} \\
 &= 2.3 \text{ kW}
 \end{aligned}$$

10. 9702/12/M/J/18/No.33

Which graph shows the variation of voltage V with current I for a semiconductor diode?



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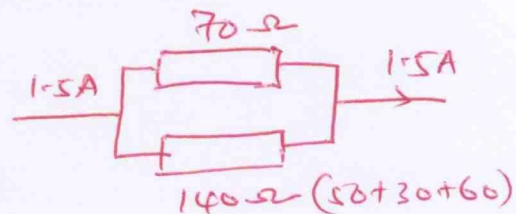
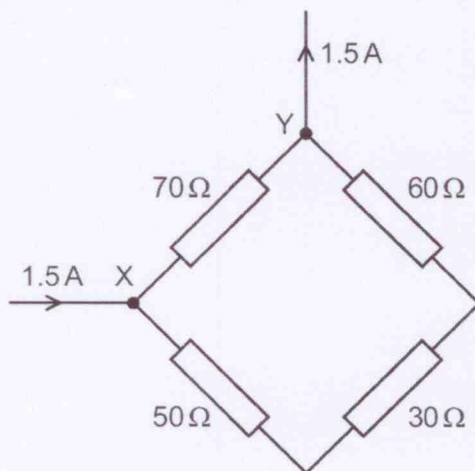
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11. 9702/12/M/J/18/No.34

Four different resistors are arranged as shown.

A current of 1.5 A enters the network at junction X and leaves through junction Y.



$$R_T = \frac{70 \times 140}{70 + 140} = 46.7 \Omega$$

$$V = IR = 1.5 A \times 46.7 \Omega = 70 V$$

$$I = \frac{70 V}{140 \Omega} = 0.5 A$$

What is the current in the resistor of resistance 30 Ω?

A 0.21 A

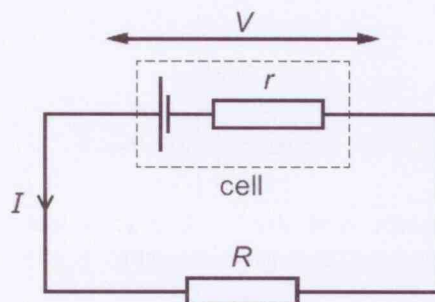
B 0.50 A

C 0.75 A

D 1.0 A

12. 9702/12/M/J/18/No.35

A cell of constant electromotive force drives a current I through an external resistor of resistance R . The terminal potential difference (p.d.) across the cell is V .



When the internal resistance r of the cell increases, what is the effect on V and on I ?

	V	I
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

$$V = E - Ir$$

If r increases, the Ir increases
So V decreases

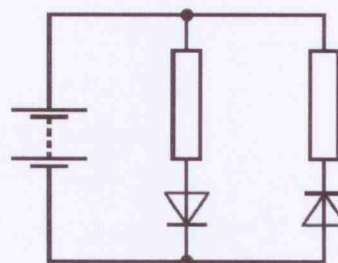
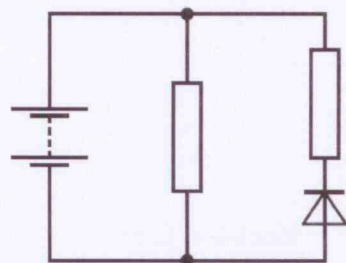
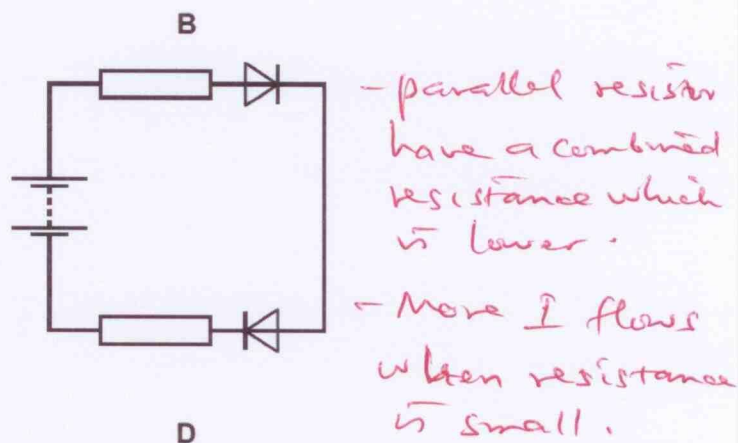
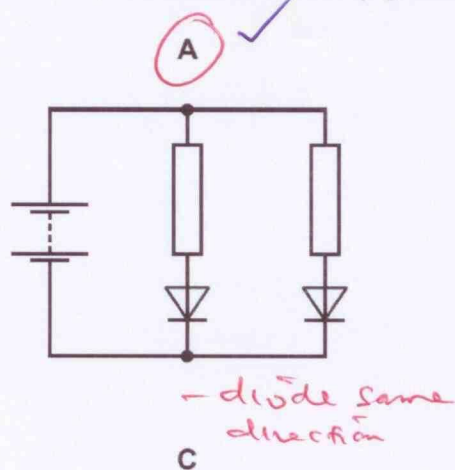
$$E = IR + Ir = I(R + r)$$

$I = \frac{E}{R+r}$ when r increases,
denominator is large
so I decreases.

13. 9702/12/M/J/18/No.36

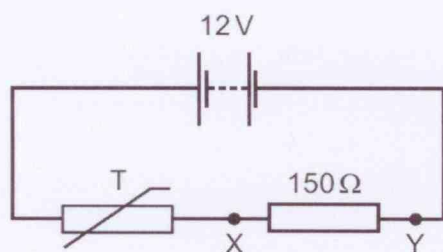
In the circuits shown, the batteries are identical and all have negligible internal resistance. All of the resistors have the same resistance. The diodes have zero resistance when conducting and infinite resistance when not conducting.

In which circuit is the current in the battery greatest?



14. 9702/12/M/J/18/No.37

A thermistor is an electrical component with a resistance that varies with temperature. A thermistor T is used in a fire alarm system. The alarm is triggered when the potential difference between X and Y is 4.5 V.



What is the resistance of T when the alarm is triggered?

A 90 Ω

B 150 Ω

C 250 Ω ✓

D 400 Ω

$$V_{out} = \frac{150 \times 12}{150 + T}$$

$$150 + T = \frac{150 \times 12}{V_{out}} \quad (V_{out} = 4.5V)$$

$$= \frac{150 \times 12}{4.5}$$

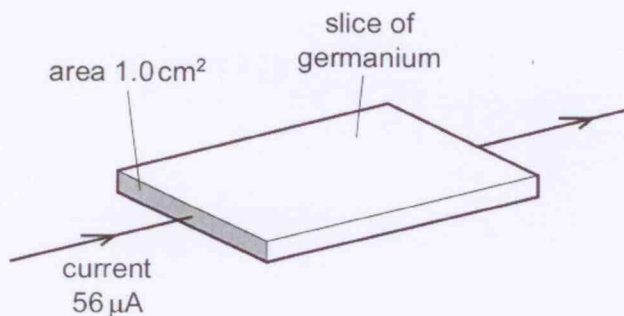
$$150 + T = 400$$

$$T = 400 - 150$$

$$= 250 \Omega$$

15. 9702/13/M/J/18/No.30

A slice of germanium of cross-sectional area 1.0 cm^2 carries a current of $56 \mu\text{A}$. The number density of charge carriers in the germanium is $2.0 \times 10^{13} \text{ cm}^{-3}$. Each charge carrier has a charge equal to the charge on an electron.



$$v = \frac{I}{nAe}$$

$$= \frac{56 \times 10^{-6}}{2 \times 10^{13} \times 1 \times 1.6 \times 10^{-19}}$$

$$= 17.5 \text{ cm s}^{-1}$$

$$= 17.5 \times 10^{-2} \text{ m s}^{-1}$$

$$= 0.175 \text{ m s}^{-1}$$

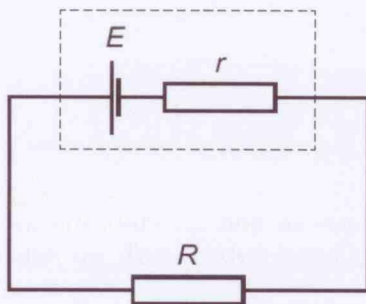
$$\approx \underline{\underline{0.18 \text{ m s}^{-1}}}$$

What is the average drift velocity of the charge carriers in the germanium?

- ☒ A 0.18 m s^{-1} ☐ B 18 m s^{-1} ☐ C 180 m s^{-1} ☐ D 1800 m s^{-1}

16. 9702/13/M/J/18/No.31

A cell of electromotive force (e.m.f.) E and internal resistance r is connected to an external resistor of resistance R , as shown.



$$E = I(R + r)$$

$$I = \frac{E}{R + r}$$

$$P = I^2 R$$

$$= \left(\frac{E}{R + r} \right)^2 \times R$$

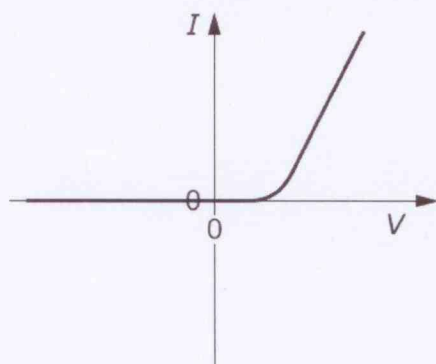
$$= \frac{E^2 R}{(R + r)^2}$$

What is the power dissipated in the external resistor?

- A $\frac{E^2(R+r)}{R^2}$ ☒ B $\frac{E^2 R}{(R+r)^2}$ C $\frac{E^2(R+r)}{r^2}$ D $\frac{E^2 r}{(R+r)^2}$

17. 9702/13/M/J/18/No.32

The graph shows the I - V characteristic of an electrical component.



What is the component?

- A a filament lamp
- B a metallic conductor at constant temperature
- C a resistor
- ☒ D a semiconductor diode

18. 9702/13/M/J/18/No.33

A metal wire of length 1.4 m has a uniform cross-sectional area of $7.8 \times 10^{-7} \text{ m}^2$.

The resistivity of the metal is $1.7 \times 10^{-8} \Omega \text{ m}$.

What is the resistance of the wire?

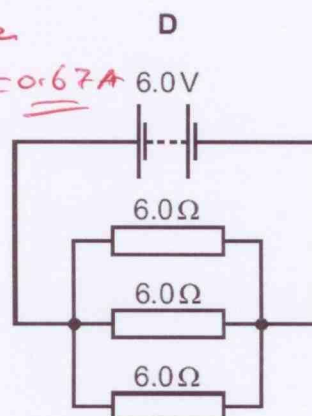
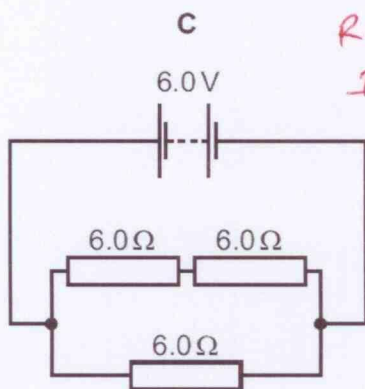
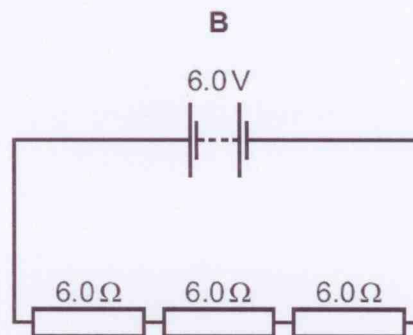
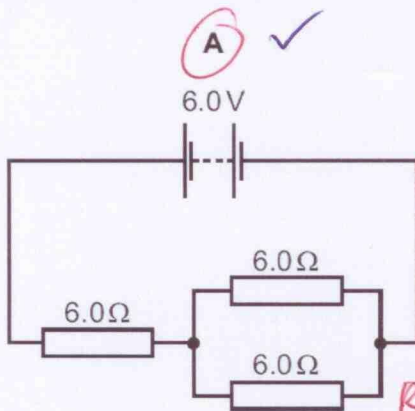
- A 0.016Ω
- ☒ B 0.031Ω
- C 33Ω
- D 64Ω

$$\begin{aligned} R &= \frac{\rho l}{A} \\ &= \frac{1.7 \times 10^{-8} \times 1.4}{7.8 \times 10^{-7}} \\ &= 0.0305 \Omega \\ &\approx \underline{\underline{0.031 \Omega}} \end{aligned}$$

19. 9702/13/M/J/18/No.34

A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors each of resistance 6.0 Ω .

Which circuit will produce a current through the battery of 0.67 A?



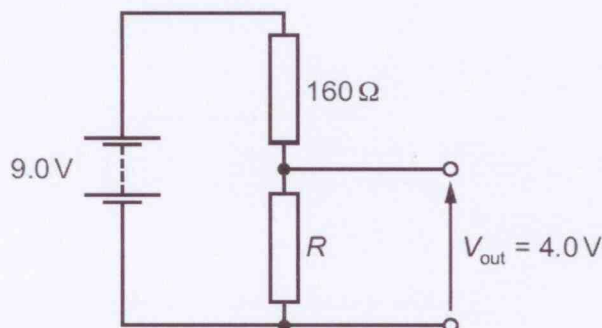
$$R_p = \frac{6 \times 6}{6 + 6} = 3 \Omega$$

$$R_T = 3 + 6 = 9 \Omega$$

$$I = \frac{V}{R} = \frac{6V}{9\Omega} = 0.67A$$

20. 9702/13/M/J/18/No.37

The circuit diagram shows a battery of electromotive force (e.m.f.) 9.0 V and negligible internal resistance. It is connected to two resistors of resistances 160 Ω and R . The output potential difference V_{out} is 4.0 V.



$$V_{out} = \frac{R}{160 + R} \times 9$$

$$160 + R = \frac{R \times 9}{4}$$

$$4(160 + R) = 9R$$

$$640 + 4R = 9R$$

$$640 = 9R - 4R$$

$$640 = 5R$$

$$R = \frac{640}{5} = 128 \Omega$$

What is the resistance R ?

A 32 Ω

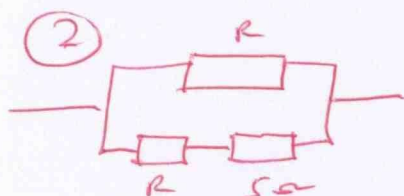
B 49 Ω

C 71 Ω

D 128 Ω ✓

21. 9702/13/M/J/18/No.35

The diagram shows a network of three resistors. Two of these, marked R, are identical. The other resistor has a resistance of 5.0Ω .

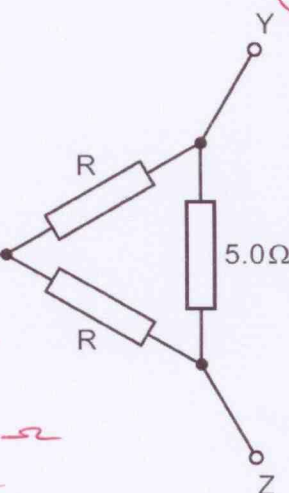


$$R_T = \frac{R \times (R+5)}{R + (R+5)} = \frac{R^2 + 5R}{2R+5}$$

$$= \frac{2.5^2 \times (5 \times 2.5)}{(2 \times 2.5) + 5} = \frac{18.75}{10}$$

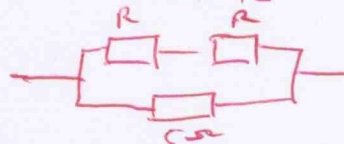
$$= 1.875\Omega$$

$$\approx \underline{\underline{1.9\Omega}}$$



① - draw parallel resistors of the arrangement

$$R_T = \frac{2R \times 5}{2R+5} = 2.5$$



$$2.5 = \frac{10R}{2R+5}$$

$$10R = 2.5(2R+5)$$

$$10R = 5R + 12.5$$

$$5R = 12.5$$

$$R = \frac{12.5}{5} = 2.5\Omega$$

The resistance between Y and Z is found to be 2.5Ω .

What is the resistance between X and Y?

A 0.30Ω

B 0.53Ω

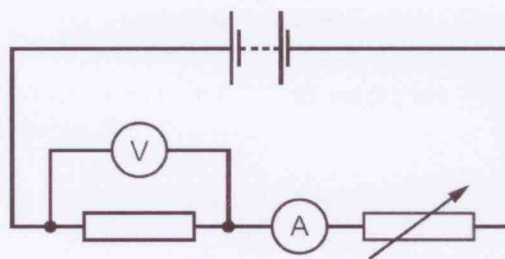
C 1.9Ω

D 3.3Ω

22. 9702/13/M/J/18/No.36

The diagram shows a battery, a fixed resistor, an ammeter and a variable resistor connected in series.

