

PHYSICS



EXAM QUESTION PACK

10 D.C. CIRCUITS

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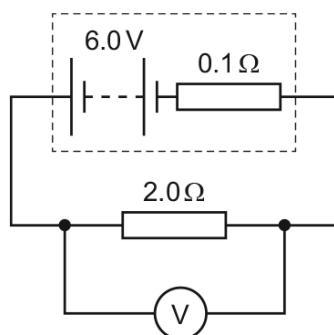
Chapter 12

D.C. circuits

12.1 Practical circuits

1181. 9702_m20_qp_12 Q: 36

The diagram shows a circuit.



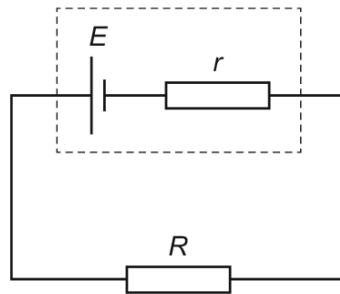
What is the reading on the voltmeter?

- A** 0.3V **B** 5.7V **C** 6.0V **D** 6.3V

1182. 9702_s20_qp_11 Q: 36

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

A maximum power P can be dissipated by the resistor without overheating.

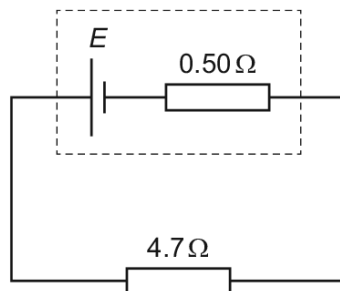


What is the maximum value of E if the resistor does not overheat?

- A** $R\sqrt{\frac{P}{(R-r)}}$
 B $R\sqrt{\frac{P}{(R+r)}}$
 C $(R-r)\sqrt{\frac{P}{R}}$
 D $(R+r)\sqrt{\frac{P}{R}}$

1183. 9702_s20_qp_12 Q: 36

A cell of electromotive force (e.m.f.) E and internal resistance $0.50\ \Omega$ is connected to a resistor of resistance $4.7\ \Omega$.



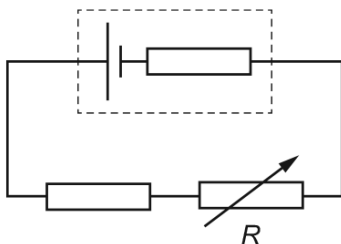
The maximum power that can be dissipated by the resistor without overheating is $0.50\ \text{W}$.

What is the maximum value of E for the resistor **not** to overheat?

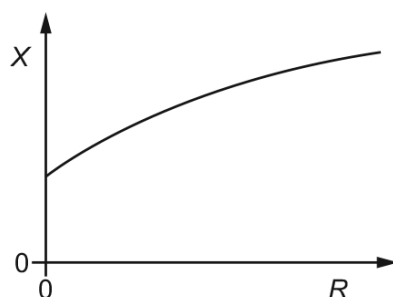
- A** $1.4\ \text{V}$
 B $1.5\ \text{V}$
 C $1.7\ \text{V}$
 D $2.9\ \text{V}$

1184. 9702_s20_qp_13 Q: 37

A fixed resistor and a variable resistor are connected in series with a cell that has an internal resistance, as shown.



The graph shows the variation of a quantity X with the resistance R of the variable resistor as R is increased from zero to its maximum value.

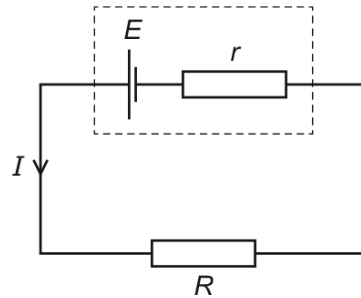


What could X represent?

- A the current in the circuit
- B the electromotive force of the cell
- C the potential difference across the internal resistance
- D the terminal potential difference across the cell

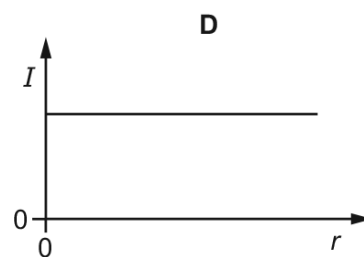
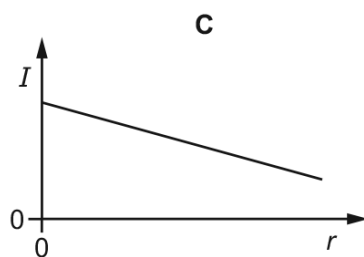
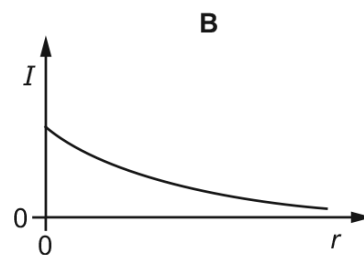
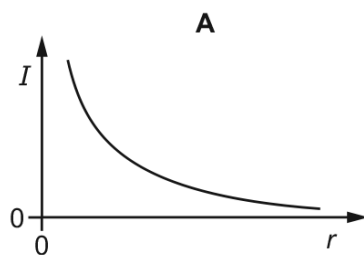
1185. 9702_m19_qp_12 Q: 36

A cell of internal resistance r and electromotive force (e.m.f.) E is connected in series with a resistor of resistance R .



The resistance R and the e.m.f. E remain fixed. The internal resistance r of the cell changes over time.

Which graph best shows the variation of the current I in the circuit with the internal resistance r ?



1186. 9702_s19_qp_11 Q: 35

When a battery is connected to a resistor, the battery gradually becomes warm. This causes the internal resistance of the battery to increase whilst its electromotive force (e.m.f.) stays unchanged.

As the internal resistance of the battery increases, how do the terminal potential difference and the output power change, if at all?

	terminal potential difference	output power
A	decreases	decreases
B	decreases	unchanged
C	unchanged	decreases
D	unchanged	unchanged

1187. 9702_s19_qp_11 Q: 36

A cell is connected to a resistor of resistance $3.00\ \Omega$. The current in the resistor is $1.00\ \text{A}$.

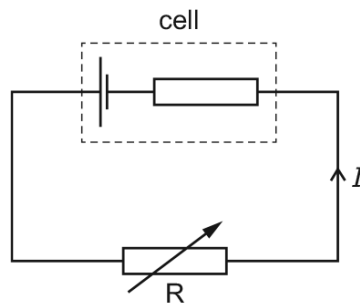
A second identical resistor is added in parallel. The current becomes $1.93\ \text{A}$.

What are the e.m.f. E and internal resistance r of the cell?

	E/V	r/Ω
A	0.113	3.11
B	3.04	0.0358
C	3.11	0.113
D	9.34	6.34

1188. 9702_s19_qp_12 Q: 35

A cell with internal resistance is connected to a variable resistor R as shown.



The resistance of R is gradually decreased.

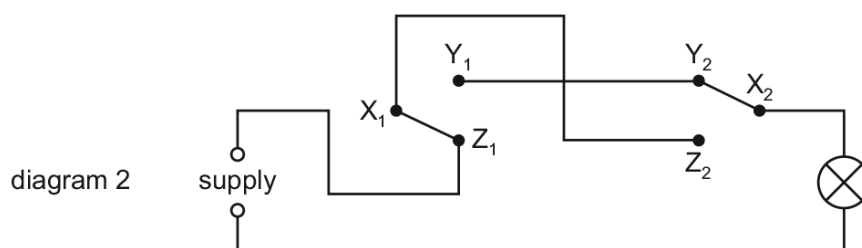
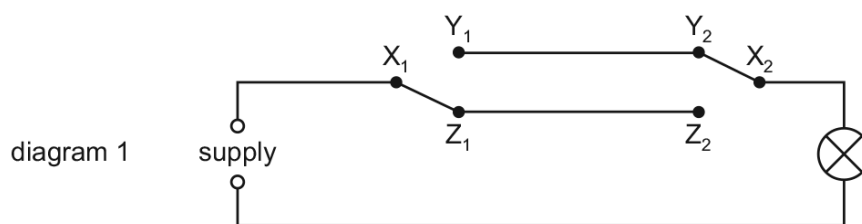
How do the current I and the terminal potential difference across the cell change?

	current I	terminal potential difference across cell
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

1189. 9702_s19_qp_13 Q: 34

Diagram 1 shows a lamp connected to a supply through two switches.

During repairs, an electrician mistakenly reverses the connections X_1 and Z_1 , so that Z_1 is connected to the supply and X_1 to the other switch at Z_2 , as shown in diagram 2.

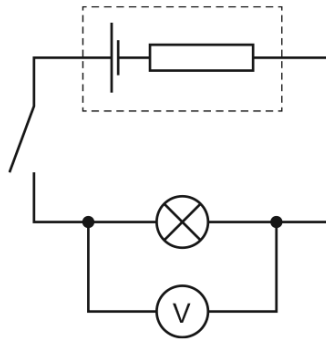


Which switch positions will now light the lamp?

A	X_1 to Y_1	X_2 to Y_2
B	X_1 to Y_1	X_2 to Z_2
C	X_1 to Z_1	X_2 to Y_2
D	X_1 to Z_1	X_2 to Z_2

1190. 9702_w19_qp_11 Q: 35

The diagram shows a circuit.

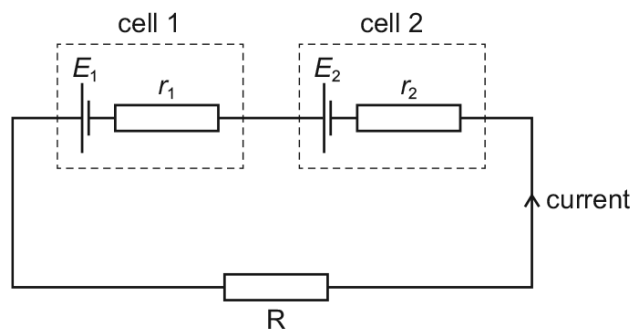


Which statement about the circuit is **not** correct?

- A Electromotive force is the energy transferred per unit charge.
- B Energy is transferred from chemical potential energy in the cell to other forms when the switch is closed.
- C The electromotive force of the cell is greater than the terminal potential difference when the switch is closed.
- D When the switch is open, the voltmeter measures the electromotive force of the cell.

1191. 9702_w19_qp_12 Q: 34

Two cells with electromotive forces E_1 and E_2 and internal resistances r_1 and r_2 are connected to a resistor R as shown.



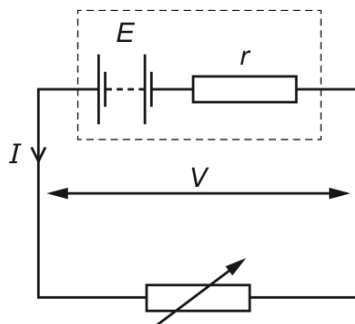
The terminal potential difference across cell 1 is zero.

Which expression gives the resistance of resistor R ?

- A $\frac{E_2 r_1 - E_1 r_2}{E_1}$
- B $\frac{E_2 r_1 - E_1 r_2}{E_2}$
- C $\frac{E_1 r_2 - E_2 r_1}{E_1}$
- D $\frac{E_1 r_2 - E_2 r_1}{E_2}$

1192. 9702_w19_qp_12 Q: 35

A battery has an electromotive force (e.m.f.) E and internal resistance r . The battery delivers a current I to a variable resistor and the potential difference (p.d.) across its terminals is V .



The variable resistor is adjusted so that I increases.

Why does V decrease?

- A The e.m.f. E decreases.
- B The internal resistance r increases.
- C The p.d. across r increases.
- D The resistance of the variable resistor increases.

1193. 9702_w19_qp_13 Q: 36

A cell of internal resistance $0.5\ \Omega$ is connected to a fixed resistor of resistance $10\ \Omega$.

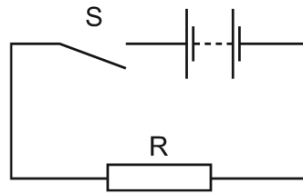
The resistance of the resistor is changed to $20\ \Omega$.

Which statement is **not** correct?

- A The current in the circuit will halve.
- B The e.m.f. of the cell will remain constant.
- C The power dissipated by the fixed resistor will decrease.
- D The terminal p.d. of the cell will increase.

1194. 9702_m18_qp_12 Q: 32

The diagram shows a simple circuit.

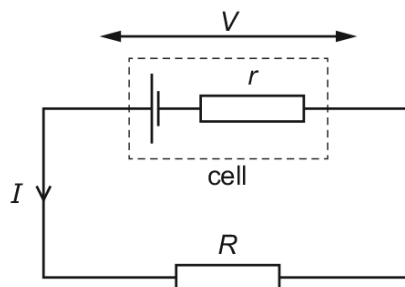


Which statement is correct?

- 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 .

1195. 9702_s18_qp_12 Q: 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 .

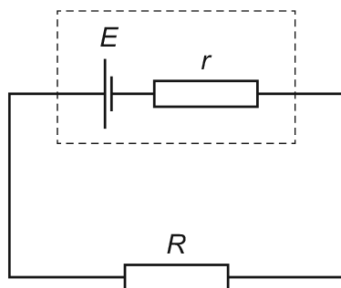


When the internal resistance r of the cell increases, what is the effect on V and on I ?

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

1196. 9702_s18_qp_13 Q: 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.



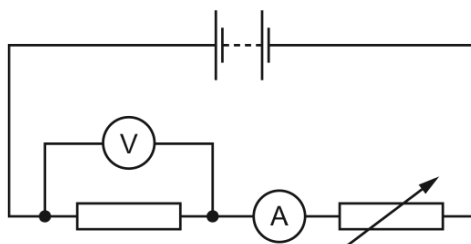
What is the power dissipated in the external resistor?

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

1197. 9702_s18_qp_13 Q: 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.



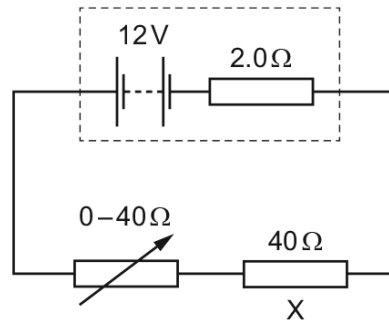
The resistance of the variable resistor is reduced.

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

1198. 9702_w18_qp_13 Q: 35

A resistor X of resistance $40\ \Omega$ and a variable resistor are connected to a battery of electromotive force (e.m.f.) 12 V and internal resistance $2.0\ \Omega$, as shown.



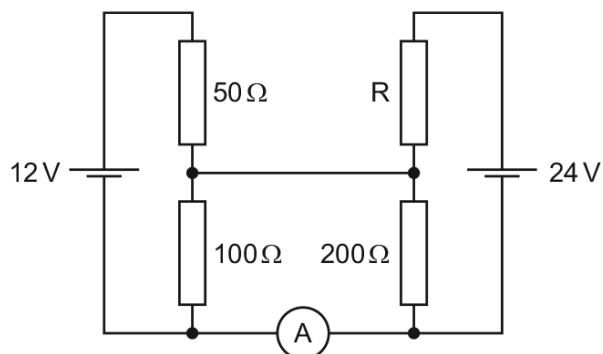
The resistance of the variable resistor is changed from 0 to $40\ \Omega$.

What is the change in power dissipated in resistor X?

- A** 2.4 W **B** 2.7 W **C** 3.6 W **D** 5.6 W

1199. 9702_w18_qp_13 Q: 37

In the circuit shown, the ammeter reading is zero.

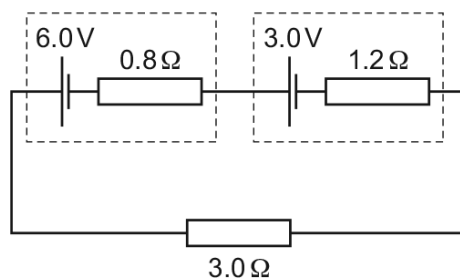


What is the resistance of resistor R?

- A** $100\ \Omega$ **B** $200\ \Omega$ **C** $400\ \Omega$ **D** $600\ \Omega$

1200. 9702_m17_qp_12 Q: 35

Two cells are connected to a load resistor of resistance 3.0Ω . The electromotive force (e.m.f.) and the internal resistance of each of the cells is shown.

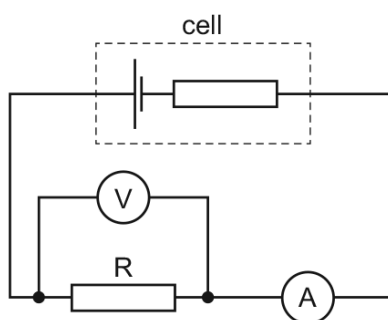


What is the current in the load resistor?