A voltmeter is connected across the fixed resistor.



The resistance of the variable resistor is reduced.

Which row describes the changes in the readings of the ammeter and of the voltmeter?

	ammeter	voltmeter
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

- decreasing resistance of variable resistor, decreases total circuit resistance.

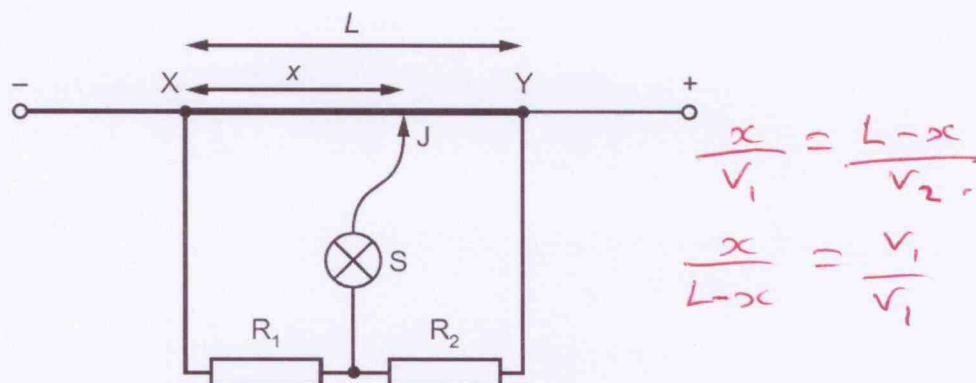
- so current increases

$V \propto I$.

- so voltage also increases.

23. 9702/13/M/J/18/No.38

In the circuit shown, XY is a length L of uniform resistance wire. A potential difference is applied across XY. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a lamp S.



J is moved along XY to a point at which the lamp is off. This point is at a distance x from X.

The potential difference across R_1 is V_1 and the potential difference across R_2 is V_2 .

What is the value of the ratio $\frac{V_1}{V_2}$?

A $\frac{L}{x}$

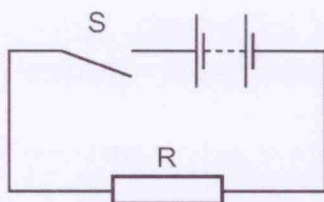
B $\frac{x}{L}$

C $\frac{L-x}{x}$

☒ D $\frac{x}{L-x}$

24. 9702/12/F/M/18/No.32

The diagram shows a simple circuit.



Which statement is correct?

A When switch S is closed, the e.m.f. of the battery falls because work is done against the internal resistance of the battery.

B When switch S is closed, the e.m.f. of the battery falls because work is done against the resistance of R.

☒ C When switch S is closed, the potential difference across the battery falls because work is done against the internal resistance of the battery.

D When switch S is closed, the potential difference across the battery falls because work is done against the resistance of R.

25. 9702/12/F/M/18/No.33

A resistor has resistance R . When the potential difference across the resistor is V , the current in the resistor is I . The power dissipated in the resistor is P . Work W is done when charge Q flows through the resistor.

What is **not** a valid relationship between these variables?

A $I = \frac{P}{V}$

B $Q = \frac{W}{V}$

C $R = \frac{P}{I^2}$

☒ D $R = \frac{V}{P}$

$$P = IV$$

$$I = \frac{P}{V}$$

$$V = \frac{W}{Q}$$

$$Q = \frac{W}{V}$$

$$P = I^2 R$$

$$R = \frac{P}{I^2}$$

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P}$$

26. 9702/12/F/M/18/No.34

A wire of resistance 9.55Ω has a diameter of 0.280 mm .

It is made of metal of resistivity $4.90 \times 10^{-7} \Omega \text{ m}$.

What is the length of the wire?

☒ A 1.20 m

B 4.80 m

C 19.0 m

D 76.8 m

$$R = \frac{\rho l}{A}$$

$$l = \frac{R \times A}{\rho}$$

$$l = \frac{9.55 \times \pi \times \left(\frac{0.28 \times 10^{-3}}{2}\right)^2}{4.90 \times 10^{-7}}$$

$$\approx 1.200088394$$

$$\approx \underline{\underline{1.20 \text{ m}}}$$

27. 9702/12/F/M/18/No.35

Charge carriers, each of charge q , move along a wire of fixed length. The number density of the charge carriers in the wire is n .

What is also required, for this wire, to determine the average drift velocity of the charge carriers in terms of n and q ?

☒ A current per unit of cross-sectional area

B potential difference per unit of length

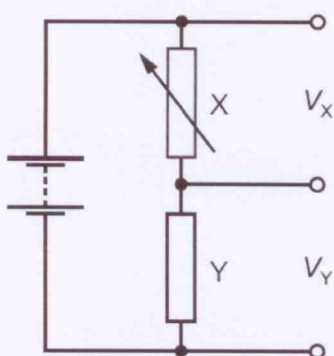
C resistance and cross-sectional area

D resistivity and length

$$v = \frac{I}{n A q}$$

28. 9702/12/F/M/18/No.36

A potential divider circuit is constructed with one variable resistor X and one fixed resistor Y, as shown.



The potential difference across resistor X is V_X and the potential difference of resistor Y is V_Y .

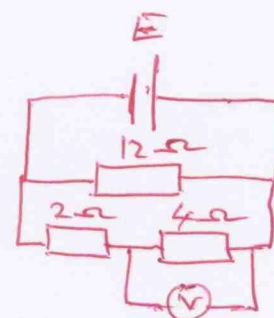
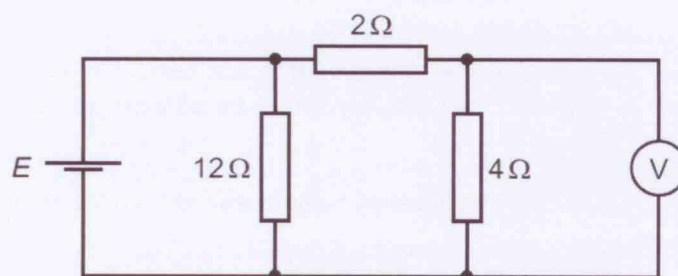
As the resistance of X is increased, what happens to V_X and to V_Y ?

	V_X	V_Y
A	falls	rises
B	falls	stays the same
C	rises	falls
D	rises	stays the same

- high resistance has high V_{out}

29. 9702/12/F/M/18/No.37

A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected into a circuit, as shown.



The voltmeter has a very high resistance and reads a potential difference V_{out} .

What is the ratio $\frac{V_{out}}{E}$?

A $\frac{1}{6}$

B $\frac{1}{3}$

C $\frac{1}{2}$

D $\frac{2}{3}$

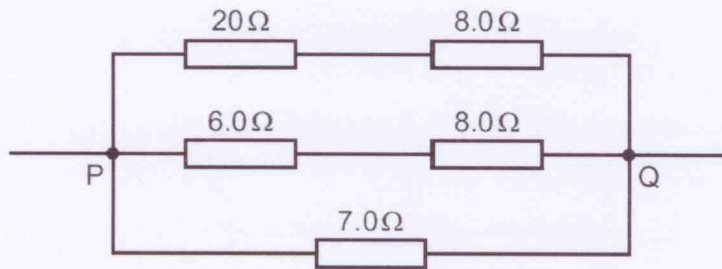
- voltage (p.d) across parallel resistors is same as the p.d of cell (E).

$$V_{out} = \frac{4 \times E}{2 + 4}$$

$$\frac{V_{out}}{E} = \frac{4}{6} = \frac{2}{3}$$

30. 9702/12/F/M/18/No.38

Five resistors are connected as shown.



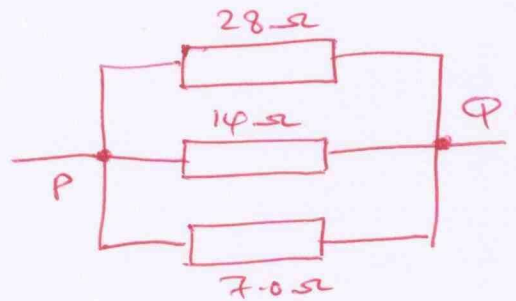
What is the total resistance between points P and Q?

A 0.25Ω

B 0.61Ω

C 4.0Ω

D 16Ω



$$\frac{1}{R_T} = \frac{1}{28} + \frac{1}{14} + \frac{1}{7}$$

$$\frac{1}{R_T} = \frac{1+2+4}{28} = \frac{7}{28} = \frac{1}{4}$$

$$\frac{1}{R_T} = \frac{1}{4}$$

$$R_T = \underline{\underline{4\Omega}}$$

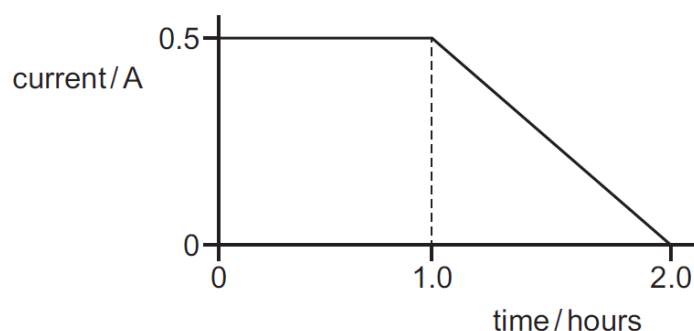
1. June/2021/Paper_11/No.32

Which two units are used to define the coulomb?

- A ampere and second
- B ampere and volt
- C volt and ohm
- D volt and second

2. June/2021/Paper_11/No.33

A mobile phone battery is charged by connecting it to a constant potential difference of 5.0 V. After a time of 1.0 hour, the initial current of 0.50 A slowly decreases to zero, as shown.



What is the best estimate of the energy transferred to the battery during the time of 2.0 hours shown in the graph?

- A 2700 J B 9000 J C 14 000 J D 18 000 J

3. June/2021/Paper_11/No.34

A length of wire is connected into an electric circuit. The current in the wire is measured.

Which change on its own could increase the current in the wire?

- A an increase in the length of the wire
- B an increase in the radius of the wire
- C an increase in the resistance of the wire
- D an increase in the resistivity of the wire

4. [June/2021/Paper_11/No.35](#)

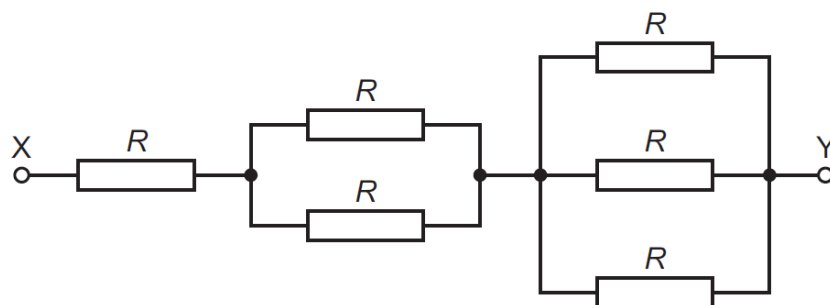
A cell is described as having an electromotive force (e.m.f.) of 6 V.

What does this mean?

- A 1 coulomb of charge always dissipates 6 J of energy in the internal resistance of the cell.
- B 1 electron gains 6 J of energy when passing through the cell.
- C There is a potential difference of 6 V applied across any external circuit connected to the cell.
- D When 1 coulomb of charge passes through the cell, 6 J of chemical energy is transformed.

5. [June/2021/Paper_11/No.36](#)

The diagram shows a network of resistors. Each resistor has resistance R .

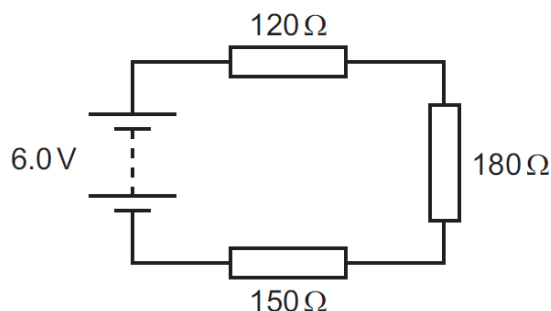


What is the total resistance of the network between points X and Y?

- A $\frac{R}{6}$
- B $\frac{6R}{11}$
- C $\frac{11R}{6}$
- D $6R$

6. [June/2021/Paper_11/No.37](#)

Three resistors are connected in series with a battery, as shown. The battery has negligible internal resistance.



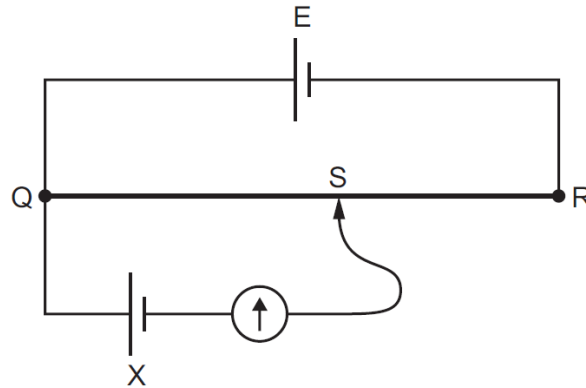
What is the potential difference across the $180\ \Omega$ resistor?

- A 1.6 V
- B 2.4 V
- C 3.6 V
- D 4.0 V

7. June/2021/Paper_11/No.38

A potentiometer circuit is used to determine the unknown electromotive force (e.m.f.) of a cell X.

In the circuit shown, E is a cell with an e.m.f. that is known accurately. QR is the potentiometer wire, which has a movable contact S. Contact S is connected to a galvanometer and to cell X.

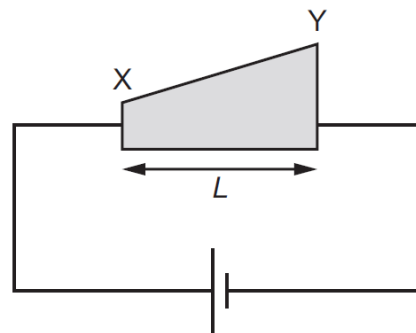


What is **not** a necessary requirement to determine the e.m.f. of X from the circuit?

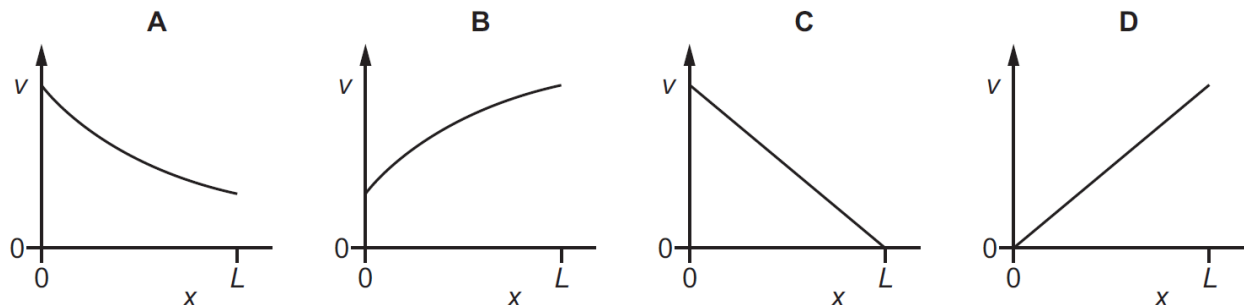
- A The e.m.f. of cell X must be lower than the e.m.f. of cell E.
- B The internal resistance of cell X must be known.
- C The lengths QS and QR must be determined accurately.
- D The resistance of the wire QR must be proportional to its length.

8. June/2021/Paper_12/No.32

A wedge-shaped metal conductor of length L , varying width and uniform thickness is connected to a cell, as shown.

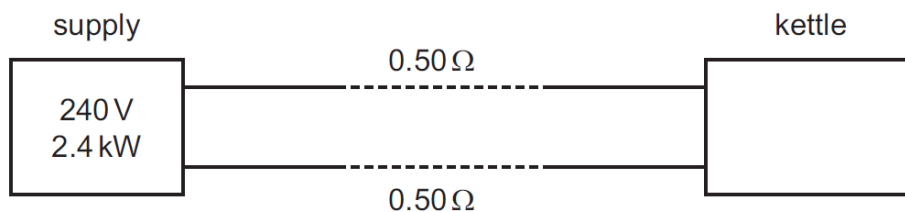


Which graph best shows how the average drift velocity v of electrons in the conductor varies with distance x from end X?



9. June/2021/Paper_12/No.33

The power output of an electrical supply is 2.4 kW at a potential difference (p.d.) of 240 V. The two wires between the supply and a kettle each have a resistance of $0.50\ \Omega$, as shown.

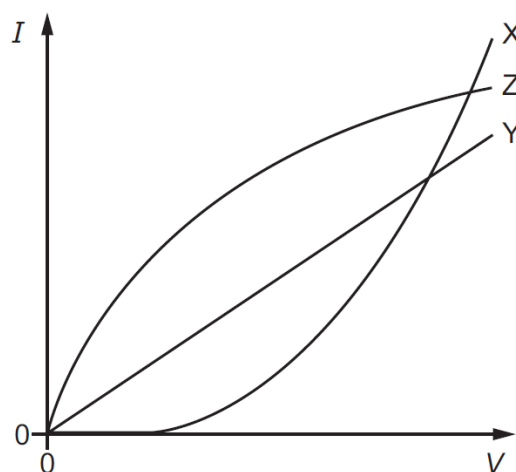


What is the power supplied to the kettle and what is the p.d. across the kettle?

	power / kW	p.d. / V
A	2.3	230
B	2.3	235
C	2.4	230
D	2.4	235

10. June/2021/Paper_12/No.34

The graph shows the variation with potential difference V of the current I in components X, Y and Z.



Which row correctly identifies the components?

	metallic conductor at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	Y	X

11. June/2021/Paper_12/No.35

A wire of resistance $9.55\ \Omega$ has a diameter of $0.280\ \text{mm}$.

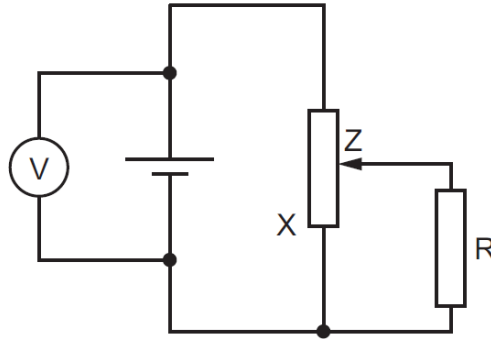
It is made of metal of resistivity $4.90 \times 10^{-7}\ \Omega\text{m}$.

What is the length of the wire?

- A 1.20 m B 4.80 m C 19.0 m D 76.0 m

12. June/2021/Paper_12/No.36

A cell of constant electromotive force (e.m.f.) but with internal resistance is connected to a fixed resistor R using a potentiometer. A voltmeter measures the potential difference (p.d.) between the terminals of the cell.



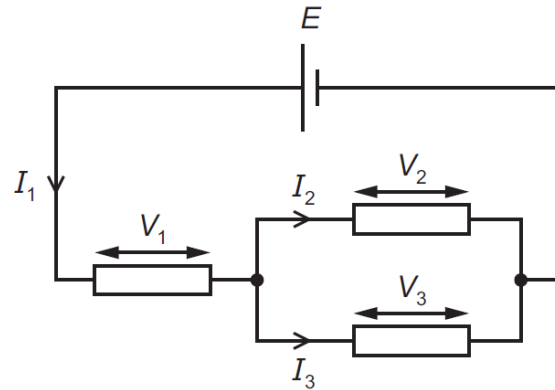
Which statement explains the change to the reading of the voltmeter as contact Z is moved towards end X of the potentiometer?

- A The voltmeter reading decreases because the current through the cell decreases.
B The voltmeter reading decreases because the current through the cell increases.
C The voltmeter reading increases because the current through the cell decreases.
D The voltmeter reading increases because the current through the cell increases.

13. June/2021/Paper_12/No.37

A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected to a circuit.

The circuit has currents I_1 , I_2 and I_3 , and potential differences V_1 , V_2 and V_3 , as shown.

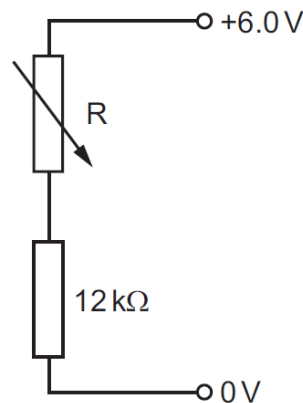


Which equation represents a statement of Kirchhoff's first law?

- A** $I_1 = I_2 + I_3$ **B** $I_1 = I_2 = I_3$ **C** $E = V_1 + V_2$ **D** $V_1 = V_2 = V_3$

14. June/2021/Paper_12/No.38

Two resistors are connected in series with a 6.0 V power supply, as shown.



What is the resistance of the variable resistor R to give a potential difference of 1.0 V across the $12\text{ k}\Omega$ resistor?

- A** $2.0\text{ k}\Omega$ **B** $10\text{ k}\Omega$ **C** $60\text{ k}\Omega$ **D** $72\text{ k}\Omega$

15. Nov/2021/Paper_11/No.32

The current I in a wire is given by the equation

$$I = nAvq$$

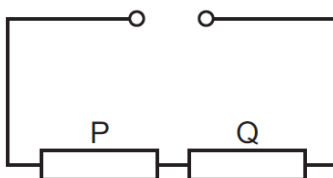
where n is the number density of the free electrons, A is the cross-sectional area of the wire, v is the average drift velocity of the free electrons and q is the charge of an electron.

Which relationship is **not** used in the derivation of this equation?

- A charge = current $\times$ time
- B distance = speed $\times$ time
- C number = number density $\times$ area
- D volume = length $\times$ area

16. Nov/2021/Paper_11/No.33

A circuit contains two resistors, P and Q, and a power supply of negligible internal resistance, as shown.



The current in resistor P is 2.0 A and the power dissipated by resistor P is 18 W.

Resistor Q dissipates 240 J of energy when a charge of 40 C passes through it.

What is the electromotive force (e.m.f.) of the power supply?

- A 3.0 V
- B 6.0 V
- C 9.0 V
- D 15 V

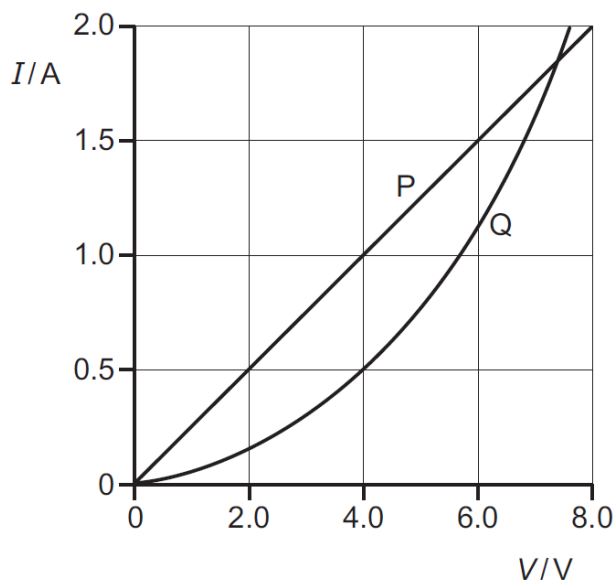
17. Nov/2021/Paper_11/No.35

What is the circuit symbol for an oscilloscope?



18. Nov/2021/Paper_11/No.34

The I – V characteristics of two electrical components P and Q are shown.



Which statement is correct?

- A For a current of 0.5 A, the power dissipated in Q is double that in P.
- B For a current of 1.9 A, the resistance of Q is approximately half that of P.
- C The resistance of Q increases as the current in it increases.
- D P is a fixed resistor and Q is a filament lamp.

19. Nov/2021/Paper_11/No.35

Two copper wires S and T, of equal length, are connected in parallel. Wire S has a diameter of 3.0 mm. Wire T has a diameter of 1.5 mm.

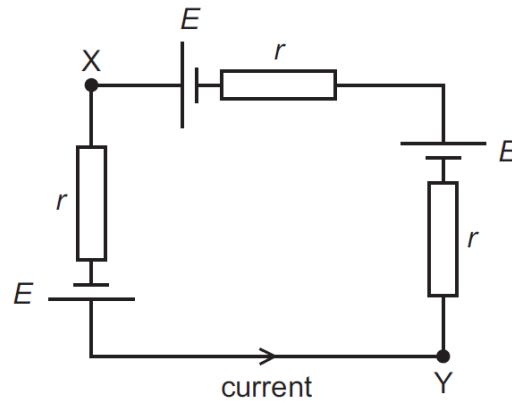
A potential difference is applied across the ends of this parallel arrangement.

What is the value of the ratio $\frac{\text{current in S}}{\text{current in T}}$?

- A $\frac{1}{4}$
- B $\frac{1}{2}$
- C 2
- D 4

20. Nov/2021/Paper_11/No.37

Three identical cells, each of electromotive force (e.m.f.) E and internal resistance r , are connected as shown.

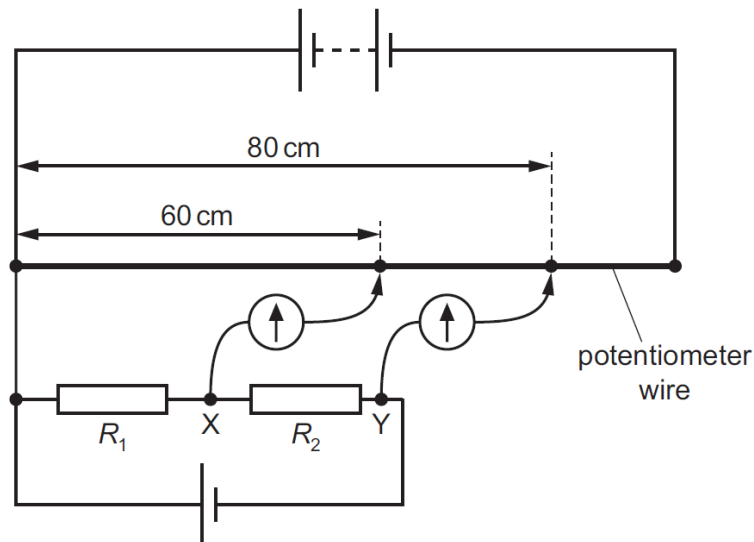


What is the potential difference between points X and Y?

- A 0 B E C $2E$ D $3E$

21. Nov/2021/Paper_11/No.38

Potential differences across two resistors of resistances R_1 and R_2 are compared using a potentiometer wire (uniform resistance wire) in the electrical circuit shown.



One terminal of a galvanometer is connected to point X. The galvanometer reads zero when its other terminal is connected to a point that is a distance of 60 cm from one end of the potentiometer wire.

One terminal of a second galvanometer is connected to point Y. This galvanometer reads zero when its other terminal is connected to a point that is a distance of 80 cm from the same end of the potentiometer wire.

What is the ratio $\frac{R_2}{R_1}$?

- A $\frac{1}{3}$ B $\frac{3}{4}$ C $\frac{3}{1}$ D $\frac{4}{3}$

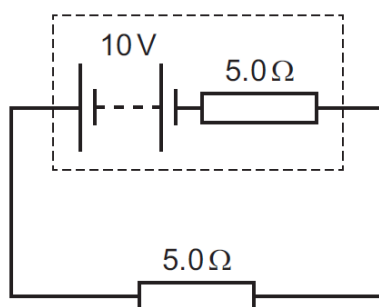
22. Nov/2021/Paper_12/No.33

What is a description of the coulomb?

- A the electric charge of one electron
- B the electric charge transferred by a current of one ampere in one second
- C the kinetic energy gained by an electron accelerated through a potential difference of one volt
- D the kinetic energy of an electron moving at a speed of one metre per second

23. Nov/2021/Paper_12/No.34

A battery of electromotive force (e.m.f.) 10 V and internal resistance $5.0\ \Omega$ is connected to a $5.0\ \Omega$ load resistor.

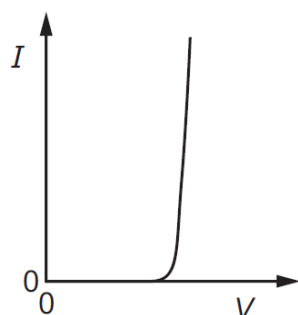


Which change occurs when the $5.0\ \Omega$ load resistor is replaced with a $50\ \Omega$ load resistor?

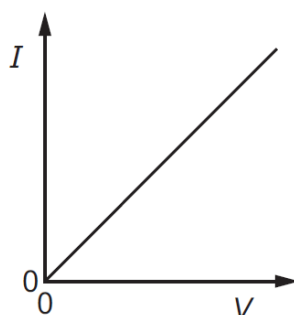
- A The current in the circuit increases.
- B The potential difference across the load resistor increases.
- C The power dissipated in the internal resistance of the battery increases.
- D The total power dissipated in the circuit increases.

24. Nov/2021/Paper_12/No.35

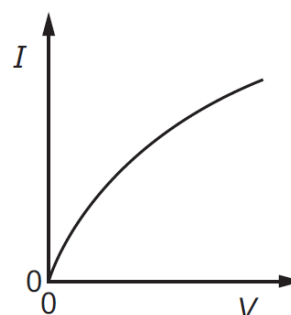
The graphs show the variation with potential difference V of the current I for three circuit components.



graph X



graph Y



graph Z

The components are a metal wire at constant temperature, a semiconductor diode and a filament lamp.

Which row correctly identifies these graphs?

	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

25. Nov/2021/Paper_12/No.36

The electromotive force (e.m.f.) of a cell is 6.0 V . It has negligible internal resistance and is connected across a resistor. The potential difference (p.d.) across the resistor is also 6.0 V .

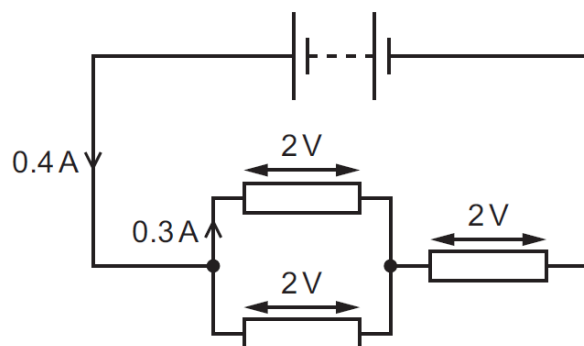
The e.m.f. and the p.d. have the same numerical value but represent different processes.

Which statement about the different processes is correct?

- A** The e.m.f. is the energy transferred from chemical energy to electrical energy in the cell and the p.d. is the energy transferred from electrical energy to thermal energy in the resistor.
- B** The p.d. is the energy transferred from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred from electrical energy to thermal energy in the resistor.
- C** The e.m.f. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the p.d. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.
- D** The p.d. is the energy transferred per unit charge from chemical energy to electrical energy in the cell and the e.m.f. is the energy transferred per unit charge from electrical energy to thermal energy in the resistor.

26. Nov/2021/Paper_12/No.37

A battery of negligible internal resistance is connected to three resistors, as shown.



The potential difference across each resistor is 2 V.

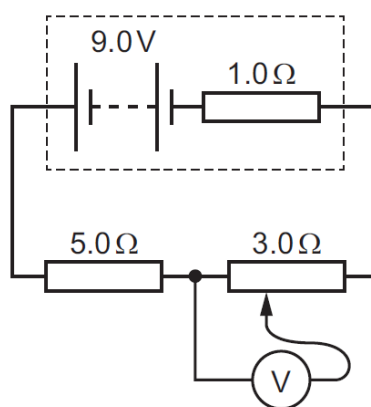
The current from the battery is 0.4 A and the current through one of the resistors connected in parallel is 0.3 A.

What is the current through the other resistor connected in parallel and what is the electromotive force (e.m.f.) of the battery?

	current / A	e.m.f. / V
A	0.1	4
B	0.3	4
C	0.1	6
D	0.3	6

27. Nov/2021/Paper_12/No.38

A battery of electromotive force (e.m.f.) 9.0 V and internal resistance 1.0Ω is connected to a fixed resistor of resistance 5.0Ω and a potentiometer of maximum resistance 3.0Ω , as shown.



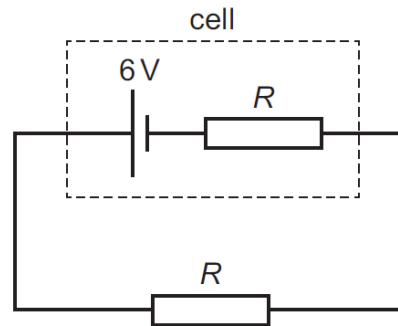
The sliding contact of the potentiometer is moved over its full range of movement.