- A** 0.60A **B** 1.2A **C** 1.8A **D** 3.0A

1201. 9702_s17_qp_11 Q: 35

The circuit shown includes a cell of constant internal resistance and an external resistor R .



A student records the ammeter and voltmeter readings. She then connects a second identical external resistor in parallel with the first external resistor.

What happens to the ammeter reading and to the voltmeter reading?

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

1202. 9702_s17_qp_12 Q: 35

A cell has a constant electromotive force.

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

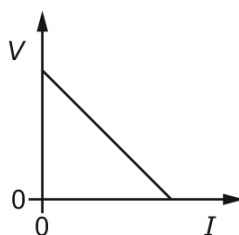
The resistance of the variable resistor is decreased.

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.
-

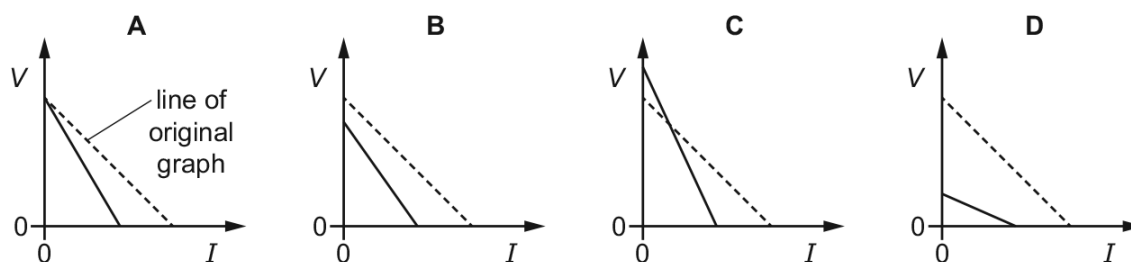
1203. 9702_s17_qp_13 Q: 34

A graph of potential difference (p.d.) V across a cell against current I in the cell is shown.



As the cell reaches the end of its useful life, its internal resistance increases and its electromotive force (e.m.f.) decreases.

Which diagram shows a graph of V against I for the cell nearing the end of its useful life?



1204. 9702_w17_qp_12 Q: 36

A typical mobile phone battery has an e.m.f. of 5.0 V and an internal resistance of $200\text{ m}\Omega$.

What is the terminal p.d. of the battery when it supplies a current of 500 mA ?

- A** 4.8 V **B** 4.9 V **C** 5.0 V **D** 5.1 V

1205. 9702_w17_qp_13 Q: 34

A simple circuit comprises a source of electromotive force (e.m.f.) connected to a load.

How does the output power P of the source depend on the internal resistance r of the source and the resistance R of the load?

- A** P is independent of both r and R .
B P depends on r but not on R .
C P depends on R but not on r .
D P depends on both r and R .

1206. 9702_m16_qp_12 Q: 37

The battery of a car has an internal resistance of 0.10Ω and an electromotive force of 12V . When the battery is connected to the starter motor, the potential difference across the battery terminals is 7.0V .

What is the current supplied to the starter motor?

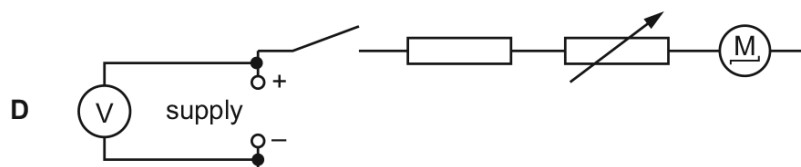
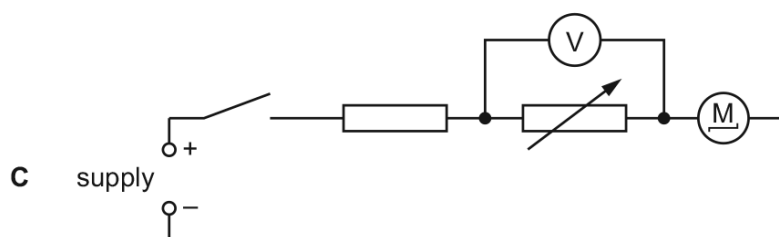
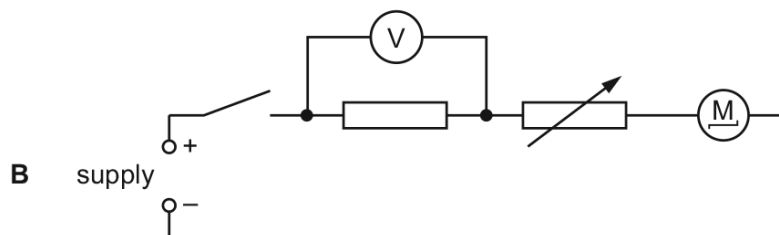
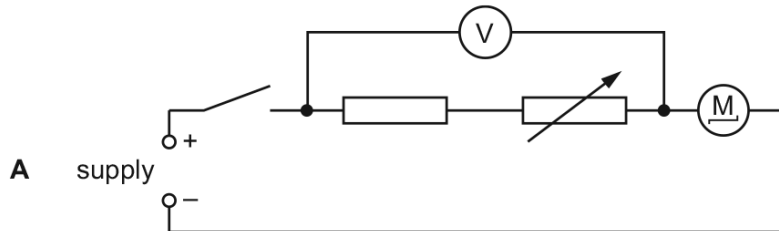
- A** 50A **B** 70A **C** 120A **D** 190A

1207. 9702_s16_qp_11 Q: 37

A voltmeter is used to monitor the operation of an electric motor. The motor speed is controlled by a variable resistor. A fixed resistor is used to limit the speed.

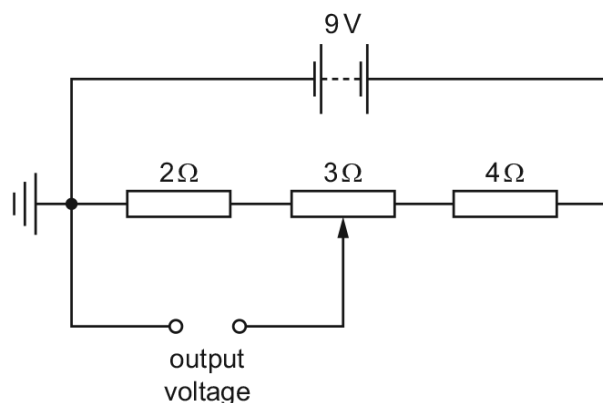
The current in the motor is gradually changed.

In which circuit is the voltmeter reading proportional to the current in the motor?



1208. 9702_s16_qp_12 Q: 37

In the circuit shown, contact may be made at any point along the 3Ω resistor (potentiometer).



The battery has e.m.f. 9 V and negligible internal resistance.

What is the maximum range of the output voltage?

- A** 0–2 V **B** 0–5 V **C** 2–3 V **D** 2–5 V

1209. 9702_w16_qp_12 Q: 36

Four statements about either potential difference or electromotive force are listed.

- 1 It involves changing electrical energy into other forms.
- 2 It involves changing other energy forms into electrical energy.
- 3 It is the energy per unit charge to move charge around a complete circuit.
- 4 It is the work done per unit charge by the charge moving from one point to another.

Which statements apply to potential difference and which apply to electromotive force?

	potential difference	electromotive force
A	1 and 3	2 and 4
B	1 and 4	2 and 3
C	2 and 3	1 and 4
D	2 and 4	1 and 3

1210. 9702_s15_qp_11 Q: 34

Which equation that links some of the following terms is correct?

potential difference (p.d.)	V
current	I
resistance	R
charge	Q
energy	E
power	P
time	t

- A** $P = \frac{Q^2 R}{t}$
- B** $ER^2 = V^2 t$
- C** $\frac{VI}{P} = t$
- D** $PQ = EI$

1211. 9702_s15_qp_12 Q: 33

Which statement is **not** valid?

- A** Current is the speed of the charged particles that carry it.
- B** Electromotive force (e.m.f.) is the energy converted to electrical energy from other forms per unit charge.
- C** The potential difference (p.d.) between two points is the work done per unit charge when moving charge from one point to the other.
- D** The resistance between two points is the p.d. between the two points per unit current.

1212. 9702_s15_qp_12 Q: 34

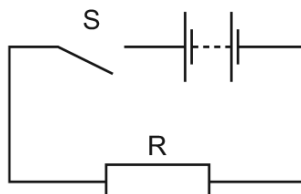
A cell of e.m.f. E delivers a charge Q to an external circuit.

Which statement is correct?

- A** The energy dissipation in the external circuit is EQ .
- B** The energy dissipation within the cell is EQ .
- C** The external resistance is EQ .
- D** The total energy dissipation in the cell and the external circuit is EQ .

1213. 9702_s15_qp_13 Q: 33

The diagram shows a simple circuit.



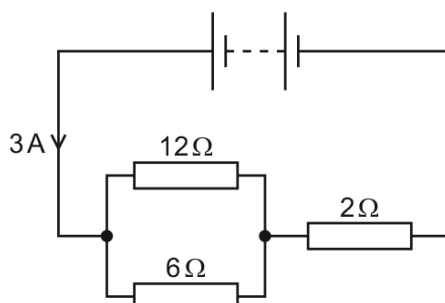
Which statement is correct?

- A** When switch S is closed, the electromotive force (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.

12.2 Kirchhoff's laws

1214. 9702_m20_qp_12 Q: 33

A battery is connected to three resistors of resistances $12\ \Omega$, $6\ \Omega$ and $2\ \Omega$, as shown.



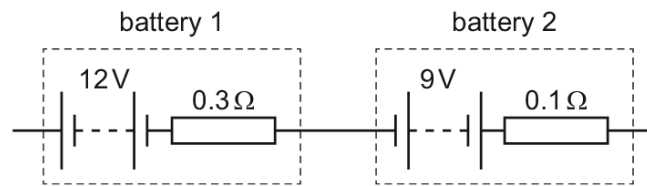
The current from the battery is 3 A.

What is the value of the ratio $\frac{\text{power dissipated in the resistor of resistance } 6\ \Omega}{\text{power dissipated in the resistor of resistance } 2\ \Omega}$?

- A** $\frac{1}{3}$
- B** $\frac{4}{3}$
- C** $\frac{2}{1}$
- D** $\frac{3}{1}$

1215. 9702_m20_qp_12 Q: 35

Two batteries are connected together, as shown.



Battery 1 has electromotive force (e.m.f.) 12 V and internal resistance 0.3Ω .

Battery 2 has e.m.f. 9 V and internal resistance 0.1Ω .

What are the e.m.f. and the internal resistance of a single battery that has the same effect as the combination?

	e.m.f. / V	internal resistance / Ω
A	3	0.2
B	3	0.4
C	21	0.2
D	21	0.4

1216. 9702_s20_qp_11 Q: 37

Three identical resistors can be connected together in four different ways.

The resistances of two of these combinations are 4.0Ω and 9.0Ω .

What is the resistance of each individual resistor?

- A** 3.0Ω **B** 6.0Ω **C** 12Ω **D** 18Ω

1217. 9702_s20_qp_12 Q: 37

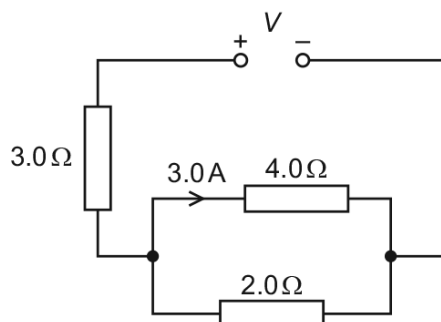
Kirchhoff's first and second laws link to the conservation of physical quantities.

Which quantities do they link to?

	first law	second law
A	charge	energy
B	charge	momentum
C	energy	charge
D	energy	momentum

1218. 9702_s20_qp_13 Q: 35

A power supply of electromotive force (e.m.f.) V and negligible internal resistance is connected in the circuit shown. There is a current of 3.0 A in the $4.0\ \Omega$ resistor.

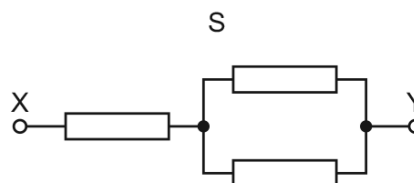
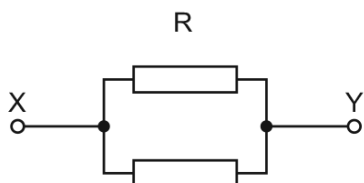
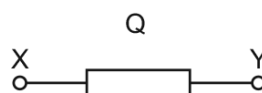
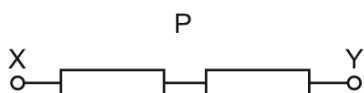


What is the value of V ?

- A** 15 V **B** 29 V **C** 39 V **D** 51 V

1219. 9702_m19_qp_12 Q: 37

Identical resistors are connected in four combinations P, Q, R and S between terminals X and Y.

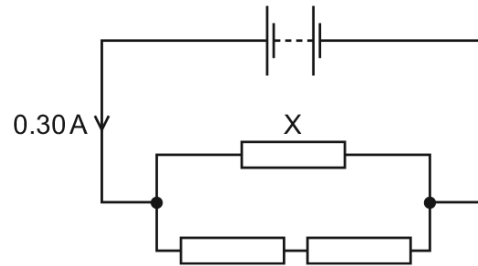


What is the order of decreasing combined resistance between X and Y (largest first)?

- A** $P \rightarrow S \rightarrow Q \rightarrow R$
B $P \rightarrow S \rightarrow R \rightarrow Q$
C $Q \rightarrow R \rightarrow S \rightarrow P$
D $S \rightarrow P \rightarrow Q \rightarrow R$

1220. 9702_s19_qp_11 Q: 37

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



All three resistors have the same resistance.

The current in the battery is 0.30 A.

What is the current in resistor X?

- A** 0.10 A **B** 0.15 A **C** 0.20 A **D** 0.30 A

1221. 9702_s19_qp_12 Q: 36

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.

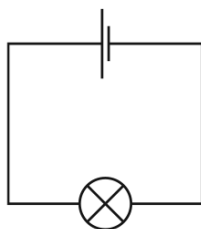
What is this physical quantity?

- A** charge
B energy
C mass
D momentum

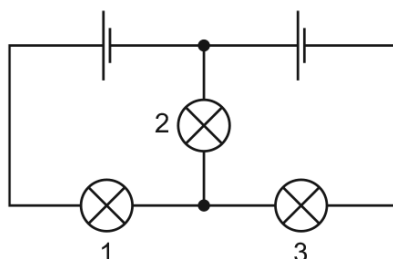
1222. 9702_s19_qp_13 Q: 36

A student has a set of identical cells and identical lamps. The cells have negligible internal resistance.

A lamp connected to a cell lights with normal brightness.



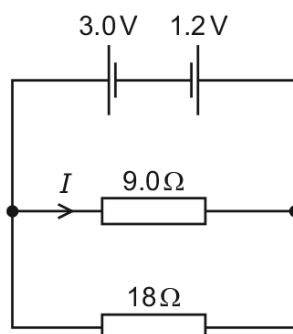
What happens when the student connects the lamps and the cells as shown?



- A** All three lamps light with normal brightness.
- B** Only lamp 2 lights with normal brightness.
- C** Only lamps 1 and 3 light with normal brightness.
- D** None of the lamps light with normal brightness.

1223. 9702_s19_qp_13 Q: 38

Two cells of electromotive force (e.m.f.) 3.0V and 1.2V and negligible internal resistance are connected to resistors of resistance 9.0Ω and 18Ω as shown.



What is the current I in the 9.0Ω resistor?

- A** 0.10A
- B** 0.20A
- C** 0.30A
- D** 0.47A

1224. 9702_w19_qp_11 Q: 34

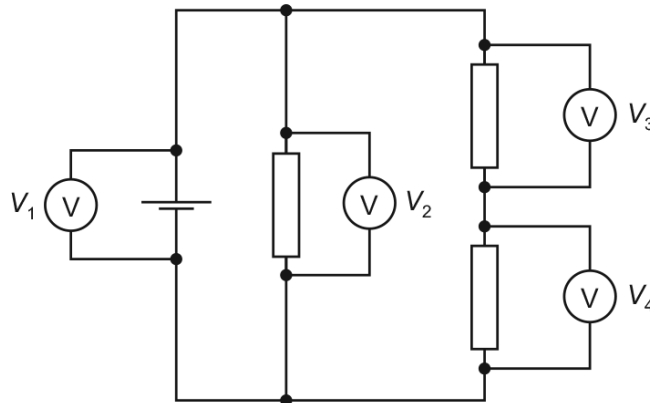
Kirchhoff's two laws for electric circuits can be derived by using conservation laws.