What is the maximum value of the potential difference that is measured by the voltmeter?

- A** 3.0 V **B** 3.4 V **C** 4.5 V **D** 5.4 V

28. Nov/2021/Paper_13/No.34

A cell has an electromotive force (e.m.f.) of 6 V and internal resistance R . An external resistor, also of resistance R , is connected across this cell, as shown.



Power P is dissipated by the external resistor.

The cell is replaced by a different cell that has an e.m.f. of 6 V and negligible internal resistance.

What is the new power that is dissipated in the external resistor?

- A $0.5P$ B P C $2P$ D $4P$

29. Nov/2021/Paper_13/No.35

A wire of uniform cross-section has resistance R .

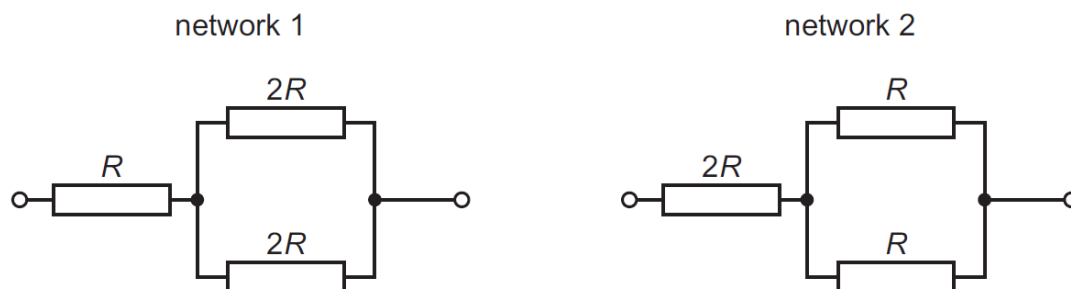
A second wire is made of the same material but is twice as long and has twice the diameter of the first wire.

What is the resistance of the second wire?

- A $\frac{R}{8}$ B $\frac{R}{2}$ C R D $8R$

30. Nov/2021/Paper_13/No.36

The diagram shows two resistor networks.

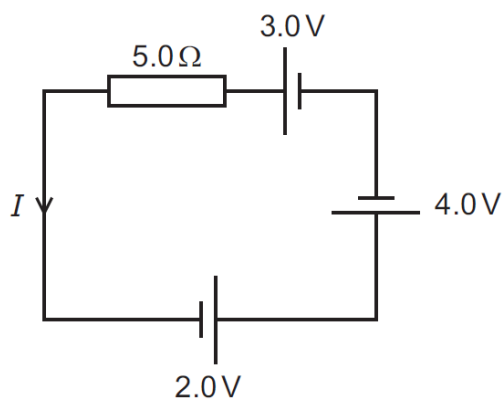


What is the ratio $\frac{\text{total resistance of network 1}}{\text{total resistance of network 2}}$?

- A $\frac{4}{5}$ B $\frac{5}{4}$ C $\frac{1}{2}$ D $\frac{2}{1}$

31. Nov/2021/Paper_13/No.37

The circuit shown contains three cells of electromotive forces 3.0 V, 2.0 V and 4.0 V, in series with a resistor of resistance 5.0Ω . The cells have negligible internal resistance.



What is the current I in the circuit?

A 0.20 A

B 0.60 A

C 1.0 A

D 1.8 A

1. Nov/2021/Paper_21/No.5

(a) State Kirchhoff's first law.

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

(b) The circuit shown in Fig. 5.1 contains a battery of electromotive force (e.m.f.) E and negligible internal resistance connected to four resistors R_1 , R_2 , R_3 and R_4 , each of resistance R .

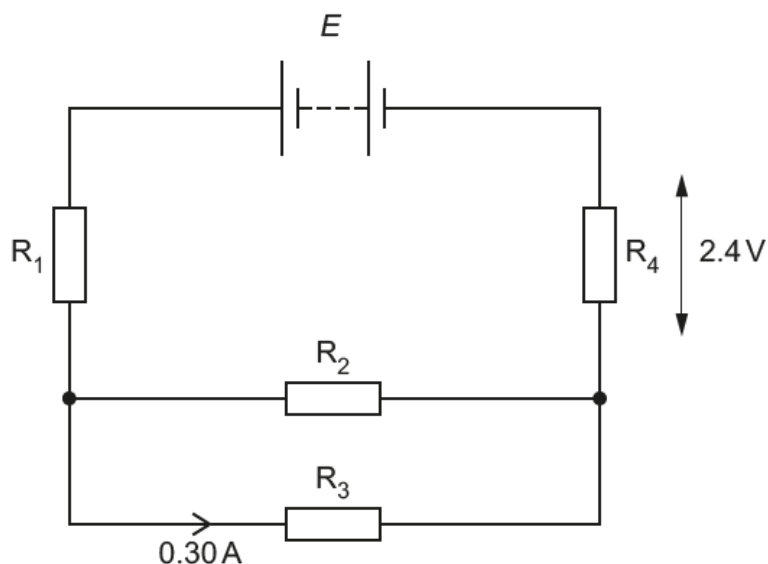


Fig. 5.1

The current in R_3 is 0.30 A and the potential difference (p.d.) across R_4 is 2.4 V .

(i) Show that R is equal to $4.0\ \Omega$.

[2]

(ii) Determine the e.m.f. E of the battery.

$E = \dots\dots\dots\text{ V}$ [2]

- (c) The battery in (b) is replaced with another battery of the same e.m.f. E but with an internal resistance that is not negligible.

State and explain the change, if any, in the total power produced by the battery.

.....

.....

..... [2]

- (d) The resistors in the circuit of Fig. 5.1 are made from nichrome wire of uniform radius $240\text{ }\mu\text{m}$. The length of this wire needed to make each resistor is 0.67 m .

Calculate the resistivity of nichrome.

resistivity = ... $\Omega\text{ m}$ [3]

[Total: 11]

A cell of electromotive force (e.m.f.) 0.48 V is connected to a metal wire X, as shown in Fig. 6.1.

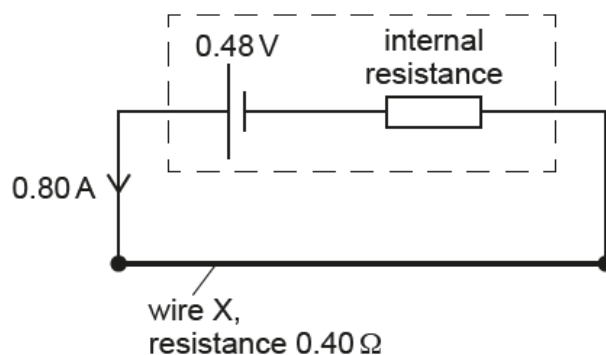


Fig. 6.1

The cell has internal resistance. The current in the cell is 0.80 A .

Wire X has length 3.0 m , cross-sectional area $1.3 \times 10^{-7}\text{ m}^2$ and resistance $0.40\ \Omega$.

(a) Calculate the charge passing through the cell in a time of 7.5 minutes .

charge = ... C [2]

(b) Calculate the percentage efficiency with which the cell supplies power to wire X.

efficiency = ... % [3]

- (c) There are 3.2×10^{22} free (conduction) electrons contained in the volume of wire X.

For wire X, calculate:

- (i) the number density n of the free electrons

$$n = \dots\dots\dots \text{m}^{-3} \quad [1]$$

- (ii) the average drift speed of the free electrons.

$$\text{average drift speed} = \dots\dots\dots \text{ms}^{-1} \quad [2]$$

- (d) A wire Y has the same cross-sectional area as wire X and is made of the same metal. Wire Y is longer than wire X.

Wire X in the circuit is now replaced by wire Y. Assume that wire Y has the same temperature as wire X.

State and explain whether the average drift speed of the free electrons in wire Y is greater than, the same as, or less than that in wire X.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 11]

- (a) A resistance wire of uniform cross-sectional area $3.3 \times 10^{-7} \text{ m}^2$ and length 2.0 m is made of metal of resistivity $5.0 \times 10^{-7} \Omega \text{ m}$.

Show that the resistance of the wire is 3.0Ω .

[2]

- (b) The ends of the resistance wire in (a) are connected to the terminals X and Y in the circuit shown in Fig. 6.1.

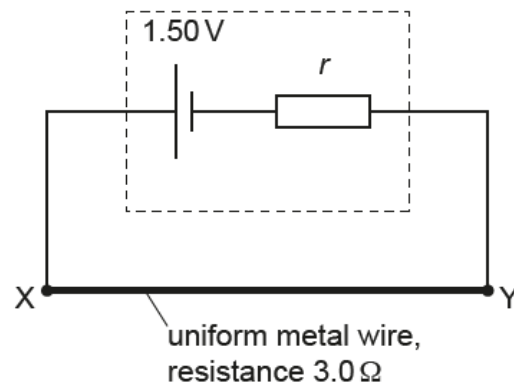


Fig. 6.1

The cell has an electromotive force (e.m.f.) of 1.50 V and internal resistance r . The potential difference between X and Y is 1.20 V.

Calculate:

- (i) the current in the circuit

current = ... A [1]

- (ii) the internal resistance r .

$r =$ Ω [2]

- (c) A galvanometer and a cell of e.m.f. E with negligible internal resistance are connected to the circuit in (b), as shown in Fig. 6.2.

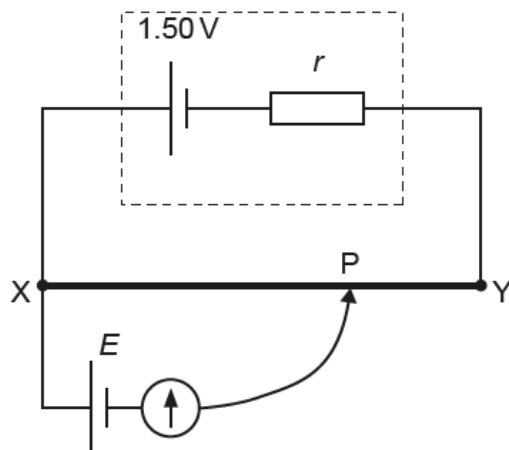


Fig. 6.2

The resistance wire between X and Y has a length of 2.0 m. The galvanometer has a reading of zero when the connection P is adjusted so that the length XP is 1.4 m.

Determine the e.m.f. E of the cell.

$$E = \dots\dots\dots \text{ V [2]}$$

- (d) The circuit in Fig. 6.2 is modified by replacing the original resistance wire with a second resistance wire. The second wire has the same length as the original wire and is made of the same metal.

The second wire has a smaller cross-sectional area than the original wire.

Connection P is adjusted on the second wire so that the galvanometer has a reading of zero.

State and explain whether length XP for the second wire is shorter than, longer than or the same as length XP for the original wire when the galvanometer reading is zero.

.....

.....

.....

.....

..... [3]

[Total:10]

(a) State Kirchhoff's second law.

.....

 [2]

(b) A battery has electromotive force (e.m.f.) 4.0V and internal resistance 0.35Ω . The battery is connected to a uniform resistance wire XY and a fixed resistor of resistance R , as shown in Fig. 5.1.

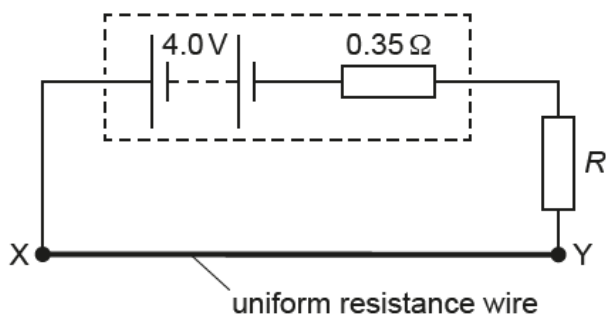


Fig. 5.1

Wire XY has resistance 0.90Ω . The potential difference across wire XY is 1.8V .

Calculate:

(i) the current in wire XY

current = ... A [1]

(ii) the number of free electrons that pass a point in the battery in a time of 45s

number = ... [2]

(iii) resistance R .

$R = \dots\dots\dots \Omega$ [2]

(c) A cell of e.m.f. 1.2 V is connected to the circuit in (b), as shown in Fig. 5.2.

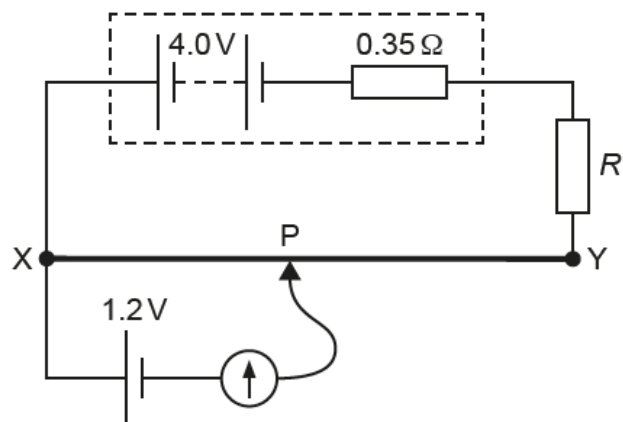


Fig. 5.2

The connection P is moved along the wire XY. The galvanometer reading is zero when distance XP is 0.30 m.

- (i) Calculate the total length L of wire XY.

$L = \dots\dots\dots$ m [2]

- (ii) The fixed resistor is replaced by a different fixed resistor of resistance greater than R .

State and explain the change, if any, that must be made to the position of P on wire XY so that the galvanometer reading is zero.

.....

.....

.....

..... [2]

[Total: 11]

(a) Define the *ohm*.

.....
 [1]

(b) A wire is made of metal of resistivity ρ . The length L of the wire is gradually increased. Assume that the volume V of the wire remains constant as its length is increased.

Show that the resistance R of the extending wire is proportional to L^2 .

[2]

(c) A battery of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R , as shown in Fig. 5.1.

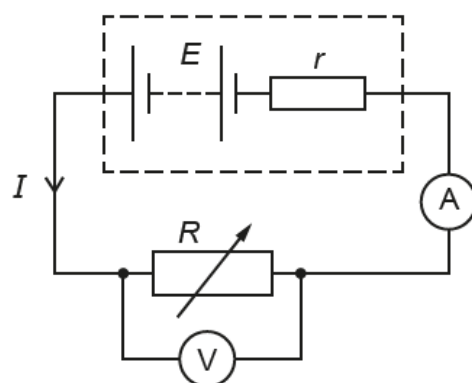


Fig. 5.1

An ammeter measures the current I in the circuit. A voltmeter measures the potential difference V across the variable resistor.

The resistance R is now varied to change the values of I and V .

The variation with I of V is shown in Fig. 5.2.

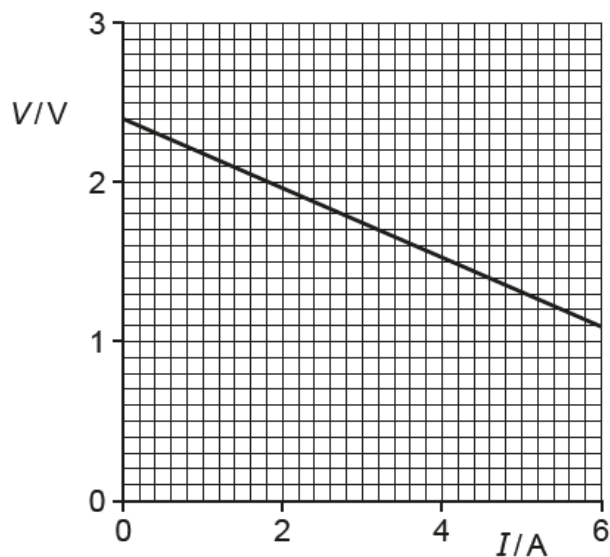


Fig. 5.2

- (i) Use Fig. 5.2 to state the e.m.f. E of the battery.

$E =$ V [1]

- (ii) Use Fig. 5.2 to determine the power dissipated in the variable resistor when there is a current of 5.0A.

power = ... W [3]

- (iii) State what is represented by the value of the gradient of the graph.

..... [1]

[Total: 8]

(a) Define the *electromotive force (e.m.f.)* of a source.

.....

 [2]

(b) The circuit shown in Fig. 5.1 contains a battery of e.m.f. E that has internal resistance r , a variable resistor, a voltmeter and an ammeter.

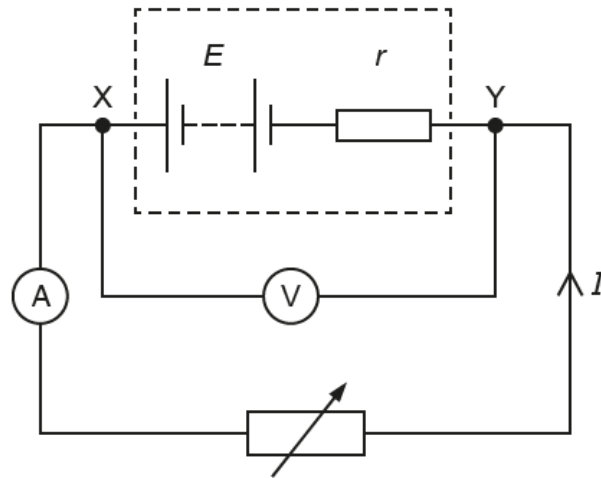


Fig. 5.1

Readings from the two meters are taken for different settings of the variable resistor. The variation with current I of the potential difference (p.d.) V across the terminals XY of the battery is shown in Fig. 5.2.

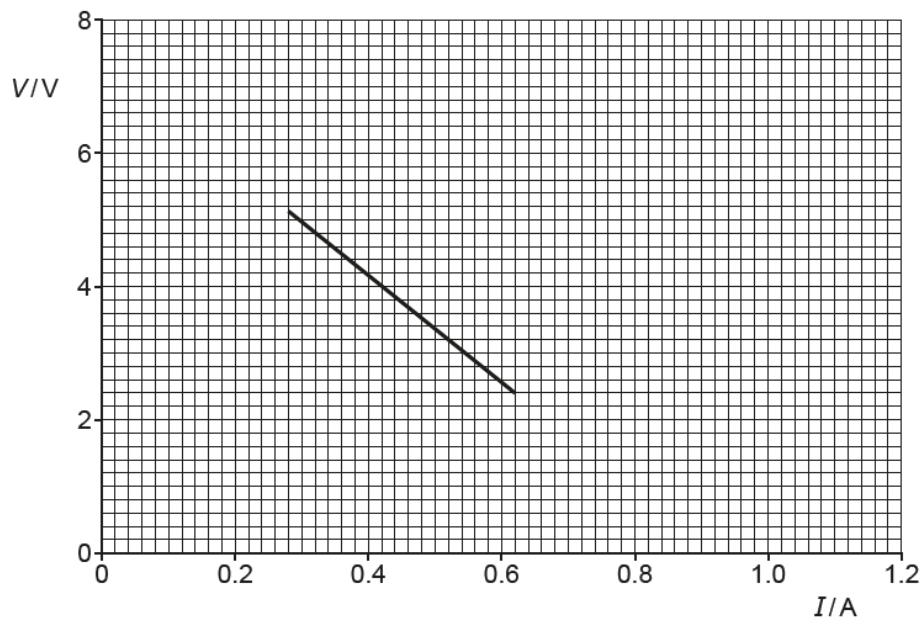


Fig. 5.2

Explain why V is not constant.

.....

.....

.....

..... [3]

(c) For the battery in (b), use Fig. 5.2 to determine:

(i) the e.m.f. E

$$E = \text{..... V [1]}$$

(ii) the maximum current that the battery can supply

$$\text{maximum current} = \text{..... A [1]}$$

(iii) the internal resistance r .

$$r = \text{..... } \Omega \text{ [2]}$$

(d) On Fig. 5.2, sketch a line to show a possible variation with I of V for a battery with a lower e.m.f. and a lower internal resistance than the battery in (b). Your line should extend over at least the same range of currents as the original line. [2]

[Total: 11]

(a) State Kirchhoff's first law.

.....
 [1]

(b) A battery of electromotive force (e.m.f.) 12.0V and internal resistance r is connected to a filament lamp and a resistor, as shown in Fig. 6.1.

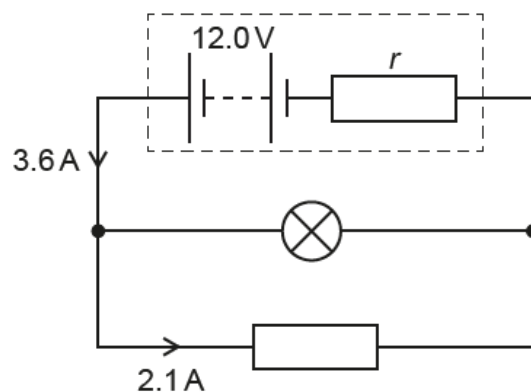


Fig. 6.1

The current in the battery is 3.6A and the current in the resistor is 2.1A. The I - V characteristic for the lamp is shown in Fig. 6.2.

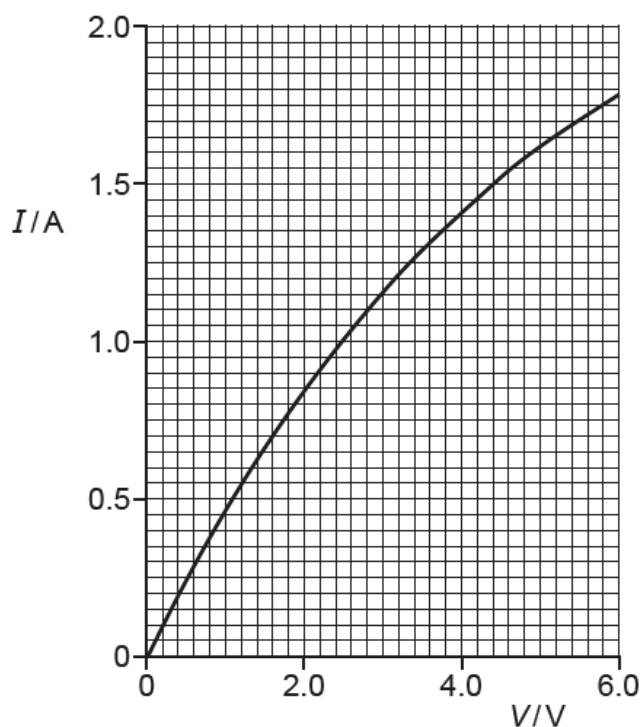


Fig. 6.2

- (i) Determine the resistance of the lamp in Fig. 6.1.

resistance = ... Ω [3]

- (ii) Determine the internal resistance r of the battery.

$r =$ Ω [2]

- (iii) The initial energy stored in the battery is 470 kJ. Assume that the e.m.f. and the current in the battery do not change with time.

Calculate the time taken for the energy stored in the battery to become 240 kJ.

time = ... s [2]

- (iv) The filament wire of the lamp is connected in series with the adjacent copper connecting wire of the circuit, as illustrated in Fig. 6.3.

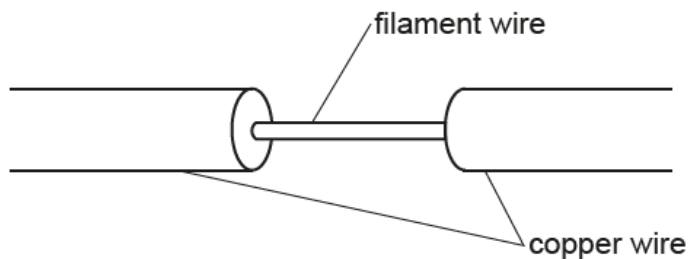


Fig. 6.3 (not to scale)

Some data for the filament wire and the adjacent copper connecting wire are given in Table 6.1.

Table 6.1

	filament wire	copper wire
cross-sectional area	A	$360A$
number density of free electrons	n	$2.5n$

Calculate the ratio

$$\frac{\text{average drift speed of free electrons in filament wire}}{\text{average drift speed of free electrons in copper wire}} .$$

ratio = ... [2]

[Total: 10]

1. **June/2023/Paper_ 9702/11/No.30**

The electric current in a metal wire is 4.0 mA.

How many electrons pass a fixed point in the wire in a time of 10 hours?

- A** 2.5×10^{17} **B** 2.5×10^{20} **C** 9.0×10^{20} **D** 9.0×10^{23}

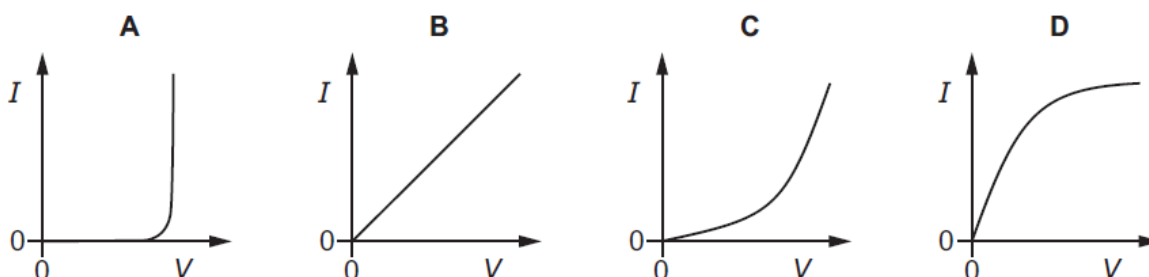
2. **June/2023/Paper_ 9702/11/No.31**

What is the definition of the potential difference across an electrical component?

- A** the charge per unit time passing through the component
B the energy transferred per unit charge
C the force per unit charge
D the resistance per unit current

3. **June/2023/Paper_ 9702/11/No.32**

Which graph shows the I – V characteristic of a filament lamp?



4. **June/2023/Paper_ 9702/11/No.33**

A metal wire has a length of 2.50 m and a cross-sectional area of $4.50 \times 10^{-6} \text{ m}^2$. The resistivity of the metal is $3.50 \times 10^{-7} \Omega \text{ m}$.

The wire is stretched so that its length increases to 2.65 m. The wire remains cylindrical and the **volume** of the wire remains constant.

What is the change in the resistance of the wire?

- A** 0.012Ω **B** 0.024Ω **C** 0.19Ω **D** 0.22Ω

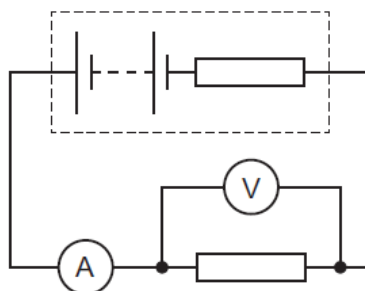
5. June/2023/Paper_9702/11/No.34

Which circuit symbol represents a microphone?



6. June/2023/Paper_9702/11/No.35

A battery with internal resistance is connected to a fixed resistor, an ammeter and a voltmeter, as shown.



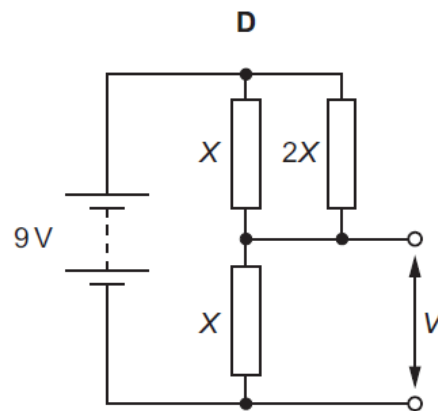
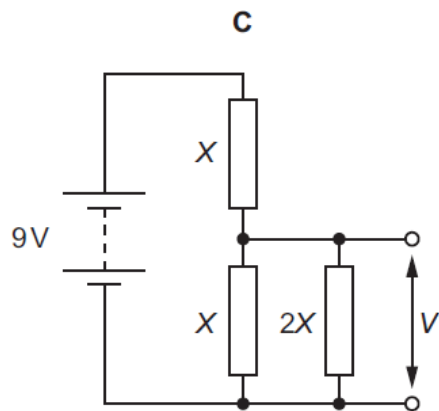
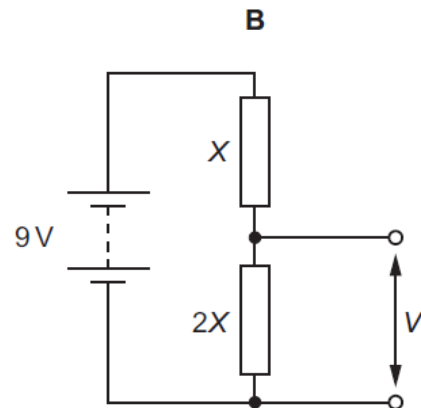
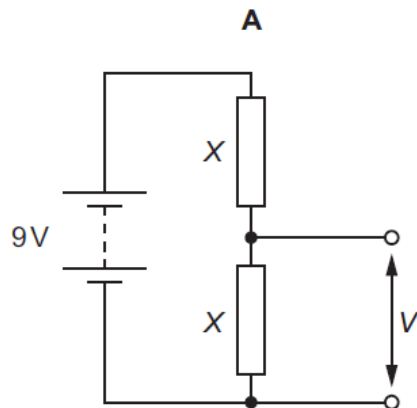
The battery is replaced by a different battery that has the same electromotive force (e.m.f.) but a greater internal resistance.

What happens to the readings on the ammeter and voltmeter?

	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	stays the same	decreases
D	stays the same	stays the same

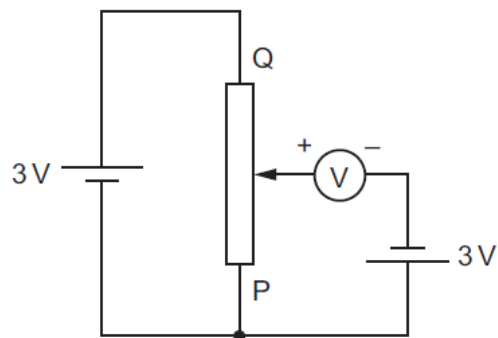
Four potential divider circuits each consist of a battery of electromotive force (e.m.f.) 9 V and negligible internal resistance connected to a combination of resistors. Each of the resistors in the circuits has a resistance of X or $2X$.

Which circuit has the largest output voltage V ?



8. June/2023/Paper_9702/11/No.37

A voltmeter is connected into a circuit with the polarity shown.



The sliding contact is moved to end P of the potentiometer and then to end Q.

What are the two readings of the voltmeter?

	sliding contact at end P	sliding contact at end Q
A	0 V	3 V
B	0 V	6 V
C	3 V	3 V
D	3 V	6 V

9. June/2023/Paper_9702/12/No.30

Which charge can be carried by a charge carrier?

- A** $1.1 \times 10^{-19} \text{ C}$
- B** $4.0 \times 10^{-19} \text{ C}$
- C** $4.8 \times 10^{-19} \text{ C}$
- D** $9.1 \times 10^{-19} \text{ C}$

10. June/2023/Paper_9702/12/No.31

A resistor of resistance R is connected across a cell of electromotive force (e.m.f.) E and negligible internal resistance.

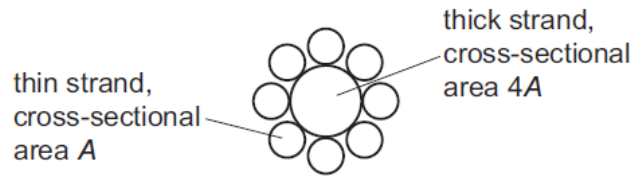
Which single change to the circuit would lead to the largest increase in the power dissipated in the resistor?

- A** doubling the value of E
- B** doubling the value of R
- C** halving the value of E
- D** halving the value of R

11. June/2023/Paper_9702/12/No.32

An electrical cable is made up of one thick strand of copper wire that is surrounded by eight thin strands of copper wire. All nine strands of wire are connected in parallel with each other.

A cross-section of the cable is shown.



Each thin strand of wire has cross-sectional area A and length L .

The thick strand of wire has cross-sectional area $4A$ and length L .

The cable has total resistance R .

Which expression gives the resistivity of copper?

A $\frac{4A}{33RL}$

B $\frac{12A}{RL}$

C $\frac{4AR}{L}$

D $\frac{12AR}{L}$

12. June/2023/Paper_9702/12/No.33

A car has sensors for detecting the light intensity and temperature of its environment.

The sensors make use of a light-dependent resistor (LDR) and a thermistor.

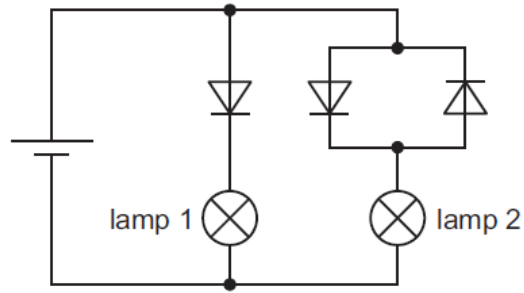
The car moves from a warm and dark environment into a cold and bright environment.