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

1225. 9702_w19_qp_11 Q: 36

The diagram shows a circuit containing four voltmeters. The readings on the voltmeters are V_1 , V_2 , V_3 and V_4 . All the readings are positive.

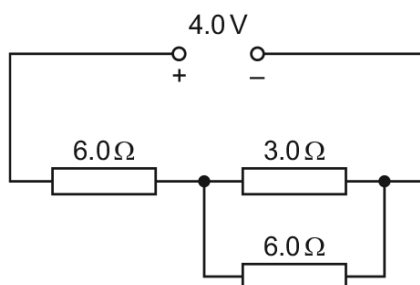


Which equation relating the voltmeter readings is correct?

- A** $V_1 = V_2 + V_4$
- B** $V_1 = V_2 + V_3 + V_4$
- C** $V_2 + V_3 = V_4$
- D** $V_3 + V_4 - V_2 = 0$

1226. 9702_w19_qp_11 Q: 37

A network consists of a $3.0\,\Omega$ resistor and two $6.0\,\Omega$ resistors, as shown.



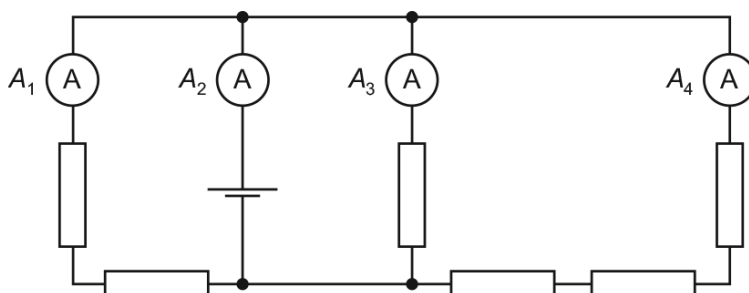
The potential difference (p.d.) across the network is 4.0 V .

What is the current through the $3.0\,\Omega$ resistor?

- A** 0.17 A **B** 0.25 A **C** 0.33 A **D** 1.3 A

1227. 9702_w19_qp_11 Q: 38

In the circuit shown, all the resistors are identical and all the ammeters have negligible resistance.



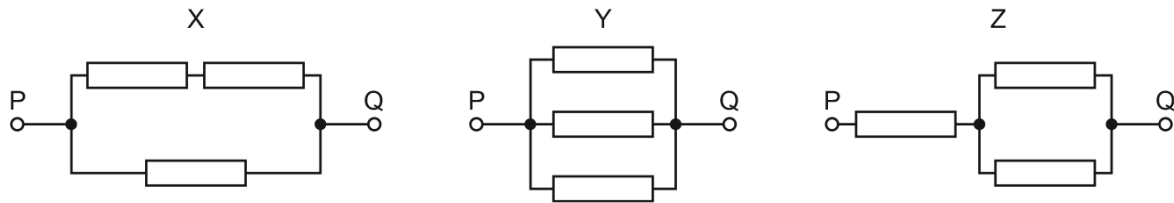
The reading A_1 is 0.6 A .

What are the readings on the other ammeters?

	A_2/A	A_3/A	A_4/A
A	1.0	0.3	0.1
B	1.4	0.6	0.2
C	1.8	0.9	0.3
D	2.2	1.2	0.4

1228. 9702_w19_qp_12 Q: 36

Three identical resistors are connected between terminals P and Q in different networks X, Y and Z as shown.

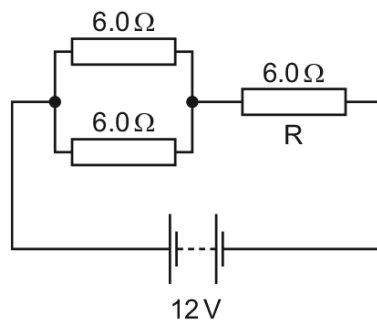


What is the order of increasing combined resistance between P and Q (lowest first)?

- A $X \rightarrow Y \rightarrow Z$
- B $X \rightarrow Z \rightarrow Y$
- C $Y \rightarrow X \rightarrow Z$
- D $Y \rightarrow Z \rightarrow X$

1229. 9702_w19_qp_13 Q: 34

A battery of electromotive force (e.m.f.) 12V and negligible internal resistance is connected to three resistors, each of resistance 6.0Ω , as shown.



What is the power dissipated in resistor R?

- A 2.7W
- B 6.0W
- C 11W
- D 24W

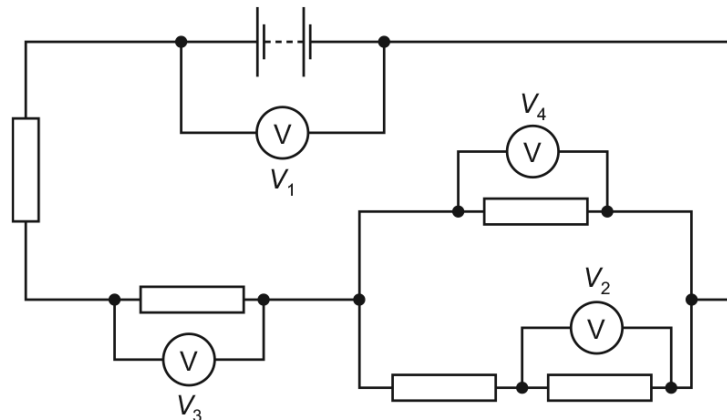
1230. 9702_w19_qp_13 Q: 37

Which row correctly describes Kirchhoff's laws?

	Kirchhoff's first law	physics principle applied for first law	Kirchhoff's second law	physics principle applied for second law
A	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy
B	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge
C	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge
D	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy

1231. 9702_w19_qp_13 Q: 38

In the circuit shown, all the resistors are identical.



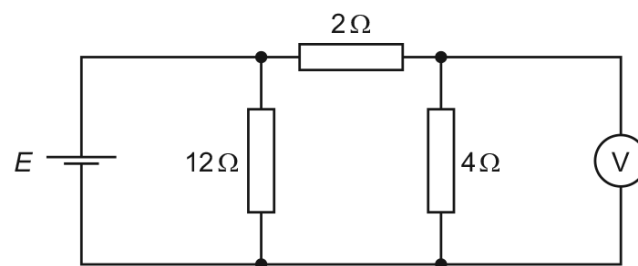
The reading V_1 is 8.0 V and the reading V_2 is 1.0 V.

What are the readings on the other voltmeters?

	V_3/V	V_4/V
A	1.5	1.0
B	3.0	2.0
C	4.5	3.0
D	6.0	4.0

1232. 9702_m18_qp_12 Q: 37

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



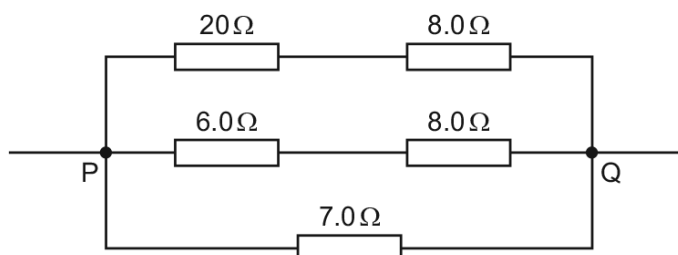
The voltmeter has a very high resistance and reads a potential difference V_{out} .

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

- A** $\frac{1}{6}$ **B** $\frac{1}{3}$ **C** $\frac{1}{2}$ **D** $\frac{2}{3}$

1233. 9702_m18_qp_12 Q: 38

Five resistors are connected as shown.



What is the total resistance between points P and Q?

- A** $0.25\ \Omega$ **B** $0.61\ \Omega$ **C** $4.0\ \Omega$ **D** $16\ \Omega$

1234. 9702_s18_qp_11 Q: 33

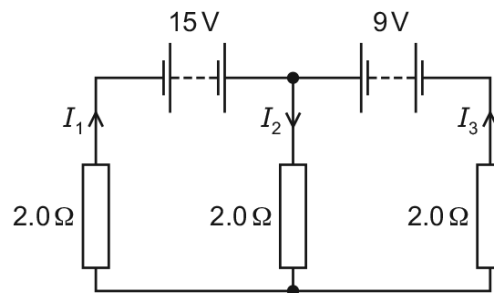
The sum of the electrical currents into a point in a circuit is equal to the sum of the currents out of the point.

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.

1235. 9702_s18_qp_11 Q: 34

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

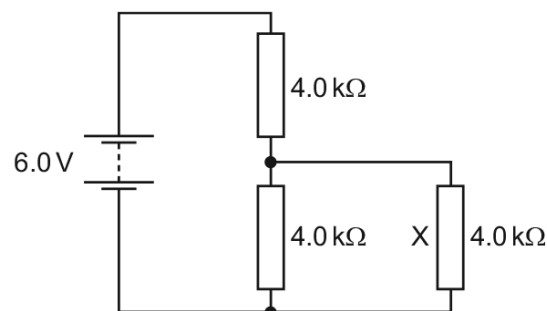


What are the values of the currents I_1 , I_2 and I_3 ?

	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

1236. 9702_s18_qp_11 Q: 35

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



Each resistor has a resistance of 4.0 kΩ.

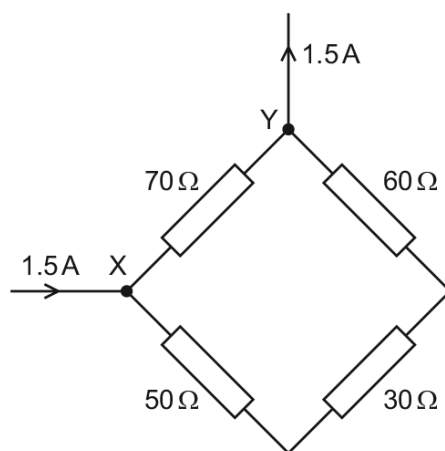
What is the current in resistor X?

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

1237. 9702_s18_qp_12 Q: 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.



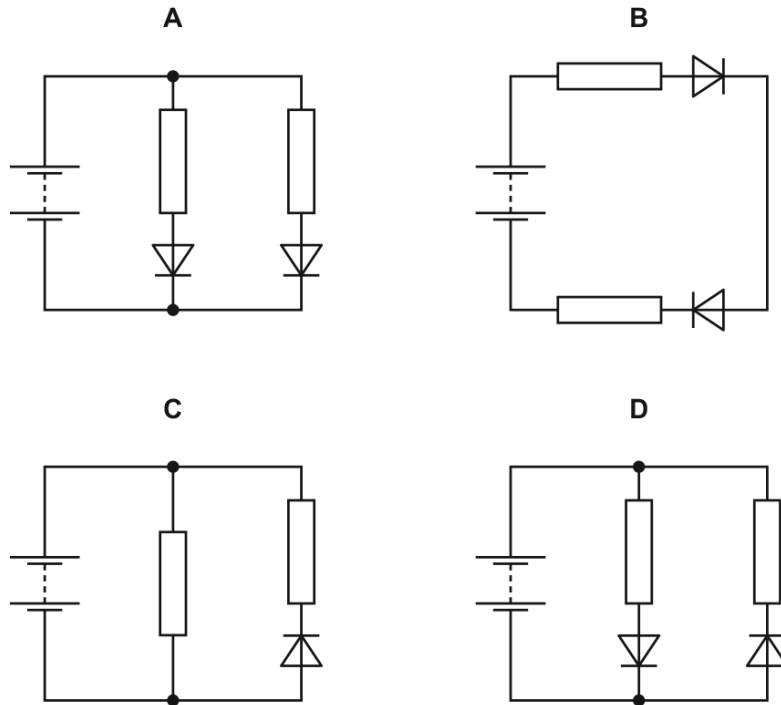
What is the current in the resistor of resistance 30 Ω ?

- A** 0.21 A **B** 0.50 A **C** 0.75 A **D** 1.0 A
-

1238. 9702_s18_qp_12 Q: 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.

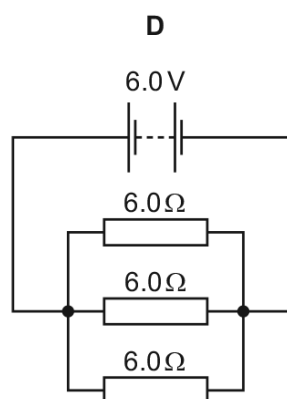
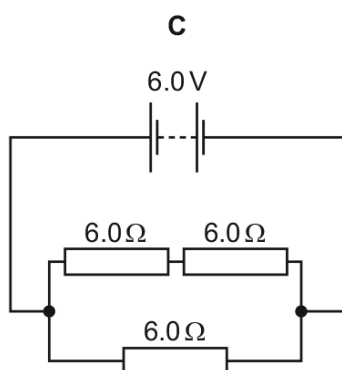
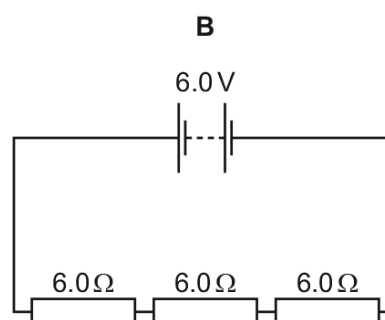
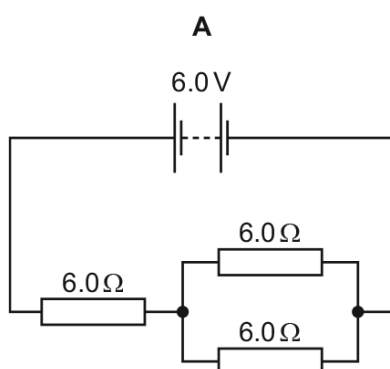
In which circuit is the current in the battery greatest?



1239. 9702_s18_qp_13 Q: 34

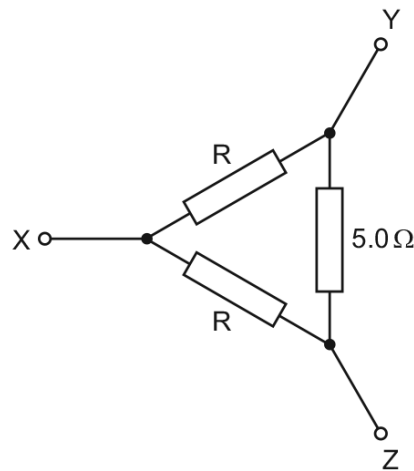
A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors each of resistance $6.0\ \Omega$.

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



1240. 9702_s18_qp_13 Q: 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 .



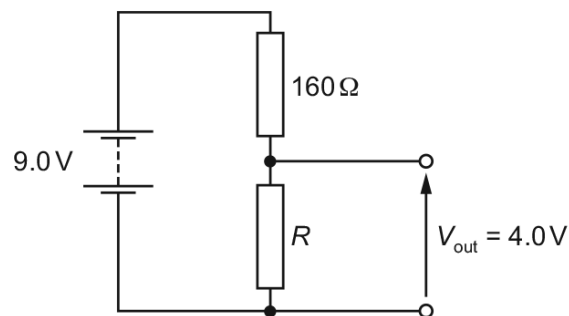
The resistance between Y and Z is found to be 2.5Ω .

What is the resistance between X and Y?

- A** 0.30Ω **B** 0.53Ω **C** 1.9Ω **D** 3.3Ω

1241. 9702_s18_qp_13 Q: 37

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

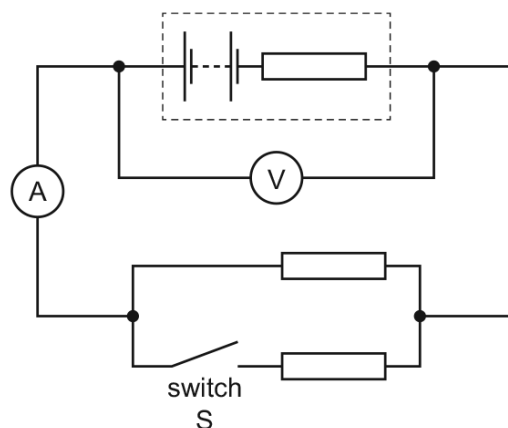


What is the resistance R ?