What are the changes to the resistances of the LDR and thermistor?

	resistance of LDR	resistance of thermistor
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

13. June/2023/Paper_ 9702/12/No.34

A student assembles the circuit shown.



Which row describes the state of the two lamps?

	lamp 1	lamp 2
A	off	off
B	on	off
C	off	on
D	on	on

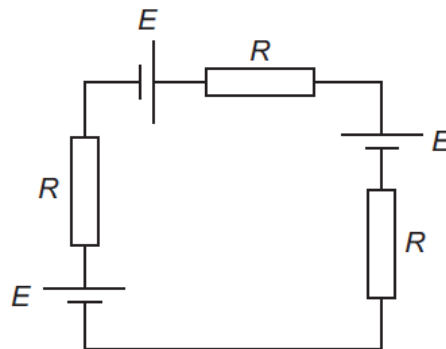
14. June/2023/Paper_ 9702/12/No.35

Kirchhoff's first law is a consequence of the conservation of which quantity?

- A** charge
- B** energy
- C** momentum
- D** potential difference

15. June/2023/Paper_ 9702/12/No.36

Three identical cells each have electromotive force (e.m.f.) E and negligible internal resistance. The cells are connected to three identical resistors, each of resistance R , as shown.

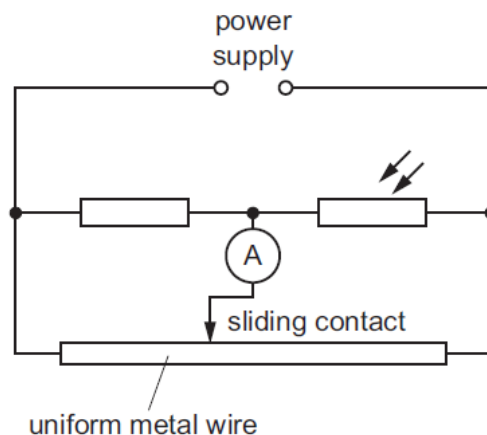


What is the potential difference across one of the resistors?

- A** 0
- B** $\frac{E}{3}$
- C** $\frac{2E}{3}$
- D** E

16. June/2023/Paper_9702/12/No.37

In the potentiometer circuit shown, the reading on the ammeter is zero.



The light-dependent resistor (LDR) is then covered and the ammeter gives a non-zero reading.

Which change could return the ammeter reading to zero?

- A decreasing the supply voltage
- B increasing the supply voltage
- C moving the sliding contact to the left
- D moving the sliding contact to the right

17. June/2023/Paper_9702/13/No.30

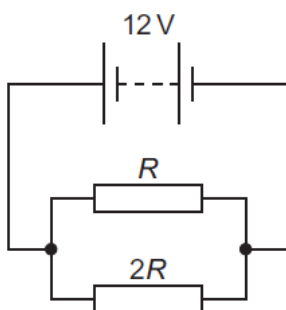
A metal wire is connected between the terminals of a cell so that there is a current in the wire.

Which statement is correct?

- A Negatively charged electrons in the wire move from the negative terminal to the positive terminal.
- B Negatively charged nuclei in the wire move from the negative terminal to the positive terminal.
- C Positively charged electrons in the wire move from the positive terminal to the negative terminal.
- D Positively charged nuclei in the wire move from the positive terminal to the negative terminal.

18. June/2023/Paper_9702/13/No.31

Two resistors of resistances R and $2R$ are connected in parallel with a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance.



The total power dissipated by the two resistors is 36 W .

What is the value of R ?

- A** $0.50\ \Omega$ **B** $2.7\ \Omega$ **C** $4.0\ \Omega$ **D** $6.0\ \Omega$

19. June/2023/Paper_9702/13/No.32

A wire has a length of 3.0 m and is made of metal of resistivity $4.9 \times 10^{-7}\ \Omega\text{ m}$.

A potential difference (p.d.) of 12 V is applied across the wire so that it has a current of 1.4 A .

What is the cross-sectional area of the wire?

- A** $1.2 \times 10^{-7}\text{ m}^2$
B $1.7 \times 10^{-7}\text{ m}^2$
C $1.1 \times 10^{-6}\text{ m}^2$
D $1.3 \times 10^{-5}\text{ m}^2$

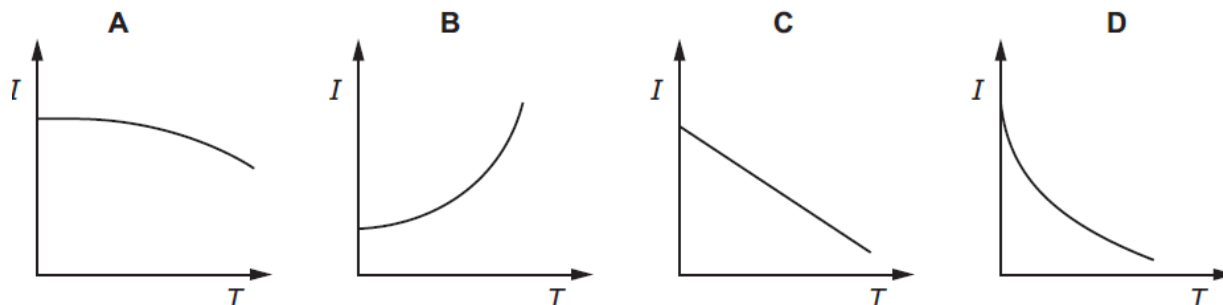
20. June/2023/Paper_9702/13/No.33

A cell of negligible internal resistance is connected in series with a thermistor, a fixed resistor and an ammeter.

The thermistor is placed in a beaker of water and the temperature of the water is slowly increased.

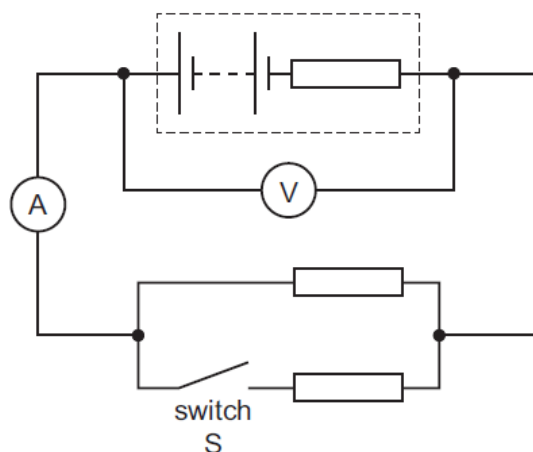
A graph of current I against the temperature T of the thermistor is plotted.

Which graph could show the variation of I with T ?



21. June/2023/Paper_9702/13/No.34

A battery with internal resistance is connected to a parallel arrangement of two resistors and a switch S , as shown.



Initially, switch S is open.

What happens to the voltmeter and ammeter readings when switch S is closed?

	voltmeter reading	ammeter reading
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

22. June/2023/Paper_9702/13/No.35

Kirchhoff's first law states that the sum of the currents entering a junction in a circuit is equal to the sum of the currents leaving it.

The law is based on the conservation of a physical quantity.

What is this physical quantity?

- A charge
- B energy
- C mass
- D momentum

23. June/2023/Paper_9702/13/No.36

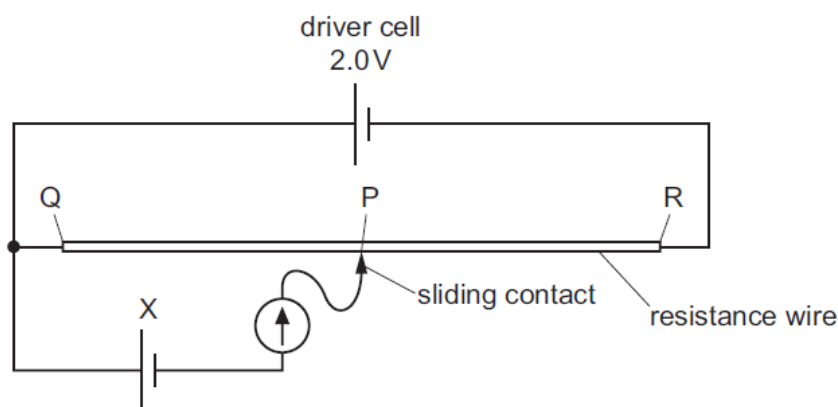
Two resistors have a combined resistance of $34\ \Omega$ when connected in series. The same resistors have a combined resistance of $7.4\ \Omega$ when connected in parallel.

What is the resistance of one of the resistors?

- A $15\ \Omega$ B $17\ \Omega$ C $23\ \Omega$ D $27\ \Omega$

24. June/2023/Paper_9702/13/No.37

A potentiometer circuit is used to investigate the electromotive force (e.m.f.) of a cell X.



The e.m.f. of cell X is known to be approximately 0.50 V .

The driver cell has negligible internal resistance and an e.m.f. of 2.0 V . The sliding contact is moved along the uniform resistance wire between ends Q and R to a point P where the reading on the galvanometer is zero.

What is an expression for the approximate length QP?

- A $\frac{QR}{4}$ B $\frac{QR}{3}$ C $\frac{2QR}{3}$ D $\frac{3QR}{4}$

25. June/2023/Paper_9702/21/No.6

A metal wire in a circuit has a length of 1.8 m and a cross-sectional area of $1.5 \times 10^{-6} \text{ m}^2$.
The total number of free electrons (charge carriers) in the wire is 2.3×10^{23} .

There is a current in the wire so that a charge of 172 C moves past a fixed point in the wire in a time of 2.5 minutes.

(a) Show that the number density of the free electrons in the wire is $8.5 \times 10^{28} \text{ m}^{-3}$.

[1]

(b) Calculate the average drift speed of the free electrons.

average drift speed = ... ms^{-1} [3]

[Total: 4]

A battery of electromotive force (e.m.f.) 9.6 V and negligible internal resistance is connected in series with two fixed resistors and a thermistor, as shown in Fig. 7.1.

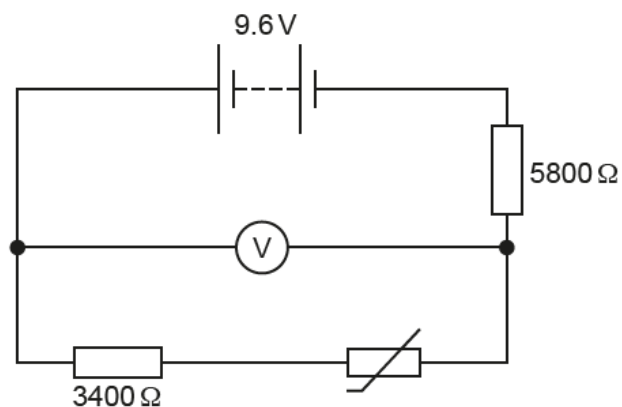


Fig. 7.1

The fixed resistors have resistances of $3400\ \Omega$ and $5800\ \Omega$. The reading on the voltmeter in the circuit is 6.0 V .

- (a) Calculate the current in the resistor of resistance $5800\ \Omega$.

current = ...A [2]

- (b) Calculate the resistance of the thermistor.

resistance = ... Ω [2]

- (c) The initial energy stored in the battery is $2.6 \times 10^4 \text{ J}$.

Assume that the e.m.f. of the battery is constant.

Determine the final energy stored in the battery after a charge of 330 C has moved through it.

final stored energy = ... J [2]

- (d) The environmental conditions change causing an increase in the resistance of the thermistor.

State whether there is a decrease, increase or no change to:

- (i) the temperature of the thermistor

..... [1]

- (ii) the current in the thermistor

..... [1]

- (iii) the potential difference across the thermistor.

..... [1]

[Total: 9]

- (a) The current in a filament lamp decreases.

State and explain how the resistance of the lamp changes.

.....
 [1]

- (b) A cylindrical wire has length L and resistance R . The **total** number of free electrons (charge carriers) contained in the volume of the wire is N . Each free electron has charge e . The potential difference between the ends of the wire is V .

Determine expressions, in terms of some or all of the symbols e , L , N , R and V for:

- (i) the current in the wire

current = ... [1]

- (ii) the average drift speed of the free electrons

average drift speed = ... [2]

- (iii) the average time taken for a free electron to move along the full length of the wire.

time taken = ... [1]

[Total: 5]

- (a) A battery of electromotive force (e.m.f.) 9.0 V and negligible internal resistance is connected to a light-dependent resistor (LDR) and a fixed resistor, as shown in Fig. 7.1.

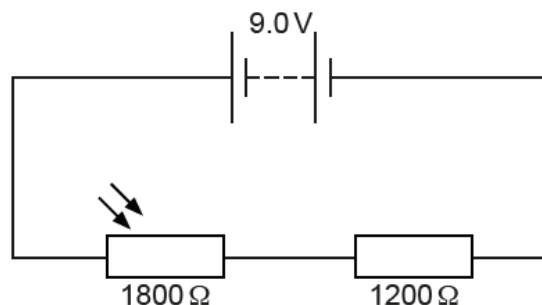


Fig. 7.1

The LDR and fixed resistor have resistances of $1800\ \Omega$ and $1200\ \Omega$ respectively.

Calculate the potential difference across the LDR.

potential difference = ... V [2]

- (b) The circuit in (a) is now modified by adding a uniform resistance wire XY and a galvanometer, as shown in Fig. 7.2.

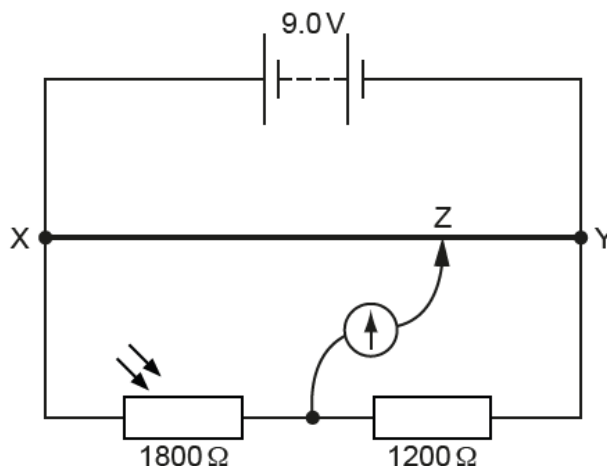


Fig. 7.2 (not to scale)

The length of the wire XY is 1.2 m . The movable connection Z is positioned on the wire XY so that the galvanometer reading is zero.

- (i) Calculate the length XZ along the resistance wire.

length XZ = ...m [2]

- (ii) The environmental conditions change causing a decrease in the resistance of the LDR. The temperature of the LDR remains constant.

State whether there is a decrease, increase or no change to:

- the intensity of the light illuminating the LDR

.....

- the total power produced by the battery

.....

- the length XZ so that the galvanometer reads zero.

.....

[3]

[Total: 7]

A student sets up a circuit with a battery, an ammeter, a heater and a light-dependent resistor (LDR) all in series.

The battery has negligible internal resistance.

A voltmeter is connected across (in parallel with) the heater.

(a) On Fig. 5.1, complete the circuit diagram of this arrangement.

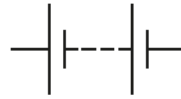


Fig. 5.1

[3]

(b) The heater is a wire made of metal of resistivity $1.1 \times 10^{-6} \Omega \text{ m}$. The wire has length 2.0 m and cross-sectional area $3.8 \times 10^{-7} \text{ m}^2$.

The reading on the voltmeter is 4.8 V.

Calculate:

(i) the resistance of the heater

resistance = ... Ω [2]

(ii) the reading on the ammeter.

reading on ammeter = ... A [1]

- (c) The heater is replaced by a new wire. The new wire is made of the same metal as the wire in (b) and has the same length but a larger diameter.

The resistance of the LDR remains constant.

- (i) State and explain whether the new wire has a resistance that is greater than, less than or the same as that of the wire in (b).

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

- (ii) State and explain whether the new reading on the voltmeter is greater than, less than or equal to 4.8 V.

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

[Total: 10]

30. March/2023/Paper_9702/12/No.30

A wire carries a current of $0.10\text{ }\mu\text{A}$. The potential difference across the wire is 10 mV .

How much energy is dissipated by the wire in a time of 10 s ?