- A** 32Ω **B** 49Ω **C** 71Ω **D** 128Ω

1242. 9702_w18_qp_11 Q: 36

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



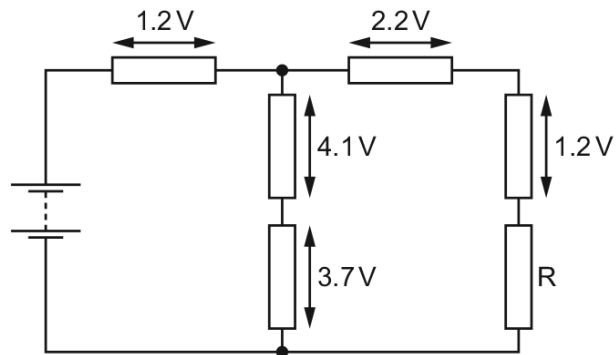
Initially switch S is open.

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

1243. 9702_w18_qp_11 Q: 37

A battery is connected to a network of six resistors, as shown.



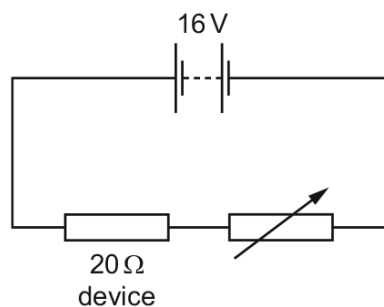
The potential differences across five of the resistors are labelled on the diagram.

What is the potential difference across resistor R?

- A** 4.4 V **B** 4.6 V **C** 6.6 V **D** 11.2 V

1244. 9702_w18_qp_12 Q: 34

An electrical device of fixed resistance $20\ \Omega$ is connected in series with a variable resistor and a battery of electromotive force (e.m.f.) 16 V and negligible internal resistance.

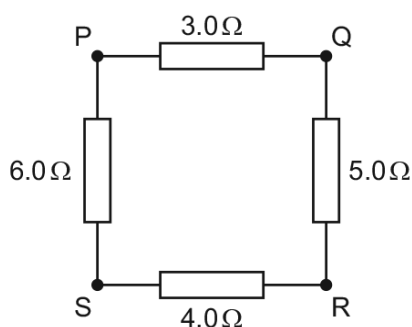


What is the resistance of the variable resistor when the power dissipated in the electrical device is 4.0 W?

- A** $16\ \Omega$ **B** $36\ \Omega$ **C** $44\ \Omega$ **D** $60\ \Omega$

1245. 9702_w18_qp_12 Q: 36

A battery of negligible internal resistance may be connected between any two points P, Q, R and S of the network of resistors shown.



Which connections will give the largest current and the smallest current in the battery?

	largest current	smallest current
A	PQ	PR
B	PQ	QS
C	RS	PR
D	RS	QS

1246. 9702_w18_qp_12 Q: 37

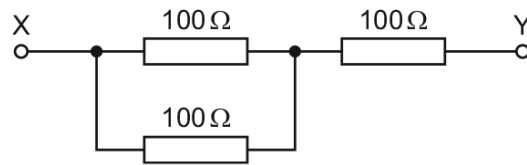
Kirchhoff's second law is a consequence of a basic principle.

What is this principle?

- A** The charge flowing in an electric circuit is conserved.
- B** The energy in an electric circuit is conserved.
- C** The sum of the electric currents entering a point in an electrical circuit is equal to the sum of the electric currents leaving that point.
- D** The sum of the potential differences in a circuit is equal to the sum of the products of the current and resistance.

1247. 9702_w18_qp_13 Q: 33

Three resistors are to be connected into a circuit with the arrangement shown.



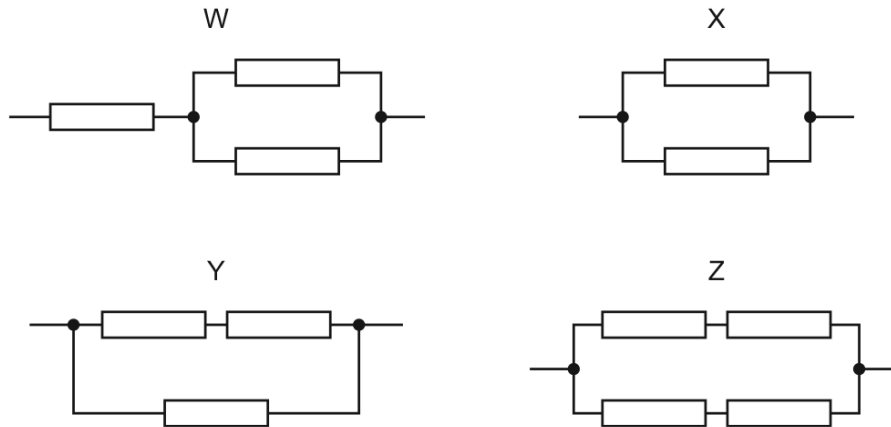
The power in any resistor must not be greater than 4.0 W.

What is the maximum voltage across XY?

- A** 24 V **B** 30 V **C** 40 V **D** 60 V

1248. 9702_w18_qp_13 Q: 36

All the resistors shown in the resistor networks W, X, Y and Z have the same resistance.

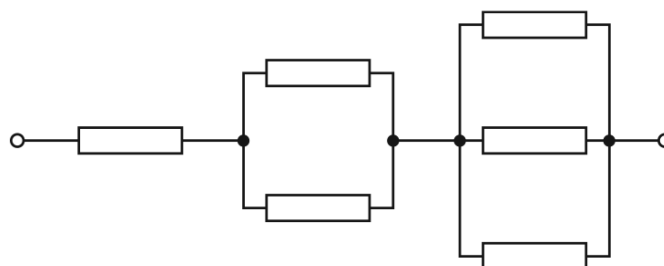


Which list gives the networks in order of increasing total resistance?

- A** $W \rightarrow Z \rightarrow Y \rightarrow X$
B $X \rightarrow W \rightarrow Y \rightarrow Z$
C $X \rightarrow Y \rightarrow W \rightarrow Z$
D $X \rightarrow Y \rightarrow Z \rightarrow W$

1249. 9702_m17_qp_12 Q: 36

Six resistors, each of resistance R , are connected as shown.



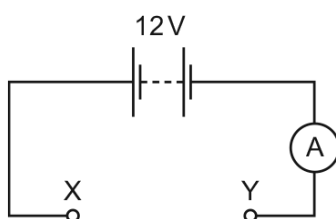
The combined resistance is $66\text{ k}\Omega$.

What is the value of R ?

- A** $11\text{ k}\Omega$ **B** $18\text{ k}\Omega$ **C** $22\text{ k}\Omega$ **D** $36\text{ k}\Omega$

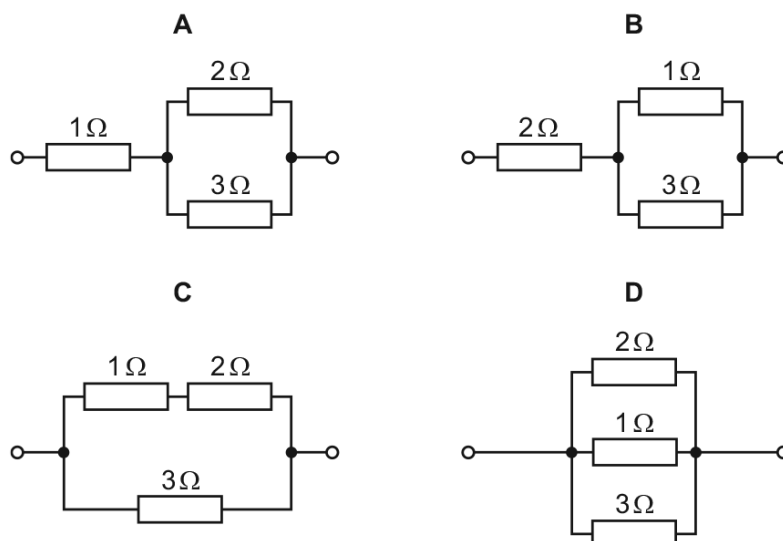
1250. 9702_s17_qp_11 Q: 37

In the circuit shown, the battery and ammeter have negligible resistance.



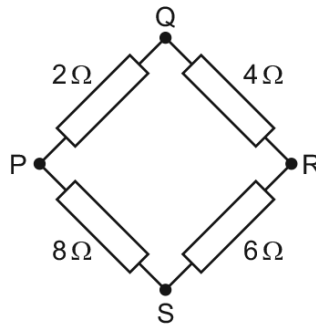
The following combinations of resistors are each separately placed between the terminals X and Y of the circuit.

Which combination would give an ammeter reading of 8 A ?



1251. 9702_s17_qp_12 Q: 36

Four resistors are connected in a square as shown.



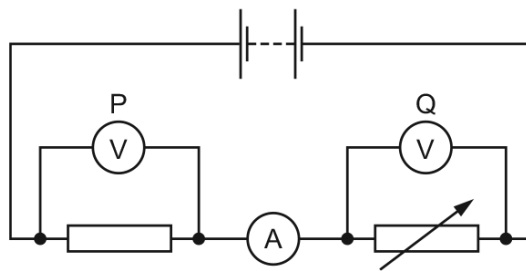
The resistance may be measured between any two junctions.

Between which two junctions is the measured resistance greatest?

- A** P and Q **B** Q and S **C** R and S **D** S and P

1252. 9702_s17_qp_12 Q: 37

A circuit is set up as shown.



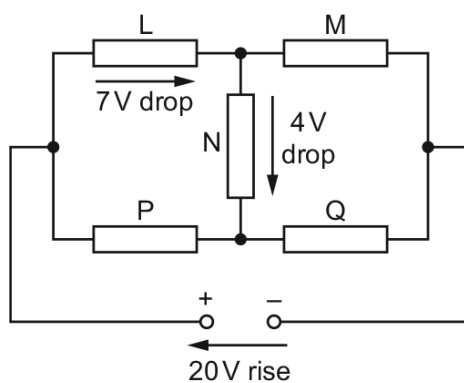
The variable resistor is adjusted so that the ammeter reading decreases.

How do the readings of the voltmeters change?

	reading on voltmeter P	reading on voltmeter Q
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

1253. 9702_s17_qp_13 Q: 35

A 20 V d.c. supply is connected to a circuit consisting of five resistors L, M, N, P and Q.



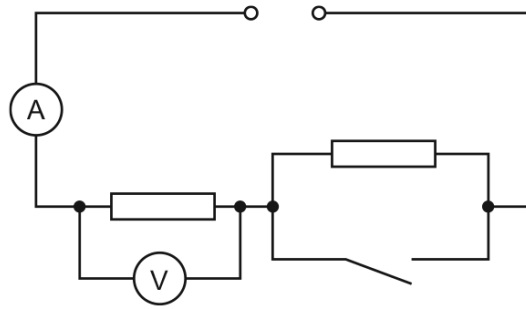
There is a potential drop of 7 V across L and a further 4 V potential drop across N.

What are the potential drops across M, P and Q?

	potential drop across M/V	potential drop across P/V	potential drop across Q/V
A	9	7	13
B	13	7	13
C	13	11	9
D	17	3	17

1254. 9702_w17_qp_11 Q: 36

In the circuit shown, the ammeter reading is I and the voltmeter reading is V .

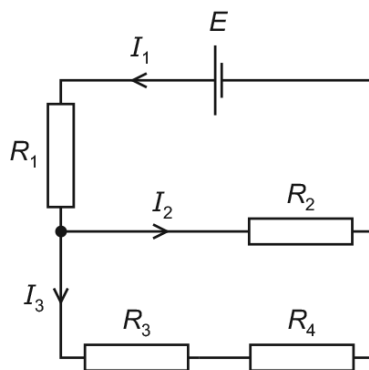


When the switch is closed, which row describes what happens to I and to V ?

	I	V
A	decreases	decreases
B	increases	increases
C	increases	stays the same
D	stays the same	increases

1255. 9702_w17_qp_11 Q: 37

A cell of electromotive force E and negligible internal resistance is connected to a network of resistors of resistances R_1 , R_2 , R_3 and R_4 as shown.



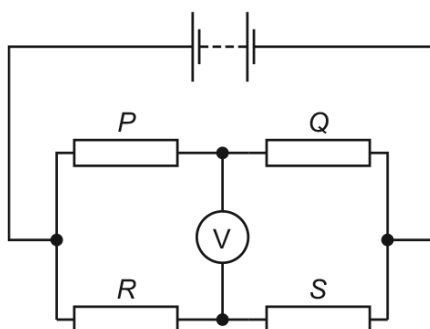
The branches of the circuit have currents I_1 , I_2 and I_3 .

Which equation is correct?

- A** $I_1 R_1 + I_2 R_2 = I_3 R_3 + I_3 R_4$
- B** $I_2 R_2 - I_3 R_4 - I_3 R_3 = 0$
- C** $E = I_1 R_1 + I_2 R_2 + I_3 R_3 + I_3 R_4$
- D** $E = I_1 R_1 + I_2 R_2 - I_3 R_3 - I_3 R_4$

1256. 9702_w17_qp_11 Q: 38

The circuit diagram shows four resistors of different resistances P , Q , R and S connected to a battery.



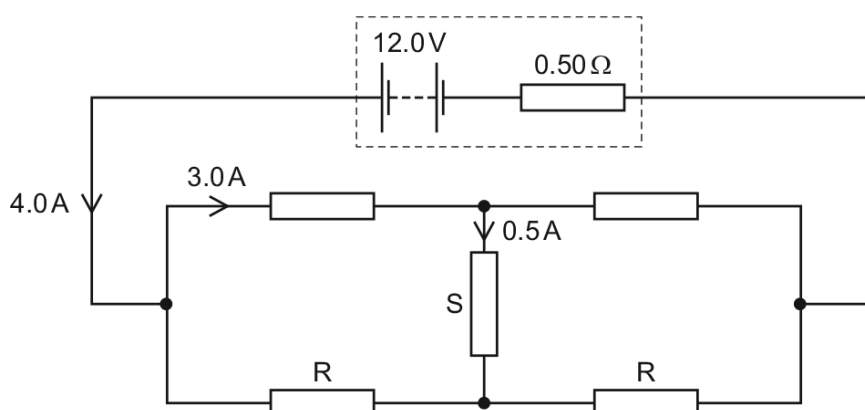
The voltmeter reading is zero.

Which equation is correct?

- A** $P - Q = R - S$
- B** $P - S = Q - R$
- C** $PQ = RS$
- D** $PS = QR$

1257. 9702_w17_qp_12 Q: 37

The circuit shown contains a resistor S that is neither in series nor in parallel with the other resistors.



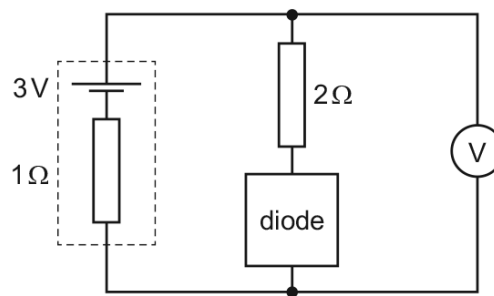
Kirchhoff's laws can be used with the data in the diagram to deduce the resistance of each of the two identical resistors labelled R .

What is the resistance of each resistor R ?

- A** 3.0Ω
- B** 4.0Ω
- C** 4.8Ω
- D** 5.0Ω

1258. 9702_w17_qp_13 Q: 35

An ideal diode has zero resistance when forward biased and infinite resistance when reverse biased. The diode is connected in series with a 2Ω resistor across the terminals of a source having electromotive force (e.m.f.) 3V and internal resistance 1Ω , as shown.



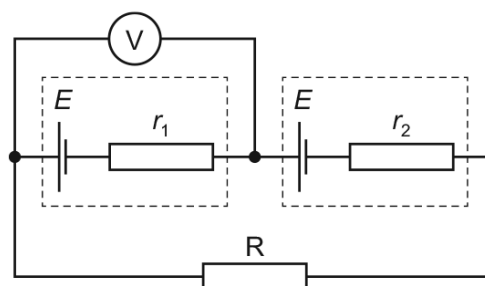
A high-resistance voltmeter is connected across the diode and resistor.

Which row gives the readings of the voltmeter for the two ways of connecting the diode?

	forward biased	reverse biased
A	1V	3V
B	2V	0V
C	2V	3V
D	3V	0V

1259. 9702_w17_qp_13 Q: 36

Two cells, each with electromotive force (e.m.f.) E , but different internal resistances r_1 and r_2 , are connected in series to a resistor R . The reading on the voltmeter is 0V .

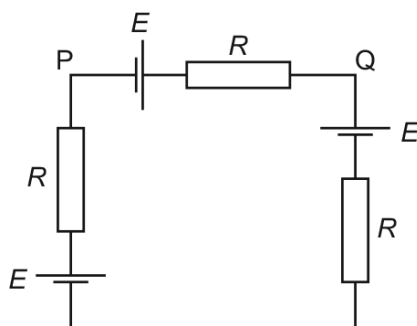


What is the resistance of R ?