- A 1.0 pJ B 10 pJ C 1.0 nJ D 10 nJ

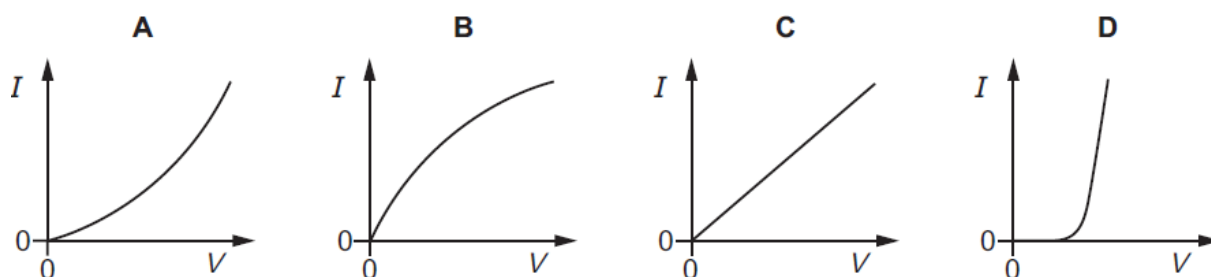
31. March/2023/Paper_9702/12/No.31

What is the definition of the potential difference across an electrical component?

- A energy transferred per unit charge
B energy transferred per unit current
C energy transferred per unit resistance
D energy transferred per unit time

32. March/2023/Paper_9702/12/No.32

Which graph represents the way the current I through a filament lamp varies with the potential difference V across it?



33. March/2023/Paper_9702/12/No.33

The table shows the properties of two different wires, P and Q.

	length	resistance	resistivity of material
wire P	l	R	ρ
wire Q	$2l$	$\frac{1}{4}R$	$\frac{1}{3}\rho$

Wire P has a cross-section of diameter d .

What is the diameter of the cross-section of wire Q?

- A $0.41d$ B $1.6d$ C $2.7d$ D $7.1d$

34. March/2023/Paper_9702/12/No.34

A cell has a constant electromotive force.

A variable resistor is connected between the terminals of the cell.

The resistance of the variable resistor is decreased.

Which statement about the change of the cell's terminal potential difference (p.d.) is correct?

- A The terminal p.d. is decreased because more work is done moving unit charge through the internal resistance of the cell.
- B The terminal p.d. is decreased because the current in the variable resistor is decreased.
- C The terminal p.d. is increased because more work is done moving unit charge through the variable resistor.
- D The terminal p.d. is increased because the current in the variable resistor is increased.

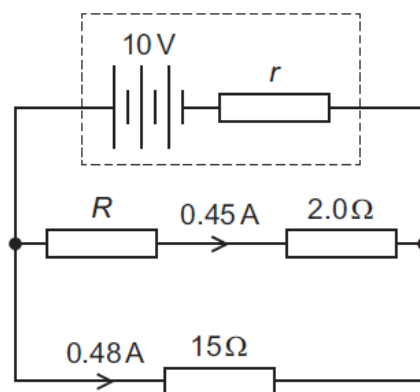
35. March/2023/Paper_9702/12/No.35

Kirchhoff's two laws for electric circuits can be derived by using conservation laws.

On which conservation laws do Kirchhoff's laws depend?

	Kirchhoff's first law	Kirchhoff's second law
A	charge	current
B	charge	energy
C	current	mass
D	energy	current

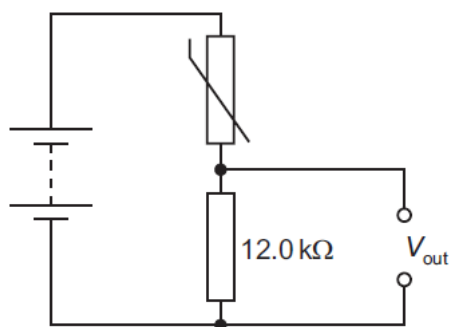
A battery of electromotive force (e.m.f.) 10 V and internal resistance r is connected to three resistors of resistances R , 2.0Ω and 15Ω , as shown. A current of 0.45 A is in the resistor of resistance 2.0Ω and a current of 0.48 A is in the resistor of resistance 15Ω .



What are the values of r and R ?

	r/Ω	R/Ω
A	3.0	14
B	3.0	20
C	5.8	14
D	5.8	20

A battery of negligible internal resistance is connected in series with a thermistor and a fixed resistor of resistance $12.0\text{ k}\Omega$, as shown.



The table shows the resistance of the thermistor at two different temperatures.

temperature $/^{\circ}\text{C}$	resistance of thermistor/ $\text{k}\Omega$
20.0	12.0
50.0	5.00

The potential difference V_{out} across the fixed resistor is 4.50 V when the thermistor is at a temperature of 20.0°C .

What is V_{out} when the thermistor is at a temperature of 50.0°C ?

- A** 2.65 V **B** 3.18 V **C** 6.35 V **D** 10.8 V

- (a) Define the potential difference across a component.

.....
 [1]

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

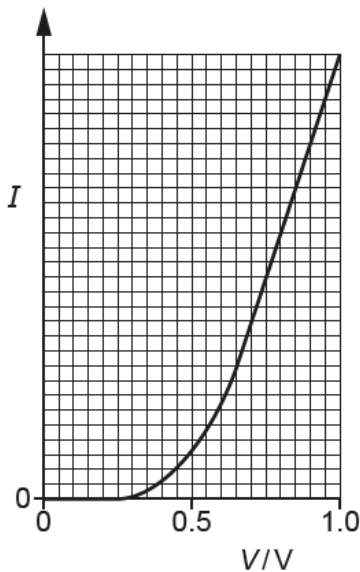


Fig. 6.1

Use Fig. 6.1 to describe qualitatively:

- (i) the resistance of the diode in the range $V = 0$ to $V = 0.25V$

..... [1]

- (ii) the variation, if any, in the resistance of the diode as V changes from $V = 0.75V$ to $V = 1.0V$.

..... [1]

- (c) A battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected to a uniform resistance wire XY, a fixed resistor and a variable resistor, as shown in Fig. 6.2.

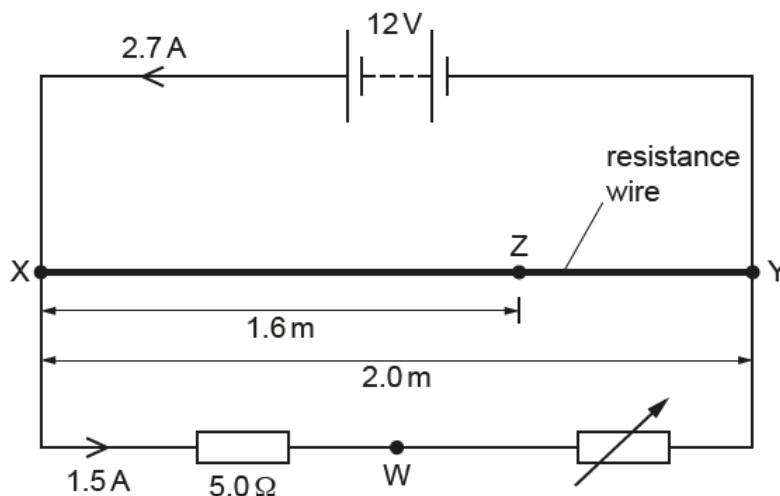


Fig. 6.2 (not to scale)

The fixed resistor has a resistance of $5.0\ \Omega$. The current in the battery is 2.7 A and the current in the fixed resistor is 1.5 A.

- (i) Calculate the current in the resistance wire.

current = ... A [1]

- (ii) Determine the resistance of the variable resistor.

resistance = ... Ω [2]

- (iii) Wire XY has a length of 2.0 m. Point Z on the wire is a distance of 1.6 m from point X. The fixed resistor is connected to the variable resistor at point W.

Determine the potential difference between points W and Z.

potential difference = ... V [3]

- (iv) The resistance of the variable resistor is now increased.

By considering the currents in every part of the circuit, state and explain whether the total power produced by the battery decreases, increases or stays the same.

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

1. Nov/2023/Paper_ 9702/11/No.30

The current I in a conductor is given by the equation shown.

$$I = Anvq$$

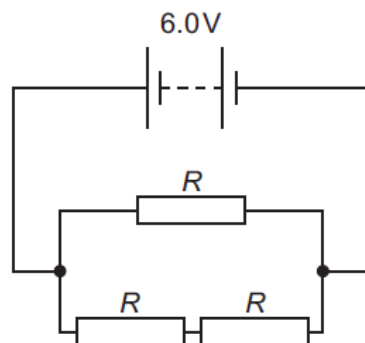
What does the letter n represent in this equation?

- A** charge carried per charge carrier
- B** number of charge carriers per unit area
- C** number of charge carriers per unit volume
- D** total mass of charge carriers per unit volume

2. Nov/2023/Paper_ 9702/11/No.31

In the circuit shown, the battery has an electromotive force (e.m.f.) of 6.0 V and negligible internal resistance.

The three resistors each have resistance R .



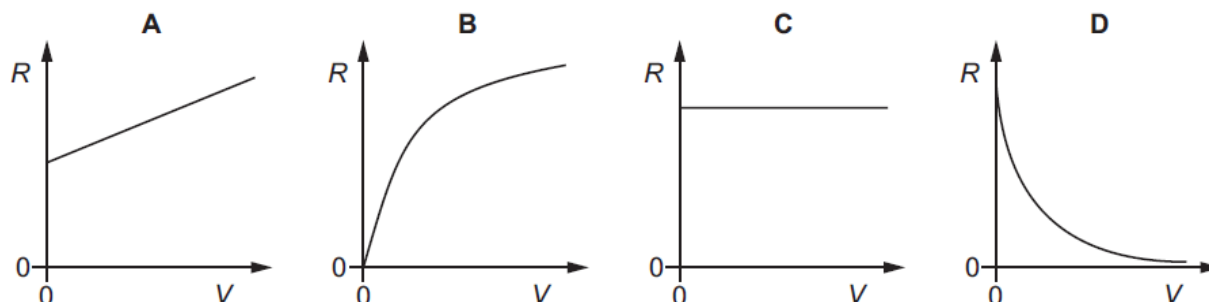
The total power dissipated in the resistor network is 24 W .

What is the value of R ?

- A** 0.50Ω **B** 1.0Ω **C** 1.5Ω **D** 2.3Ω

3. Nov/2023/Paper_ 9702/11/No.32

Which graph could show how the resistance R of a filament lamp varies with the applied potential difference (p.d.) V , as V is increased to the normal operating p.d.?



4. Nov/2023/Paper_ 9702/11/No.33

A piece of conducting putty is in the shape of a cylinder of length 60 mm and diameter 20 mm. The resistance between the ends of the cylinder is $20\ \Omega$.

What is the resistivity of the putty?

- A $0.033\ \Omega\text{m}$ B $0.10\ \Omega\text{m}$ C $0.42\ \Omega\text{m}$ D $5.2\ \Omega\text{m}$

5. Nov/2023/Paper_ 9702/11/No.34

Which statement about the electromotive force (e.m.f.) of a cell is **always** correct?

- A The e.m.f. is the energy converted from electrical to other forms in the cell.
 B The e.m.f. is the energy provided by the cell per unit charge passing through it.
 C The e.m.f. is the potential difference across the internal resistance of the cell.
 D The e.m.f. is the potential difference across the terminals of the cell.

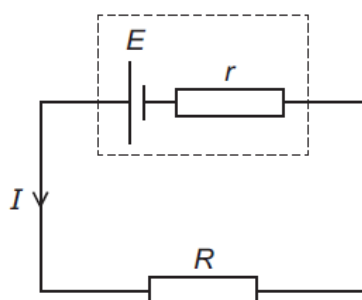
6. Nov/2023/Paper_ 9702/11/No.35

Kirchhoff's first and second laws are a consequence of the conservation of which quantities?

- A charge and energy
 B charge and resistance
 C mass and energy
 D mass and resistance

7. Nov/2023/Paper_ 9702/11/No.36

A circuit contains a cell of electromotive force E and internal resistance r connected to a resistor of resistance R . The current in the circuit is I .

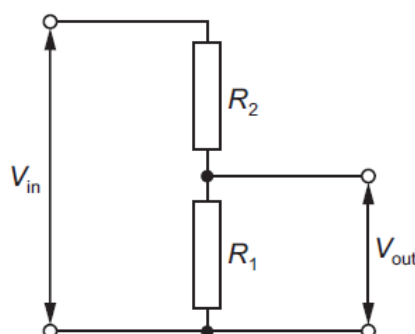


Which equation is correct?

- A $E - Ir = IR$ B $E = Ir - IR$ C $E + Ir = IR$ D $E = IR$

8. Nov/2023/Paper_ 9702/11/No.37

A potential divider consists of two resistors of resistances R_1 and R_2 connected in series across a source of potential difference (p.d.) V_{in} . The p.d. across R_1 is V_{out} .

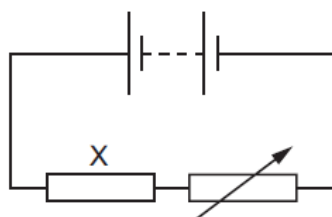


Which changes to R_1 and R_2 will increase the value of V_{out} ?

	R_1	R_2
A	doubled	doubled
B	doubled	halved
C	halved	doubled
D	halved	halved

9. Nov/2023/Paper_ 9702/12/No.31

In the circuit shown, a fixed resistor X is connected in series with a battery and a variable resistor.



The power dissipated in resistor X is 7.2 W when a current of 3.0 A passes through it.

The variable resistor is adjusted so that the power dissipated in X increases by 50% .

What is the new current in the circuit?

- A** 2.4 A **B** 3.7 A **C** 4.5 A **D** 14 A

10. Nov/2023/Paper_ 9702/12/No.32

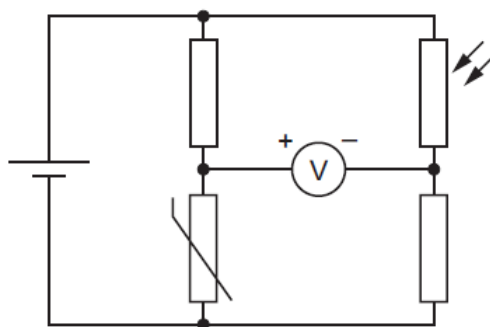
The potential difference across a metal wire is kept constant. The length l and the diameter d of the wire are both varied. The type of metal is kept the same.

How is the current in the wire related to l and d ?

- A It is directly proportional to l and inversely proportional to d .
- B It is directly proportional to l and inversely proportional to d^2 .
- C It is inversely proportional to l and directly proportional to d .
- D It is inversely proportional to l and directly proportional to d^2 .

11. Nov/2023/Paper_ 9702/12/No.33

A student sets up a circuit. The circuit diagram shows how the positive and negative terminals of a voltmeter are connected to the circuit. The voltmeter has an initial reading that is positive.

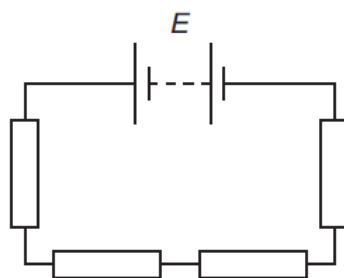


Which changes, if any, in temperature and light intensity would cause the voltmeter reading to decrease?

	temperature	light intensity
A	increase	increase
B	no change	decrease
C	decrease	no change
D	decrease	decrease

12. Nov/2023/Paper_ 9702/12/No.34

Some resistors and a battery of electromotive force (e.m.f.) E and negligible internal resistance are connected in series, as shown.



Which statement is correct?

- A The e.m.f. across each resistor equals the potential difference across the battery.
- B The potential difference across each resistor equals the e.m.f. E of the battery.
- C The sum of the e.m.f.s across the resistors equals the potential difference across the battery.
- D The sum of the potential differences across the resistors equals the e.m.f. E of the battery.

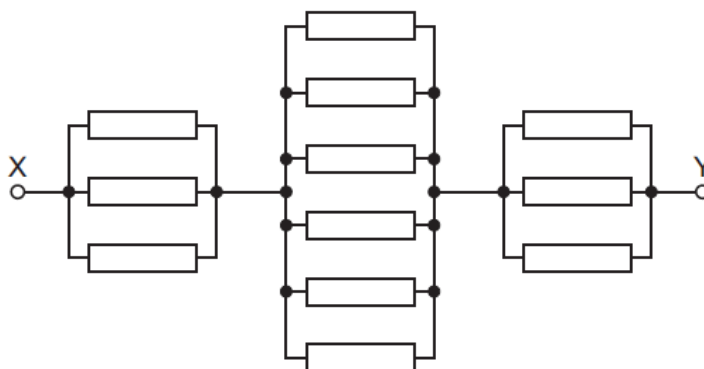
13. Nov/2023/Paper_ 9702/12/No.35

Kirchhoff's first law is a consequence of the conservation of which physical quantity?