- A** 0 **B** $r_1 - r_2$ **C** $r_1 + r_2$ **D** $\frac{r_1 r_2}{r_1 + r_2}$

1260. 9702_w17_qp_13 Q: 37

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.



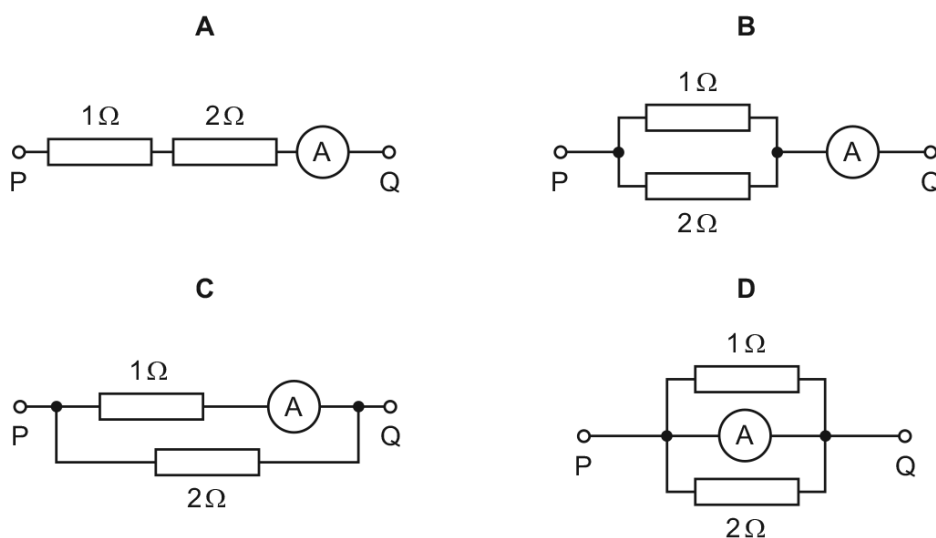
What is the potential difference between P and Q?

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

1261. 9702_w17_qp_13 Q: 38

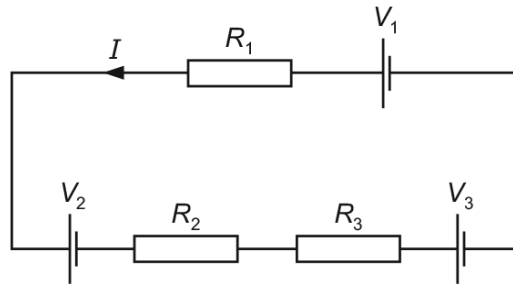
In each arrangement of resistors, the ammeter has a resistance of 2Ω .

Which arrangement gives the largest reading on the ammeter when the same potential difference is applied between points P and Q?



1262. 9702_m16_qp_12 Q: 34

Three cells with e.m.f.s V_1 , V_2 and V_3 , have negligible internal resistance. These cells are connected to three resistors with resistances R_1 , R_2 and R_3 , as shown.



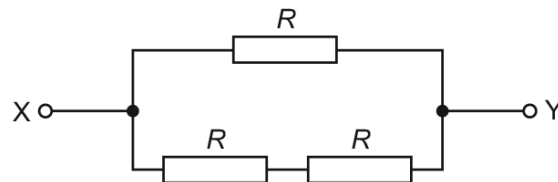
The current in the circuit is I .

Which equation is correct?

- A** $V_1 + V_2 + V_3 = I(R_1 + R_2 + R_3)$
- B** $V_1 + V_2 - V_3 = I(R_1 + R_2 + R_3)$
- C** $V_1 - V_2 + V_3 = I(R_1 + R_2 + R_3)$
- D** $V_1 - V_2 - V_3 = I(R_1 + R_2 + R_3)$

1263. 9702_m16_qp_12 Q: 35

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

1264. 9702_m16_qp_12 Q: 36

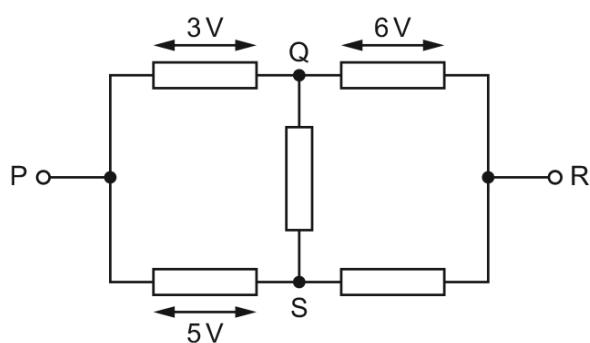
In deriving a formula for the combined resistance of three different resistors in series, Kirchhoff's laws are used.

Which physics principle is involved in this derivation?

- A** the conservation of charge
- B** the direction of the flow of charge is from negative to positive
- C** the potential difference across each resistor is the same
- D** the current varies in each resistor, in proportion to the resistor value

1265. 9702_s16_qp_11 Q: 35

There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3V.

The p.d. between Q and R is 6V.

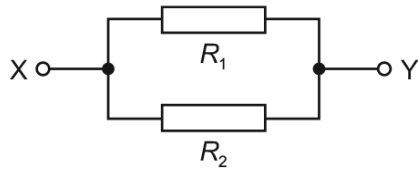
The p.d. between P and S is 5V.

Which row in the table is correct?

	p.d. between Q and S	p.d. between S and R
A	2V	4V
B	2V	10V
C	3V	4V
D	3V	10V

1266. 9702_s16_qp_11 Q: 36

Two resistors of resistances R_1 and R_2 are connected in parallel.

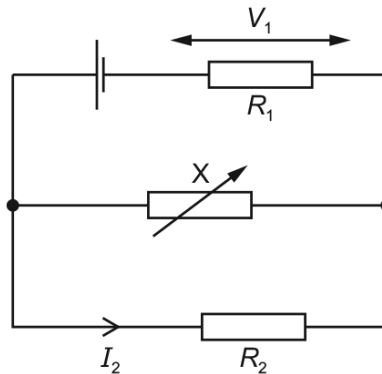


What is the combined resistance between X and Y?

- A** $R_1 + R_2$ **B** $\frac{R_1 R_2}{R_1 + R_2}$ **C** $\frac{R_1 + R_2}{R_1 R_2}$ **D** $\frac{R_1}{R_2}$

1267. 9702_s16_qp_13 Q: 35

A circuit contains a cell, two resistors of resistances R_1 and R_2 and a variable resistor X . The cell has negligible internal resistance.



V_1 is the potential difference across the resistor of resistance R_1 .

I_2 is the current through the resistor of resistance R_2 .

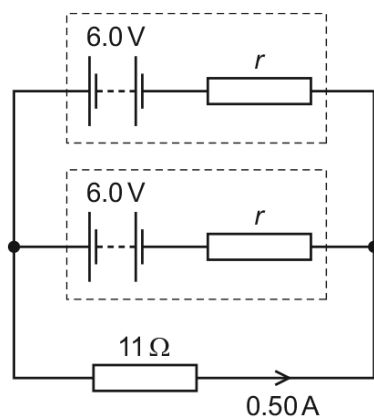
The resistance of X is reduced.

What is the effect on V_1 and I_2 ?

	V_1	I_2
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

1268. 9702_s16_qp_13 Q: 37

Two identical batteries each have e.m.f. 6.0V and internal resistance r . The batteries are connected to an external resistor of resistance 11Ω , as shown.



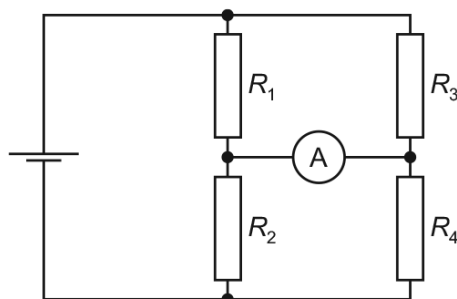
The current in the external resistor is 0.50A .

What is the internal resistance r of each battery?

- A** 1.0Ω **B** 2.0Ω **C** 4.0Ω **D** 6.5Ω

1269. 9702_w16_qp_11 Q: 36

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



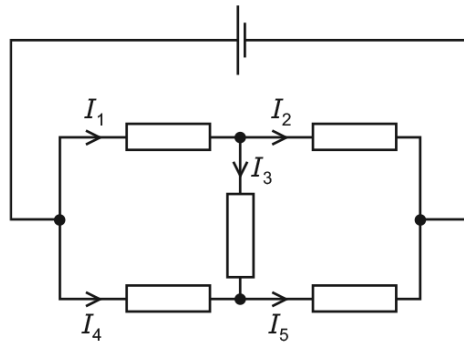
The four resistors have different resistances R_1 , R_2 , R_3 and R_4 .

Which equation is correct?

- A** $R_1 - R_3 = R_2 - R_4$
B $R_1 \times R_3 = R_2 \times R_4$
C $R_1 - R_4 = R_2 - R_3$
D $R_1 \times R_4 = R_2 \times R_3$

1270. 9702_w16_qp_11 Q: 37

The diagram shows currents I_1 , I_2 , I_3 , I_4 and I_5 in different branches of a circuit.

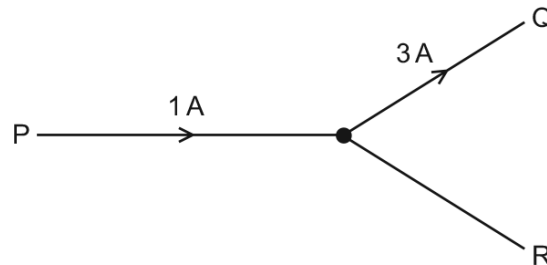


Which equation is correct?

- A** $I_1 = I_2 + I_3$
- B** $I_2 = I_1 + I_3$
- C** $I_3 = I_4 + I_5$
- D** $I_4 = I_5 + I_3$

1271. 9702_w16_qp_12 Q: 32

The diagram shows a junction in a circuit where three wires P, Q and R meet. The currents in P and Q are 1 A and 3 A respectively, in the directions shown.

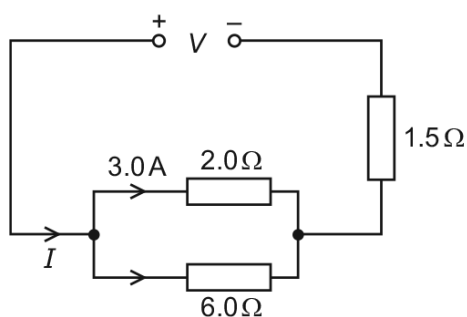


How much charge passes a given point in wire R in a time of 5 s?

- A** 0.4 C
- B** 2 C
- C** 10 C
- D** 20 C

1272. 9702_w16_qp_12 Q: 37

In the circuit shown, there is a current of 3.0 A in the $2.0\ \Omega$ resistor.

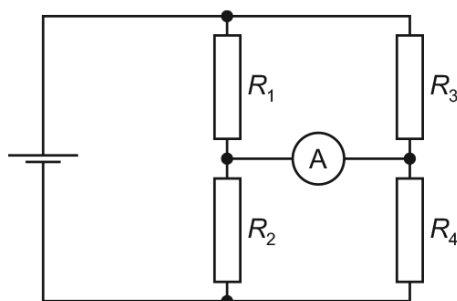


What are the values of the current I delivered by the power supply and the voltage V across it?

	I/A	V/V
A	3.0	10.5
B	4.0	9.0
C	4.0	12
D	12	18

1273. 9702_w16_qp_13 Q: 36

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



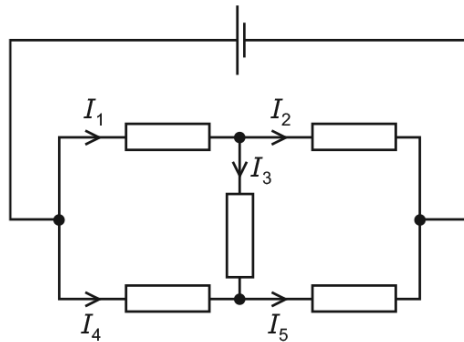
The four resistors have different resistances R_1 , R_2 , R_3 and R_4 .

Which equation is correct?

- A** $R_1 - R_3 = R_2 - R_4$
- B** $R_1 \times R_3 = R_2 \times R_4$
- C** $R_1 - R_4 = R_2 - R_3$
- D** $R_1 \times R_4 = R_2 \times R_3$

1274. 9702_w16_qp_13 Q: 37

The diagram shows currents I_1 , I_2 , I_3 , I_4 and I_5 in different branches of a circuit.

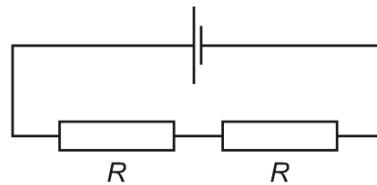
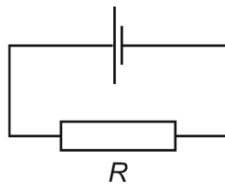


Which equation is correct?

- A** $I_1 = I_2 + I_3$
- B** $I_2 = I_1 + I_3$
- C** $I_3 = I_4 + I_5$
- D** $I_4 = I_5 + I_3$

1275. 9702_s15_qp_11 Q: 33

The diagrams show two different circuits.



The cells in each circuit have the same electromotive force and zero internal resistance. The three resistors each have the same resistance R .

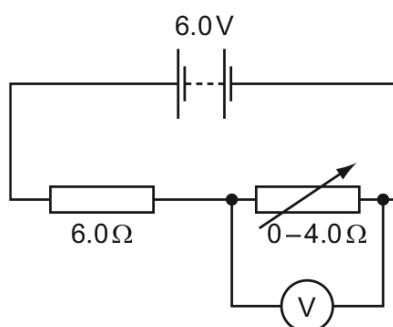
In the circuit on the left, the power dissipated in the resistor is P .

What is the total power dissipated in the circuit on the right?

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

1276. 9702_s15_qp_11 Q: 37

A battery of electromotive force (e.m.f.) 6.0V and negligible internal resistance is connected in series with a resistor of resistance 6.0Ω and a variable resistor of resistance from zero to 4.0Ω . A voltmeter is connected across the variable resistor. The resistance of the variable resistor is changed.

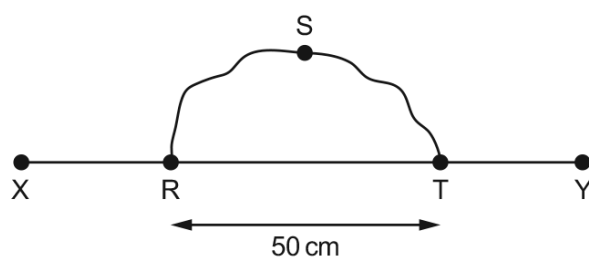


What is the range of the voltmeter reading?

- A** $0\text{V} - 2.4\text{V}$
- B** $0\text{V} - 3.6\text{V}$
- C** $2.4\text{V} - 6.0\text{V}$
- D** $3.6\text{V} - 6.0\text{V}$

1277. 9702_s15_qp_11 Q: 38

A wire RST is connected to another wire XY as shown.



Each wire is 100cm long with a resistance per unit length of $10\Omega\text{m}^{-1}$.

What is the total resistance between X and Y?

- A** 3.3Ω
- B** 5.0Ω
- C** 8.3Ω
- D** 13.3Ω

1278. 9702_s15_qp_12 Q: 35

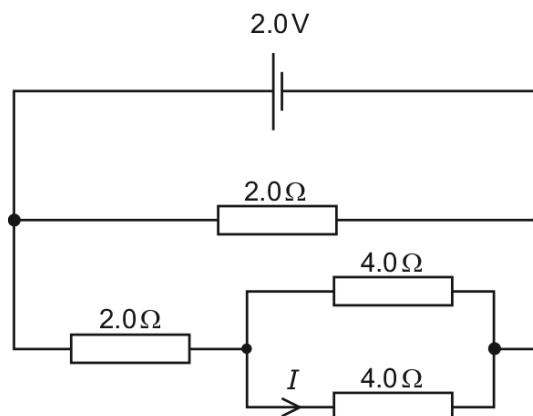
Each of Kirchhoff's two laws presumes that some quantity is conserved.

Which row states Kirchhoff's **first** law and names the quantity that is conserved?

	statement	quantity
A	the algebraic sum of currents into a junction is zero	charge
B	the algebraic sum of currents into a junction is zero	energy
C	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	charge
D	the e.m.f. in a loop is equal to the algebraic sum of the product of current and resistance round the loop	energy

1279. 9702_s15_qp_12 Q: 37

A cell of e.m.f. 2.0 V and negligible internal resistance is connected to a network of resistors as shown.