- A charge
- B energy
- C linear momentum
- D potential difference

14. Nov/2023/Paper_ 9702/12/No.36

The diagram shows a network of resistors. Each resistor has a resistance of 6.0Ω .

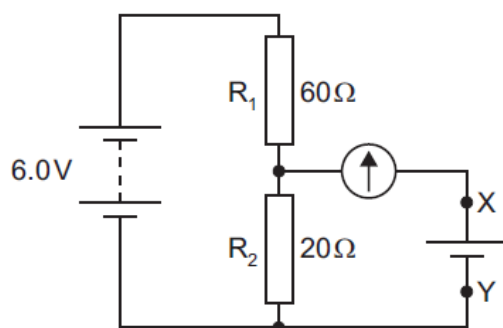


What is the total resistance of the network between points X and Y?

- A 3.0Ω
- B 5.0Ω
- C 7.2Ω
- D 18Ω

15. Nov/2023/Paper_ 9702/12/No.37

In the circuit shown, a battery of negligible internal resistance is connected in series with a pair of fixed resistors R_1 and R_2 .



The circuit is to be used to test whether the electromotive force (e.m.f.) of a particular cell is 1.5 V. The cell is connected between terminals X and Y in parallel with R_2 and in series with a galvanometer.

Which statement about the test is correct?

- A Any non-zero reading on the galvanometer means the cell has an e.m.f. of 1.5 V.
- B The battery does not need to have an e.m.f. of 6.0 V.
- C The cell may be connected either way round between X and Y.
- D The galvanometer does not need a scale calibrated in amperes.

16. Nov/2023/Paper_ 9702/13/No.2

In an electric circuit, an ammeter reads $2\mu\text{A}$.

In a second circuit, the ammeter reads 1 mA.

How many times larger is the current in the second circuit compared with the current in the first circuit?

- A 500
- B 5000
- C 500 000
- D 5 000 000

17. Nov/2023/Paper_ 9702/13/No.30

What could **not** be used to create an electric current?

- A alpha-particles
- B beta-particles
- C neutrons
- D protons

18. Nov/2023/Paper_ 9702/13/No.31

What is the definition of the potential difference (p.d.) across a component?

- A the energy transferred per unit charge
- B the energy transferred per unit current
- C the power transferred per unit charge
- D the power transferred per unit current

19. Nov/2023/Paper_ 9702/13/No.32

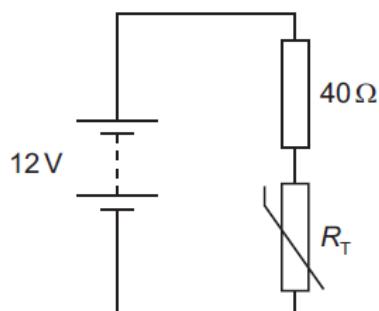
The resistance of a filament lamp increases as the current in it increases.

What is the reason for this?

- A The charge of each charge carrier increases.
- B The potential difference across the filament decreases.
- C The power dissipated by the filament decreases.
- D The temperature of the filament increases.

20. Nov/2023/Paper_ 9702/13/No.33

A battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected to a fixed resistor of resistance $40\ \Omega$ and a thermistor of resistance R_T , as shown.



Initially, the temperature of the thermistor is 15°C and the current in the circuit is 0.10 A.

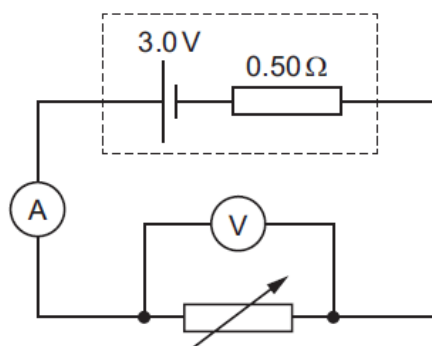
The temperature of the thermistor then changes, which causes the current to increase to 0.12 A.

How does the temperature of the thermistor change and what is R_T at the new temperature?

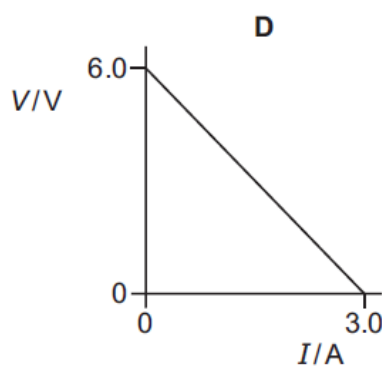
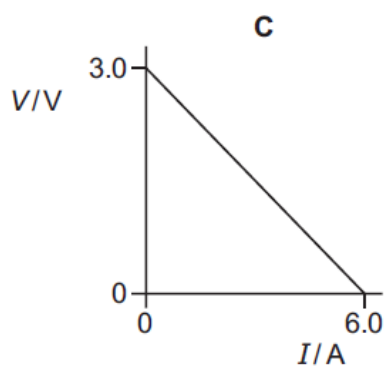
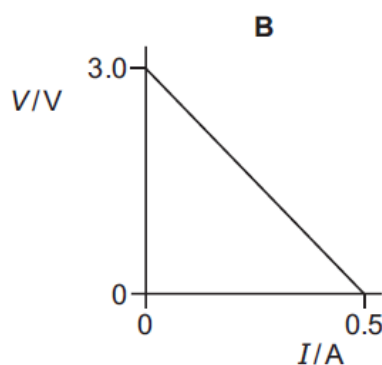
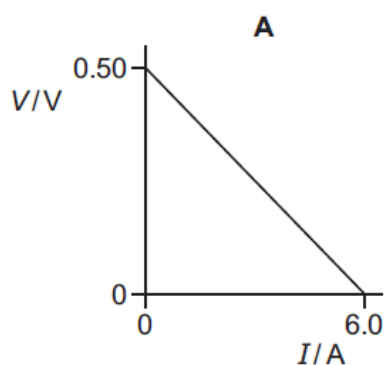
	temperature of thermistor	R_T at new temperature / Ω
A	increases	60
B	decreases	60
C	increases	100
D	decreases	100

A cell of electromotive force (e.m.f.) 3.0 V and internal resistance 0.50Ω is connected to a variable resistor, a voltmeter and an ammeter, as shown. The resistance of the variable resistor is varied.

The reading on the ammeter I and the reading on the voltmeter V are recorded.

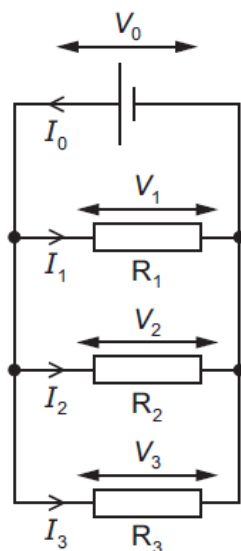


Which graph shows how V varies with I ?



22. Nov/2023/Paper_ 9702/13/No.35

Three resistors, R_1 , R_2 and R_3 , are connected in parallel to a cell. The currents in the resistors are I_1 , I_2 and I_3 . The potential differences across the resistors are V_1 , V_2 and V_3 . The current in the cell is I_0 . The potential difference across the cell is V_0 , as shown.

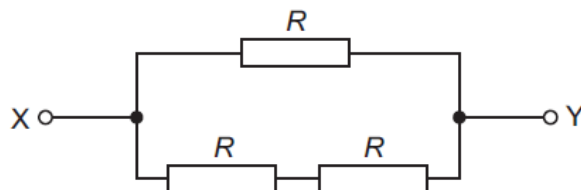


Which equation can be obtained by applying Kirchhoff's second law to the circuit?

- A $I_0 = I_1 = I_2 = I_3$
- B $I_0 = I_1 + I_2 + I_3$
- C $V_0 = V_1 = V_2 = V_3$
- D $V_0 = V_1 + V_2 + V_3$

23. Nov/2023/Paper_ 9702/13/No.36

Three resistors, each of resistance R , are connected in a network, as shown.



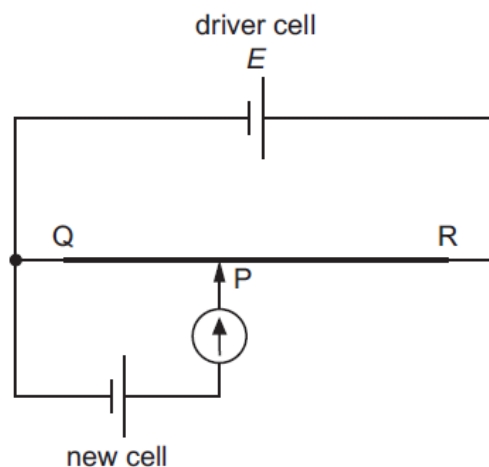
The total resistance between points X and Y is 8.0Ω .

What is the value of R ?

- A 2.7Ω
- B 4.0Ω
- C 5.3Ω
- D 12Ω

A potentiometer and a driver cell of electromotive force (e.m.f.) E are used to measure the e.m.f. of a new cell.

A sliding contact at P is moved along a resistance wire QR until the reading on the galvanometer is zero.



What is an essential requirement for the e.m.f. of the new cell to be measured accurately?

- A The e.m.f. of the driver cell must be less than the e.m.f. of the new cell.
- B The galvanometer must have a large resistance.
- C The internal resistance of the new cell must be zero.
- D The resistance per unit length of the wire QR must be constant.

A battery is connected in a circuit with a light-dependent resistor (LDR), two fixed resistors and a voltmeter, as shown in Fig. 6.1.

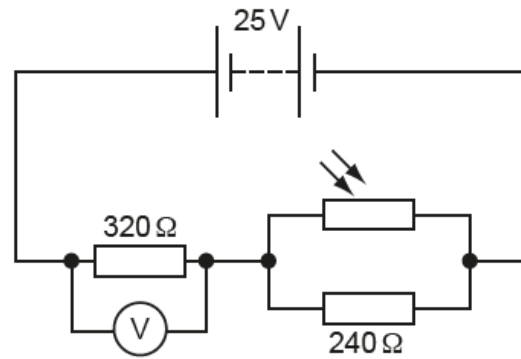


Fig. 6.1

The battery has an electromotive force (e.m.f.) of 25 V and negligible internal resistance. The resistors have resistances of 320 Ω and 240 Ω .

(a) The voltmeter displays a reading of 16 V.

(i) Show that the current in the battery is 0.050 A.

[1]

(ii) Calculate the resistance of the LDR.

resistance = ... Ω [3]

(iii) Determine the ratio

$$\frac{\text{power dissipated in the LDR}}{\text{power dissipated in the } 240\Omega \text{ resistor}}$$

ratio = ... [2]

(b) The intensity of the light incident on the LDR increases.

State and explain what happens to the voltmeter reading.

.....
.....
.....
..... [3]

[Total: 9]

- (a) A metal wire has a resistance per unit length of $0.92\Omega\text{m}^{-1}$. The wire has a uniform cross-sectional area of $5.3 \times 10^{-7}\text{m}^2$.

Calculate the resistivity of the metal of the wire.

resistivity = ... Ωm [2]

- (b) A battery of electromotive force (e.m.f.) E and negligible internal resistance is connected in series with a fixed resistor and a light-dependent resistor (LDR), as shown in Fig. 6.1.

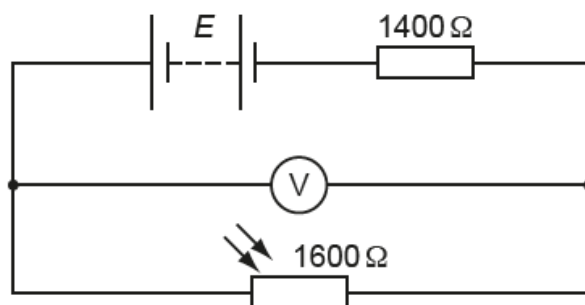


Fig. 6.1

The resistance of the fixed resistor is 1400Ω . The intensity of the light illuminating the LDR causes it to have a resistance of 1600Ω . A voltmeter connected across the LDR reads 6.4V .

- (i) Show that the current in the LDR is $4.0 \times 10^{-3}\text{A}$.

[1]

- (ii) Calculate the number of free electrons passing through the LDR in a time of 3.2 minutes.

number of free electrons = ... [2]

(iii) Calculate the e.m.f. E .

$$E = \dots\dots\dots \text{ V [2]}$$

(iv) Determine the ratio

$$\frac{\text{power dissipated in LDR}}{\text{power dissipated in fixed resistor}}.$$

$$\text{ratio} = \dots\dots\dots \text{ [2]}$$

(c) The environmental conditions change causing a decrease in the resistance of the LDR in (b). The temperature of the environment does not change.

State whether there is a decrease, increase or no change to:

(i) the intensity of the light illuminating the LDR

..... [1]

(ii) the current in the battery

..... [1]

(iii) the reading of the voltmeter.

..... [1]

[Total: 12]

(a) State Ohm's law.

.....

 [2]

(b) A battery of electromotive force (e.m.f.) 6.2V and negligible internal resistance is connected in a circuit to a uniform resistance wire, a voltmeter, a fixed resistor and a switch, as shown in Fig. 7.1.

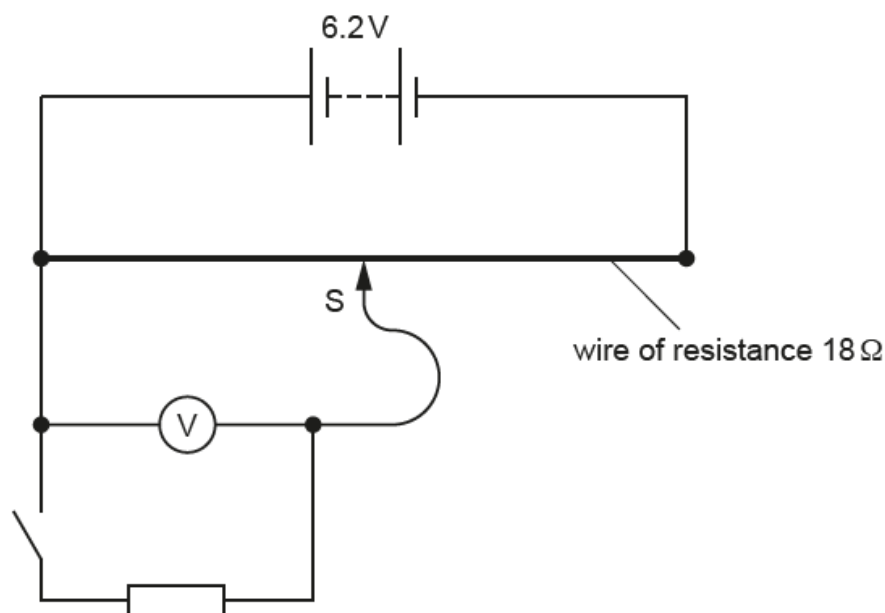


Fig. 7.1

The resistance wire has resistance 18Ω , length 0.94 m and cross-sectional area $7.2 \times 10^{-8}\text{ m}^2$. The slider S is positioned half-way along the length of the wire.

(i) Calculate the resistivity ρ of the material of the resistance wire.

$\rho = \dots\dots\dots \Omega\text{ m}$ [2]

- (ii) The switch is open.
State the reading on the voltmeter.

voltmeter reading = ... V [1]

(iii) The switch is now closed.

State whether there is an increase, decrease or no change to:

- the current in the battery

.....

- the voltmeter reading.

.....

[2]

(iv) The switch remains closed. The slider S is moved along the resistance wire so that the voltmeter reading is 3.1 V.

On Fig. 7.1, draw a cross (×) on the resistance wire to show a possible new position of the slider. [1]

(c) The circuit in (b) is altered by changing the battery for one of a different e.m.f. The switch is open.

A student records the following data for the resistance wire:

current in the wire	0.93 A
mean drift speed of charge carriers	$1.3 \times 10^{-3} \text{ m s}^{-1}$
number density of charge carriers	$9.0 \times 10^{28} \text{ m}^{-3}$.

(i) Determine the charge q of a charge carrier in the wire suggested by this data.

$q = \dots\dots\dots$ C [2]

(ii) With reference to the value of q , explain why the data recorded by the student cannot be correct.

.....

..... [1]

[Total: 11]