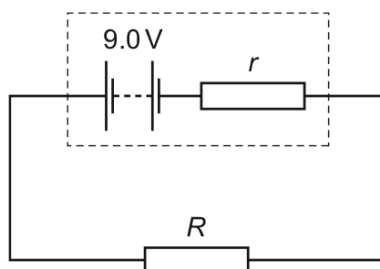


What is the current I ?

- A** 0.25A **B** 0.33A **C** 0.50A **D** 1.5A

1280. 9702_s15_qp_13 Q: 34

A simple circuit is formed by connecting a resistor of resistance R between the terminals of a battery of electromotive force (e.m.f.) 9.0 V and constant internal resistance r .



A charge of 6.0 C flows through the resistor in a time of 2.0 minutes causing it to dissipate 48 J of thermal energy.

What is the internal resistance r of the battery?

- A** $0.17\ \Omega$ **B** $0.33\ \Omega$ **C** $20\ \Omega$ **D** $160\ \Omega$

1281. 9702_s15_qp_13 Q: 35

A source of e.m.f. 9.0 mV has an internal resistance of $6.0\ \Omega$.

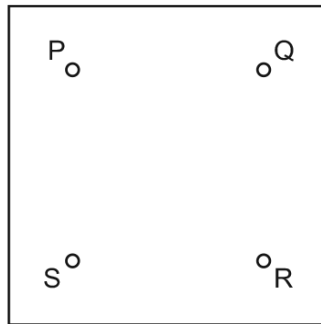
It is connected across a galvanometer of resistance $30\ \Omega$.

What is the current in the galvanometer?

- A** $250\ \mu\text{A}$ **B** $300\ \mu\text{A}$ **C** 1.5 mA **D** 2.5 mA

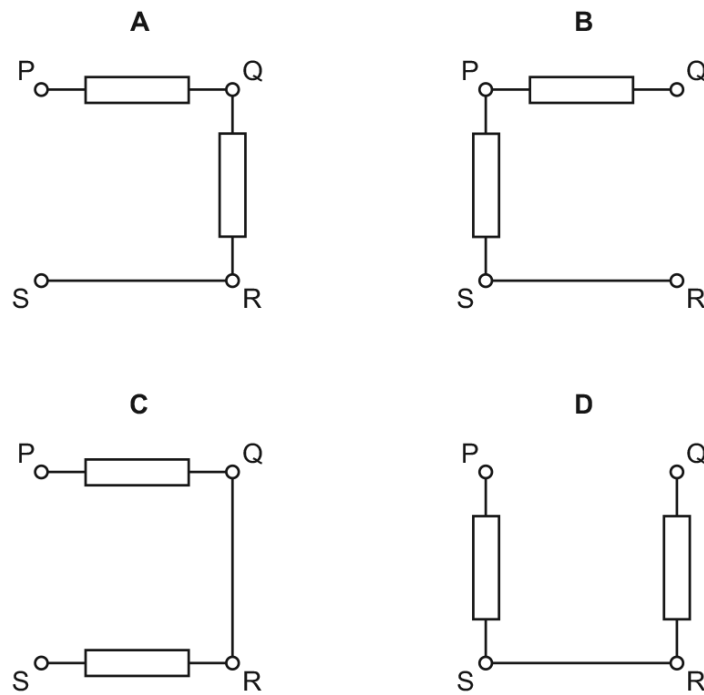
1282. 9702_s15_qp_13 Q: 36

A box with four terminals P, Q, R and S contains two identical resistors.



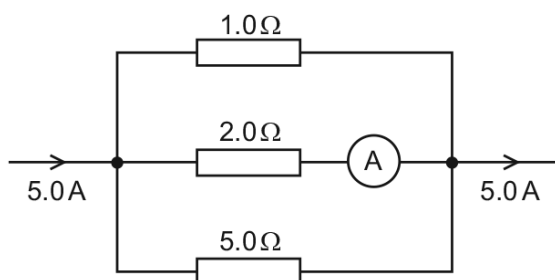
When a battery of electromotive force (e.m.f.) E and negligible internal resistance is connected across PS, a high-resistance voltmeter connected across QR reads $\frac{E}{2}$.

Which diagram shows the correct arrangement of the two resistors inside the box?



1283. 9702_s15_qp_13 Q: 37

The diagram shows part of a current-carrying circuit. The ammeter has negligible resistance.



What is the reading on the ammeter?

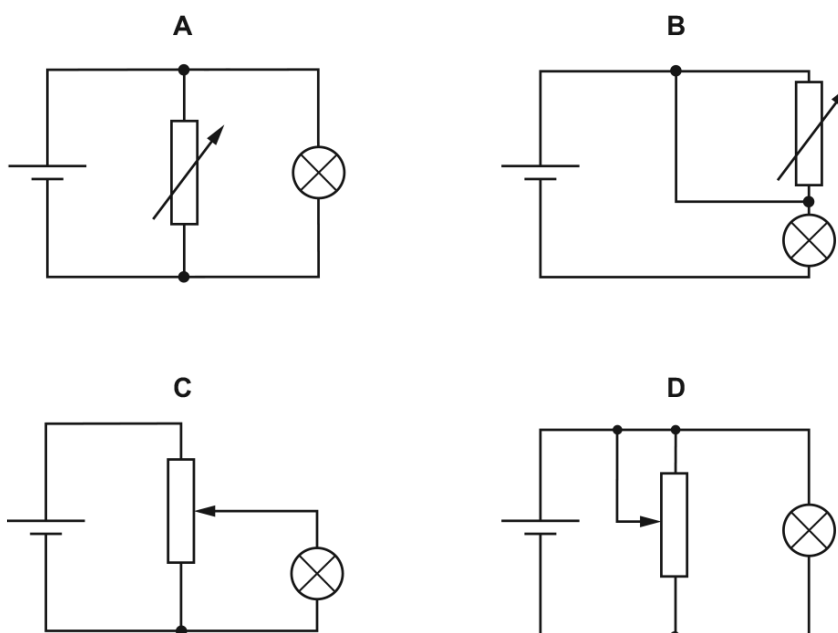
- A** 0.7 A **B** 1.3 A **C** 1.5 A **D** 1.7 A

12.3 Potential dividers

1284. 9702_m20_qp_12 Q: 37

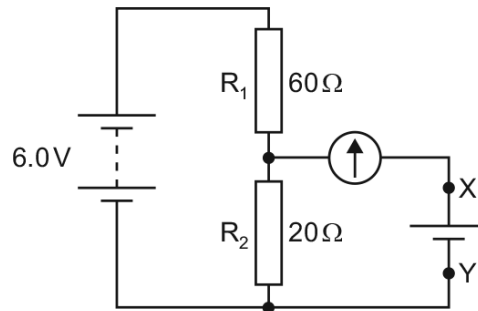
In the circuits shown, the cell has negligible internal resistance.

Which diagram shows a potential divider circuit that can vary the potential difference (p.d.) across the lamp?



1285. 9702_s20_qp_11 Q: 38

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 .



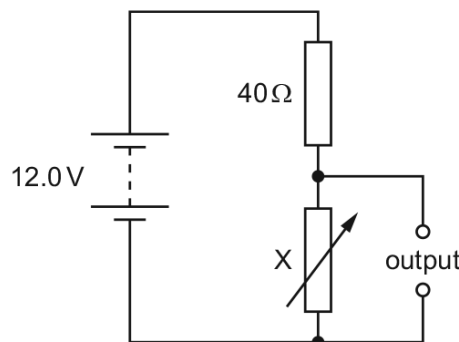
The circuit is to be used to test whether the electromotive force (e.m.f.) of a particular cell is 1.5 V. The cell is connected between terminals X and Y in parallel with R_2 and in series with a galvanometer.

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.

1286. 9702_s20_qp_12 Q: 38

In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0Ω to 500Ω . The electromotive force (e.m.f.) of the battery is 12.0 V. It has negligible internal resistance.

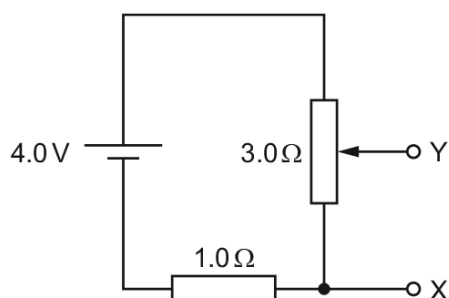


What is the maximum range of values of potential difference across the output?

- A 1.3 V to 11.1 V
- B 1.3 V to 12.0 V
- C 1.5 V to 11.1 V
- D 1.5 V to 12.0 V

1287. 9702_s20_qp_13 Q: 38

A cell of electromotive force (e.m.f.) 4.0 V and negligible internal resistance is connected to a fixed resistor of resistance $1.0\ \Omega$ and a potentiometer of maximum resistance $3.0\ \Omega$, as shown.



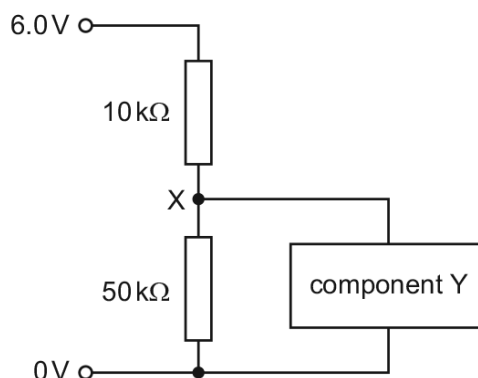
Which range of potential differences can be obtained between the terminals X and Y?

- A** 0 V to 3.0 V
- B** 0 V to 4.0 V
- C** 1.0 V to 3.0 V
- D** 1.0 V to 4.0 V

1288. 9702_m19_qp_12 Q: 38

The circuit shown consists of two resistors of resistances $10\text{ k}\Omega$ and $50\text{ k}\Omega$ and a component Y.

A 6.0 V supply is provided. The electric potential of the bottom wire is 0 V .



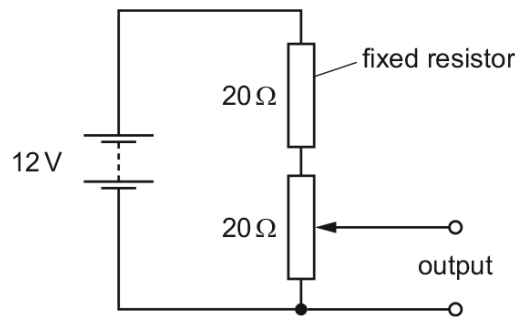
The current in component Y is negligible.

What is the electric potential at junction X?

- A** 1.0 V
- B** 1.2 V
- C** 4.8 V
- D** 5.0 V

1289. 9702_s19_qp_11 Q: 38

The diagram shows a potentiometer and a fixed resistor connected across a 12V battery of negligible internal resistance.



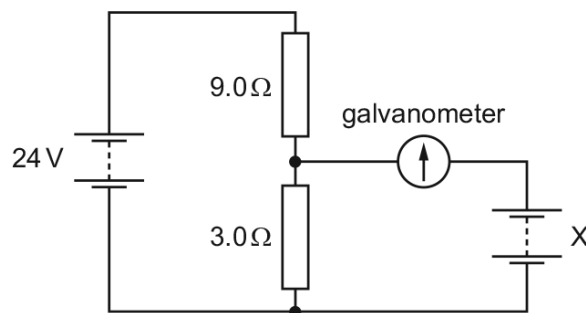
The fixed resistor and the potentiometer each have resistance $20\ \Omega$. The circuit is designed to provide a variable output voltage.

What is the range of output voltages?

- A** 0–6V **B** 0–12V **C** 6–12V **D** 12–20V

1290. 9702_s19_qp_12 Q: 37

A circuit contains two batteries, each of negligible internal resistance, and two resistors as shown.



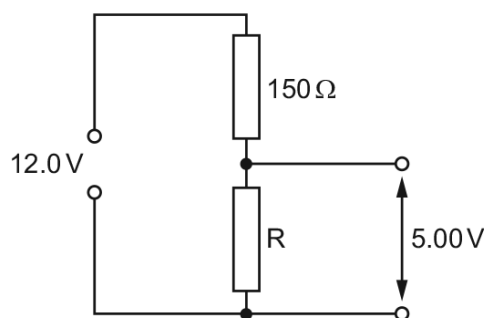
The galvanometer has a current reading of zero.

What is the electromotive force (e.m.f.) of battery X?

- A** 6.0V **B** 8.0V **C** 16.0V **D** 18.0V

1291. 9702_s19_qp_13 Q: 37

A potential divider circuit is shown.

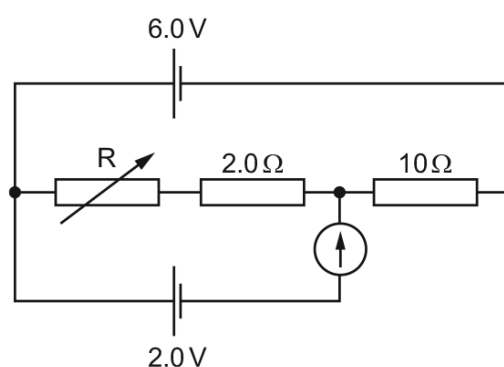


What is the resistance of resistor R in the potential divider circuit?

- A** 62.5 Ω **B** 107 Ω **C** 210 Ω **D** 360 Ω

1292. 9702_w19_qp_12 Q: 37

The diagram shows a variable resistor R and two fixed resistors connected in series in a circuit to act as a potential divider.



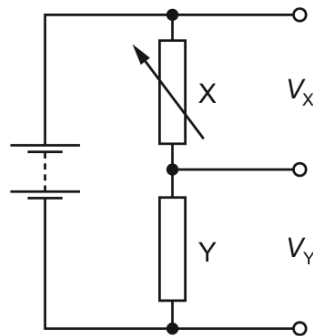
The cell of electromotive force (e.m.f.) 6.0 V has negligible internal resistance. A cell of e.m.f. 2.0 V and a galvanometer are connected into the potential divider. The resistance of R is varied until the galvanometer reads zero.

What is the resistance of resistor R?

- A** 3.0 Ω **B** 5.0 Ω **C** 8.0 Ω **D** 18 Ω

1293. 9702_m18_qp_12 Q: 36

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



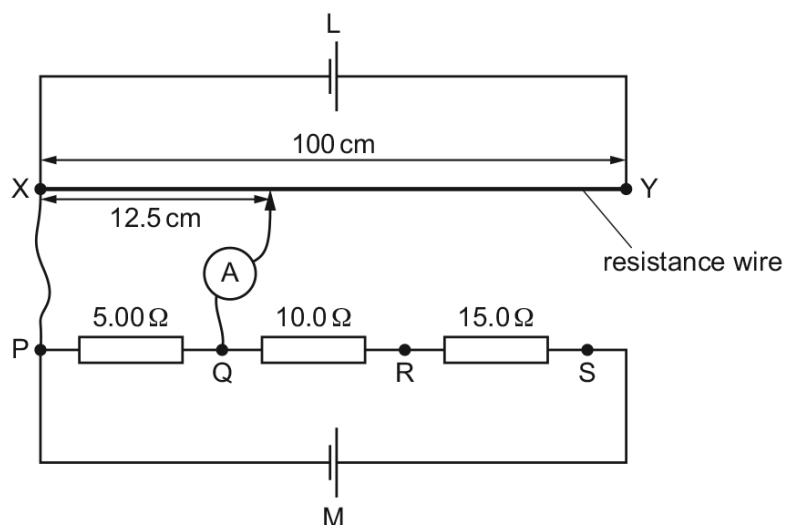
The potential difference across resistor X is V_X and the potential difference of resistor Y is V_Y .

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

1294. 9702_s18_qp_11 Q: 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.

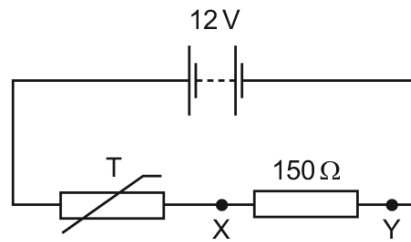
The p.d. across the other resistors is then balanced against other lengths of the resistance wire.

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

1295. 9702_s18_qp_12 Q: 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 .

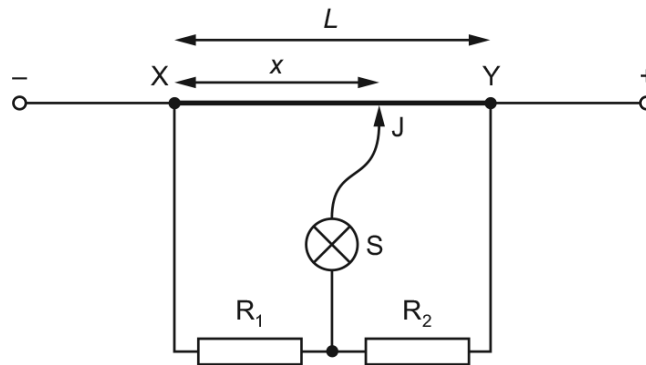


What is the resistance of T when the alarm is triggered?

- A** $90\ \Omega$ **B** $150\ \Omega$ **C** $250\ \Omega$ **D** $400\ \Omega$

1296. 9702_s18_qp_13 Q: 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 .

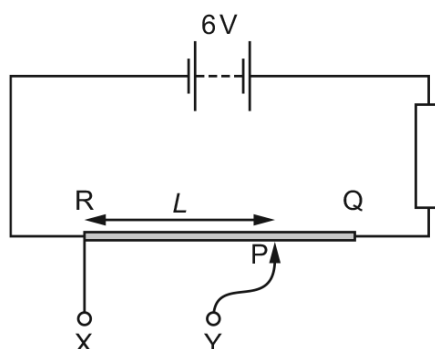
What is the value of the ratio $\frac{V_1}{V_2}$?

- A** $\frac{L}{x}$ **B** $\frac{x}{L}$ **C** $\frac{L-x}{x}$ **D** $\frac{x}{L-x}$

1297. 9702_w18_qp_11 Q: 38

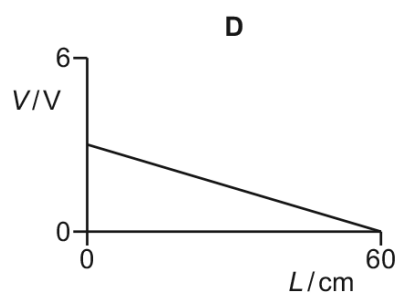
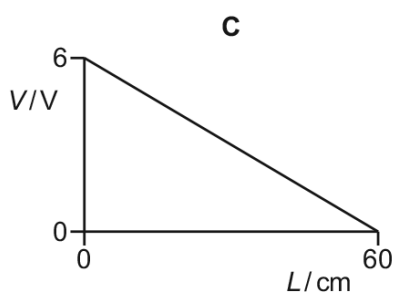
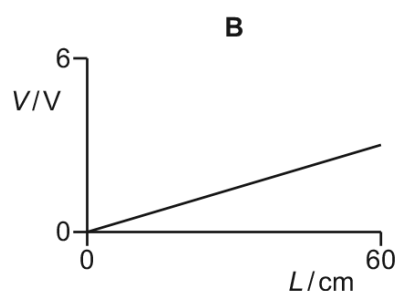
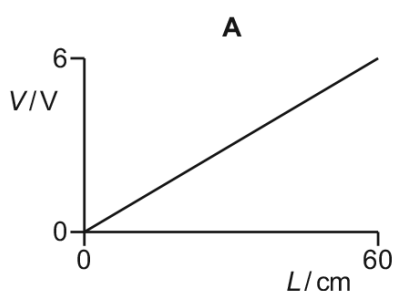
The diagram shows a battery of electromotive force (e.m.f.) 6 V , connected in series with a resistor and a uniform resistance wire RQ of length 60 cm .

The resistance of RQ is equal to the resistance of the resistor.



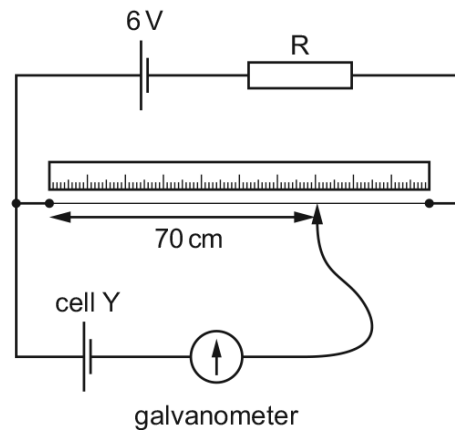
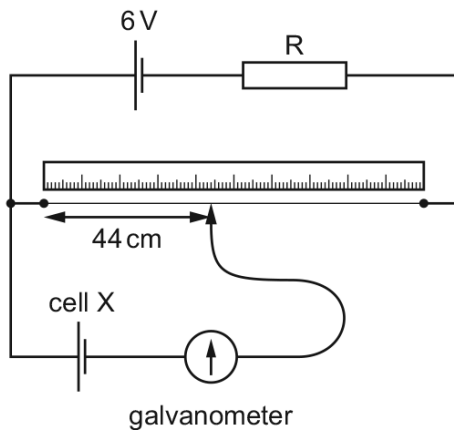
Terminal X is connected to fixed point R. Terminal Y is connected to point P, a connection that may be made at any position along the wire. L is the distance between R and P.

Which graph shows the variation with L of the potential difference (p.d.) V across XY?



1298. 9702_w18_qp_12 Q: 38

Two cells are investigated using a potentiometer. At the balance point, cell X gives a reading of 44 cm and cell Y gives a reading of 70 cm.

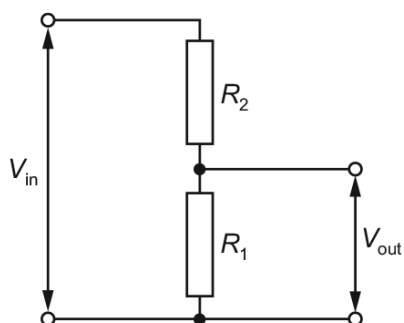


Which statement is **not** correct?

- A A potentiometer balance point results in zero current through the galvanometer.
- B At the balance point, the current through resistor R in both circuits is the same.
- C The electromotive force (e.m.f.) of cell X is larger than that of cell Y.
- D The value of the e.m.f. of each of the cells X and Y is less than 6V.

1299. 9702_m17_qp_12 Q: 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 to 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

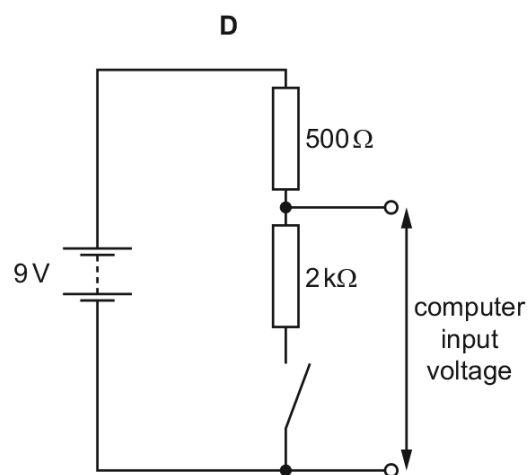
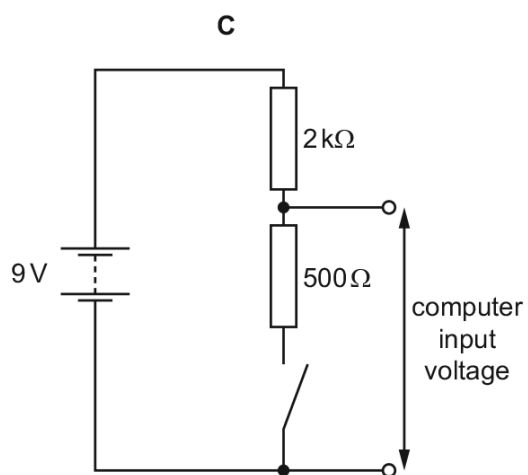
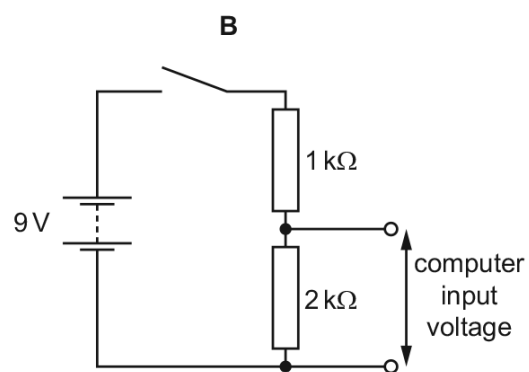
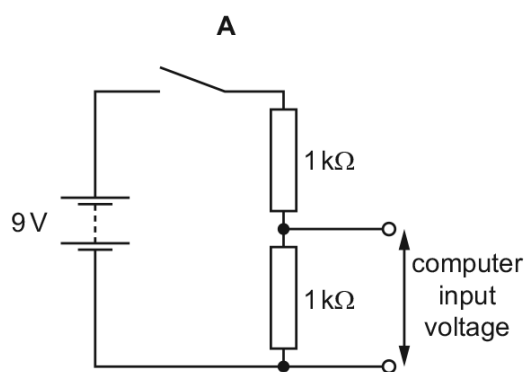
1300. 9702_s17_qp_11 Q: 36

A computer is used to detect the change of position of a switch.

To detect the change of position, the computer requires a potential difference (p.d.) of 0 V to its input at one switch position and a p.d. of between 5 V and 7 V at the other switch position.

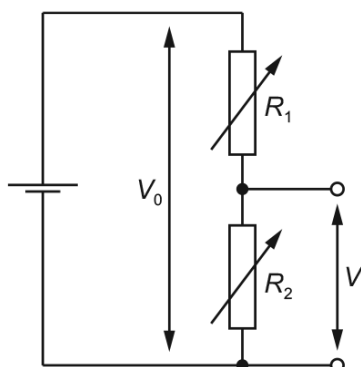
For each of the circuits, assume the battery has negligible internal resistance.

Which circuit provides an input voltage to the computer that enables it to detect the change of position of the switch?



1301. 9702_s17_qp_13 Q: 36

A potential divider circuit consists of a cell of negligible internal resistance in series with two variable resistors of resistances R_1 and R_2 . The potential difference (p.d.) across the cell is V_0 . The p.d. at the output is V .

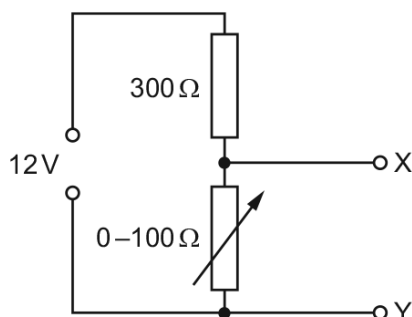


Which statement is correct?

- A** When R_1 increases, it takes a greater proportion of V_0 , so V decreases.
- B** When R_1 increases, the current through R_1 and R_2 decreases, so V increases.
- C** When R_2 decreases, it takes a smaller proportion of V_0 , so V increases.
- D** When R_2 increases, the current through R_1 and R_2 decreases, so V decreases.

1302. 9702_w17_qp_12 Q: 38

The diagram shows a potential divider connected to a 12V supply of negligible internal resistance.

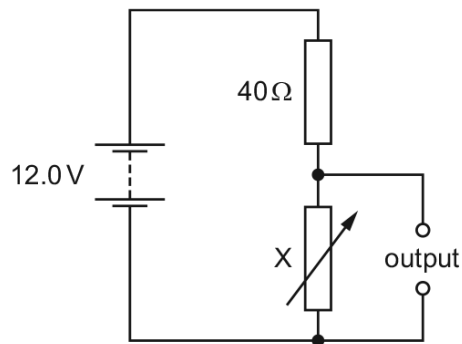


Which range of voltages can be obtained between X and Y?

- A** 0 to 3V **B** 0 to 4V **C** 0 to 8V **D** 0 to 9V

1303. 9702_s16_qp_11 Q: 34

In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0Ω to 500Ω . The e.m.f. of the battery is 12.0V . It has negligible internal resistance.

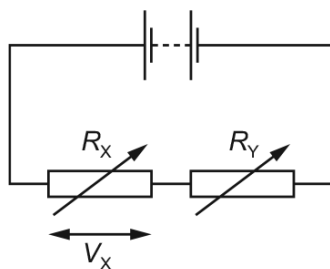


What is the maximum range of values of potential difference across the output?

- A** 1.3V to 11.1V
 - B** 1.3V to 12.0V
 - C** 1.5V to 11.1V
 - D** 1.5V to 12.0V
-

1304. 9702_s16_qp_12 Q: 36

A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



The variable resistors have resistances R_X and R_Y .
 V_X is the potential difference across resistance R_X .

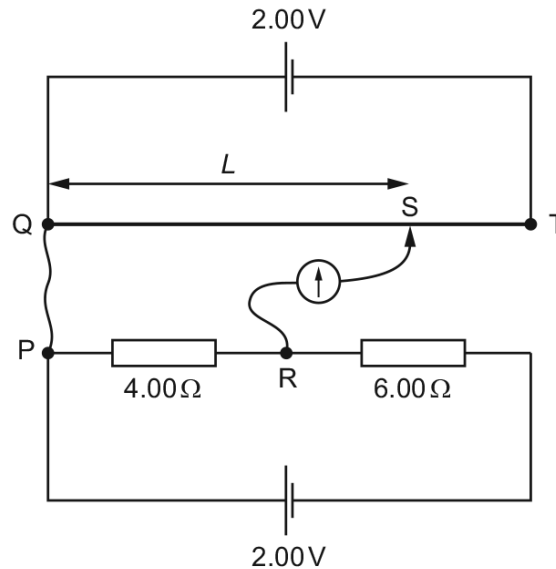
R_X and R_Y are both changed at the same time.

Which combination of changes **must** cause V_X to increase?

	R_X	R_Y
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

1305. 9702_s16_qp_13 Q: 36

A 100cm potentiometer wire QT is connected in series with a 2.00V cell. Another circuit, consisting of a 2.00V cell in series with resistors of resistance 4.00Ω and 6.00Ω , is set up alongside the potentiometer. Connections PQ and RS are then made so that the potential difference (p.d.) across the 4.00Ω resistor is balanced against the p.d. across a length L of potentiometer wire. Both cells have negligible internal resistance.

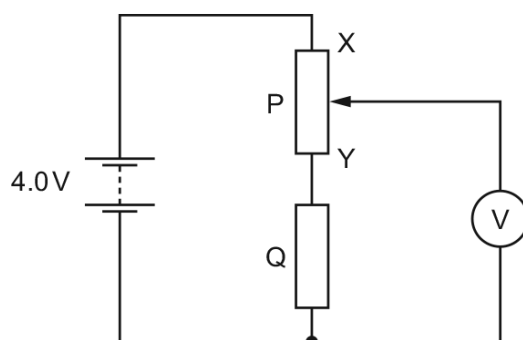


What is the balance length L ?

- A** 0cm **B** 40cm **C** 60cm **D** 100cm

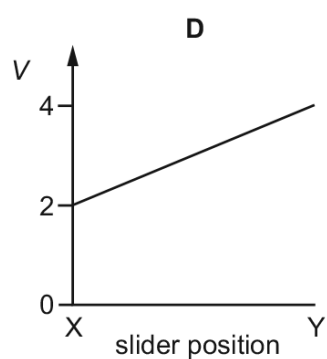
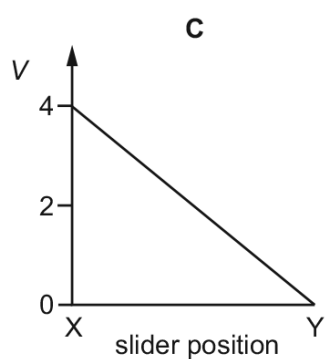
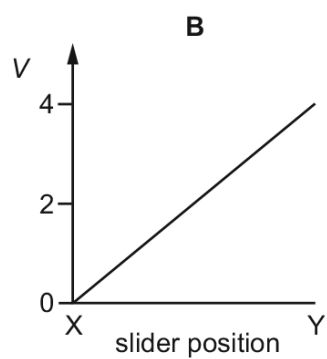
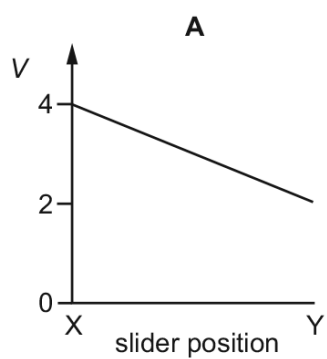
1306. 9702_w16_qp_12 Q: 38

In the circuit below, P is a potentiometer of total resistance 10Ω and Q is a fixed resistor of resistance 10Ω . The battery has an e.m.f. of 4.0V and negligible internal resistance. The voltmeter has a very high resistance.



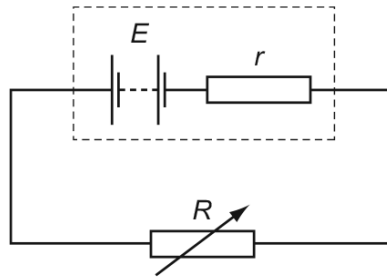
The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading V is plotted against slider position.

Which graph is obtained?



1307. 9702_s15_qp_11 Q: 36

A battery with e.m.f. E and internal resistance r is connected in series with a variable external resistor.



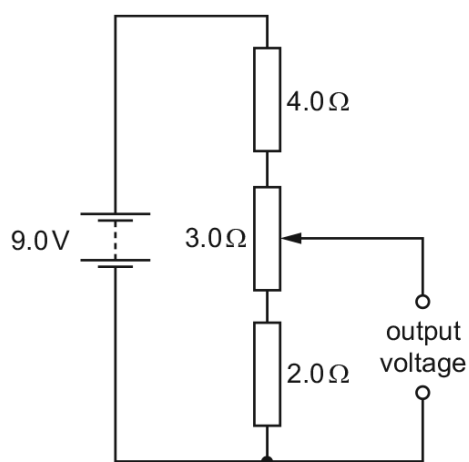
The value of the external resistance R is slowly increased from zero.

Which statement is correct? (Ignore any temperature effects.)

- A** The potential difference across the external resistance decreases.
 - B** The potential difference across the internal resistance increases.
 - C** The power dissipated in r increases and then decreases.
 - D** The power dissipated in R increases and then decreases.
-

1308. 9702_s15_qp_12 Q: 36

A potential divider circuit consists of fixed resistors of resistance 2.0Ω and 4.0Ω connected in series with a 3.0Ω resistor fitted with a sliding contact. These are connected across a battery of e.m.f. 9.0V and zero internal resistance, as shown.



What are the maximum and the minimum output voltages of this potential divider circuit?

	maximum voltage/V	minimum voltage/V
A	4.0	2.0
B	5.0	2.0
C	9.0	0
D	9.0	2.0

Paper 1 Multiple Choice Answers: D.C. Circuits

Question	Paper	Q. No.	Answer
1181	9702_m20_qp_12	36	B
1182	9702_s20_qp_11	36	D
1183	9702_s20_qp_12	36	C
1184	9702_s20_qp_13	37	D
1185	9702_m19_qp_12	36	B
1186	9702_s19_qp_11	35	A
1187	9702_s19_qp_11	36	C
1188	9702_s19_qp_12	35	C
1189	9702_s19_qp_13	34	D
1190	9702_w19_qp_11	35	D
1191	9702_w19_qp_12	34	A
1192	9702_w19_qp_12	35	C
1193	9702_w19_qp_13	36	A
1194	9702_m18_qp_12	32	C
1195	9702_s18_qp_12	35	A
1196	9702_s18_qp_13	31	B
1197	9702_s18_qp_13	36	D
1198	9702_w18_qp_13	35	A
1199	9702_w18_qp_13	37	C
1200	9702_m17_qp_12	35	C
1201	9702_s17_qp_11	35	C
1202	9702_s17_qp_12	35	A
1203	9702_s17_qp_13	34	B
1204	9702_w17_qp_12	36	B
1205	9702_w17_qp_13	34	D
1206	9702_m16_qp_12	37	A
1207	9702_s16_qp_11	37	B
1208	9702_s16_qp_12	37	D
1209	9702_w16_qp_12	36	B
1210	9702_s15_qp_11	34	D
1211	9702_s15_qp_12	33	A
1212	9702_s15_qp_12	34	D
1213	9702_s15_qp_13	33	C
1214	9702_m20_qp_12	33	B
1215	9702_m20_qp_12	35	B
1216	9702_s20_qp_11	37	B
1217	9702_s20_qp_12	37	A
1218	9702_s20_qp_13	35	C
1219	9702_m19_qp_12	37	A
1220	9702_s19_qp_11	37	C
1221	9702_s19_qp_12	36	A
1222	9702_s19_qp_13	36	C
1223	9702_s19_qp_13	38	B
1224	9702_w19_qp_11	34	B
1225	9702_w19_qp_11	36	D
1226	9702_w19_qp_11	37	C

Paper 1 Multiple Choice Answers: D.C. Circuits (continued)

Question	Paper	Q. No.	Answer
1227	9702_w19_qp_11	38	D
1228	9702_w19_qp_12	36	C
1229	9702_w19_qp_13	34	C
1230	9702_w19_qp_13	37	A
1231	9702_w19_qp_13	38	B
1232	9702_m18_qp_12	37	D
1233	9702_m18_qp_12	38	C
1234	9702_s18_qp_11	33	A
1235	9702_s18_qp_11	34	C
1236	9702_s18_qp_11	35	B
1237	9702_s18_qp_12	34	B
1238	9702_s18_qp_12	36	A
1239	9702_s18_qp_13	34	A
1240	9702_s18_qp_13	35	C
1241	9702_s18_qp_13	37	D
1242	9702_w18_qp_11	36	A
1243	9702_w18_qp_11	37	A
1244	9702_w18_qp_12	34	A
1245	9702_w18_qp_12	36	B
1246	9702_w18_qp_12	37	B
1247	9702_w18_qp_13	33	B
1248	9702_w18_qp_13	36	D
1249	9702_m17_qp_12	36	D
1250	9702_s17_qp_11	37	C
1251	9702_s17_qp_12	36	B
1252	9702_s17_qp_12	37	B
1253	9702_s17_qp_13	35	C
1254	9702_w17_qp_11	36	B
1255	9702_w17_qp_11	37	B
1256	9702_w17_qp_11	38	D
1257	9702_w17_qp_12	37	B
1258	9702_w17_qp_13	35	C
1259	9702_w17_qp_13	36	B
1260	9702_w17_qp_13	37	C
1261	9702_w17_qp_13	38	D
1262	9702_m16_qp_12	34	D
1263	9702_m16_qp_12	35	D
1264	9702_m16_qp_12	36	A
1265	9702_s16_qp_11	35	A
1266	9702_s16_qp_11	36	B
1267	9702_s16_qp_13	35	C
1268	9702_s16_qp_13	37	B
1269	9702_w16_qp_11	36	D
1270	9702_w16_qp_11	37	A
1271	9702_w16_qp_12	32	C
1272	9702_w16_qp_12	37	C

Paper 1 Multiple Choice Answers: D.C. Circuits (continued)

Question	Paper	Q. No.	Answer
1273	9702_w16_qp_13	36	D
1274	9702_w16_qp_13	37	A
1275	9702_sl5_qp_11	33	B
1276	9702_sl5_qp_11	37	A
1277	9702_sl5_qp_11	38	C
1278	9702_sl5_qp_12	35	A
1279	9702_sl5_qp_12	37	A
1280	9702_sl5_qp_13	34	C
1281	9702_sl5_qp_13	35	A
1282	9702_sl5_qp_13	36	A
1283	9702_sl5_qp_13	37	C
1284	9702_m20_qp_12	37	C
1285	9702_s20_qp_11	38	D
1286	9702_s20_qp_12	38	A
1287	9702_s20_qp_13	38	A
1288	9702_m19_qp_12	38	D
1289	9702_sl9_qp_11	38	A
1290	9702_sl9_qp_12	37	A
1291	9702_sl9_qp_13	37	B
1292	9702_w19_qp_12	37	A
1293	9702_m18_qp_12	36	C
1294	9702_sl8_qp_11	36	B
1295	9702_sl8_qp_12	37	C
1296	9702_sl8_qp_13	38	D
1297	9702_w18_qp_11	38	B
1298	9702_w18_qp_12	38	C
1299	9702_m17_qp_12	37	B
1300	9702_sl7_qp_11	36	B
1301	9702_sl7_qp_13	36	A
1302	9702_w17_qp_12	38	A
1303	9702_sl6_qp_11	34	A
1304	9702_sl6_qp_12	36	B
1305	9702_sl6_qp_13	36	B
1306	9702_w16_qp_12	38	A
1307	9702_sl5_qp_11	36	D
1308	9702_sl5_qp_12	36	B

Chapter 12

D.C. circuits

12.1 Practical circuits

212. 9702_m20_qp_22 Q: 6

A uniform electric field is produced between two parallel metal plates. The electric field strength is $1.4 \times 10^4 \text{ NC}^{-1}$. The potential difference between the plates is 350 V.

(a) Calculate the separation of the plates.

separation = ... m [2]

(b) A nucleus of mass $8.3 \times 10^{-27} \text{ kg}$ is now placed in the electric field. The electric force acting on the nucleus is $6.7 \times 10^{-15} \text{ N}$.

(i) Calculate the charge on the nucleus in terms of e , where e is the elementary charge.

charge = ... e [3]

(ii) Calculate the mass, in u , of the nucleus.

mass = ... u [1]

(iii) Use your answers in (b)(i) and (b)(ii) to determine the number of neutrons in the nucleus.

number = ... [1]

[Total: 7]

213. 9702_s15_qp_21 Q: 5

The variation with potential difference (p.d.) V of current I for a semiconductor diode is shown in Fig. 5.1.

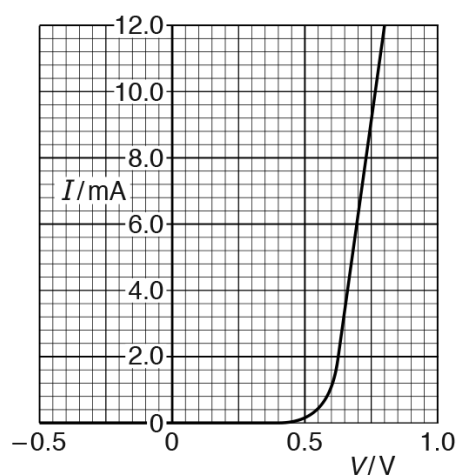


Fig. 5.1

- (a) Use Fig. 5.1 to describe the variation of the resistance of the diode between $V = -0.5\text{V}$ and $V = 0.8\text{V}$.

.....

[2]

- (b) On Fig. 5.2, sketch the variation with p.d. V of current I for a filament lamp. Numerical values are not required.

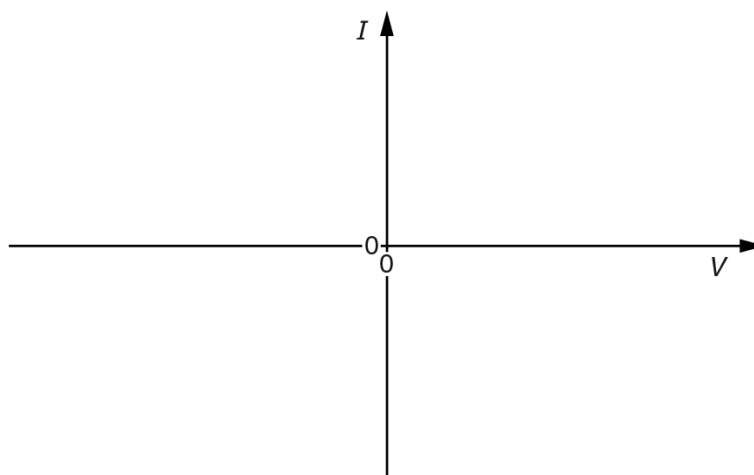


Fig. 5.2

[2]

- (c) Fig. 5.3 shows a power supply of electromotive force (e.m.f.) 12V and internal resistance $0.50\ \Omega$ connected to a filament lamp and switch.

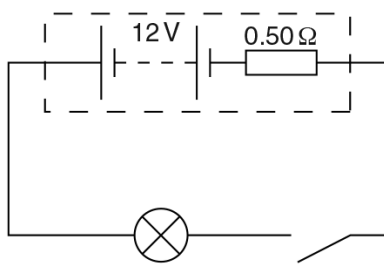


Fig. 5.3

The filament lamp has a power of 36W when the p.d. across it is 12V.

- (i) Calculate the resistance of the lamp when the p.d. across it is 12V.

resistance = ... Ω [1]

- (ii) The switch is closed and the current in the lamp is 2.8A. Calculate the resistance of the lamp.

resistance = ... Ω [3]

- (d) Explain how the two values of resistance calculated in (c) provide evidence for the shape of the sketch you have drawn in (b).

.....
[1]

12.2 Kirchhoff's laws

214. 9702_m20_qp_22 Q: 5

- (a) Define the *ohm*.

.....

 [1]

- (b) A wire has a resistance of $1.8\ \Omega$. The wire has a uniform cross-sectional area of $0.38\ \text{mm}^2$ and is made of metal of resistivity $9.6 \times 10^{-7}\ \Omega\text{m}$.

Calculate the length of the wire.

length = ... m [3]

- (c) A resistor X of resistance $1.8\ \Omega$ is connected to a resistor Y of resistance $0.60\ \Omega$ and a battery P, as shown in Fig. 5.1.

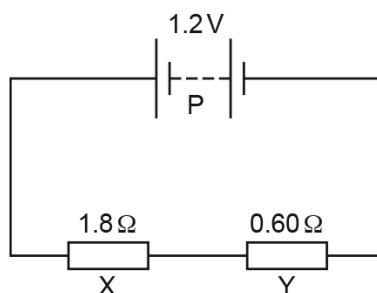


Fig. 5.1

The battery P has an electromotive force (e.m.f.) of $1.2\ \text{V}$ and negligible internal resistance.

- (i) Explain, in terms of energy, why the potential difference (p.d.) across resistor X is less than the e.m.f. of the battery.

.....

 [1]

- (ii) Calculate the potential difference across resistor X.

potential difference = ... V [2]

- (d) Another battery Q of e.m.f. 1.2V and negligible internal resistance is now connected into the circuit of Fig. 5.1 to produce the new circuit shown in Fig. 5.2.

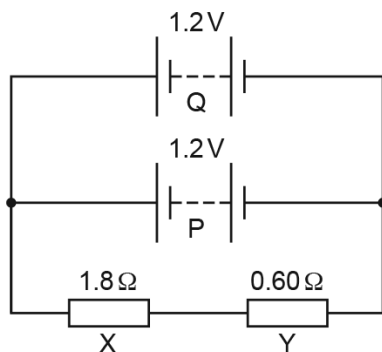


Fig. 5.2

State whether the addition of battery Q causes the current to decrease, increase or remain the same in:

- (i) resistor X [1]
 (ii) battery P. [1]

- (e) The circuit shown in Fig. 5.2 is modified to produce the new circuit shown in Fig. 5.3.

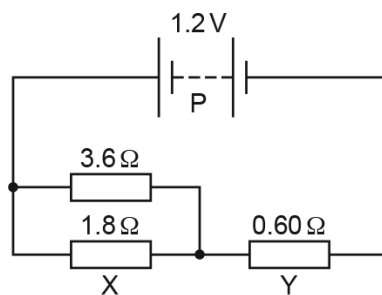


Fig. 5.3

Calculate:

- (i) the total resistance of the two resistors connected in parallel

resistance = ... Ω [1]

- (ii) the current in resistor Y.

current = ... A [2]

[Total: 12]

215. 9702_s20_qp_22 Q: 6

- (a) A battery of electromotive force (e.m.f.) 7.8 V and internal resistance r is connected to a filament lamp, as shown in Fig. 6.1.

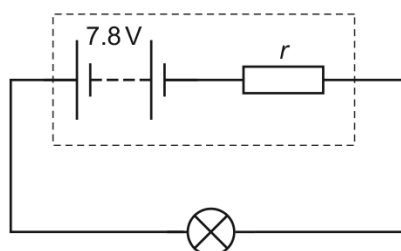


Fig. 6.1

A total charge of 750 C moves through the battery in a time interval of 1500 s . During this time the filament lamp dissipates 5.7 kJ of energy. The e.m.f. of the battery remains constant.

- (i) Explain, in terms of energy and without a calculation, why the potential difference across the lamp must be less than the e.m.f. of the battery.

.....
 [1]

- (ii) Calculate:

1. the current in the circuit

current = ... A [2]

2. the potential difference across the lamp

potential difference = ... V [2]

3. the internal resistance of the battery.

internal resistance = ... Ω [2]

- (b) A student is provided with three resistors of resistances $90\ \Omega$, $45\ \Omega$ and $20\ \Omega$.
- (i) Sketch a circuit diagram showing how **two** of these three resistors may be connected together to give a combined resistance of $30\ \Omega$ between the terminals shown. Label the values of the resistances on your diagram.



[1]

- (ii) A potential divider circuit is produced by connecting the three resistors to a battery of e.m.f. 9.0V and negligible internal resistance. The potential divider circuit provides an output potential difference V_{OUT} of 3.6V . The circuit diagram is shown in Fig. 6.2.

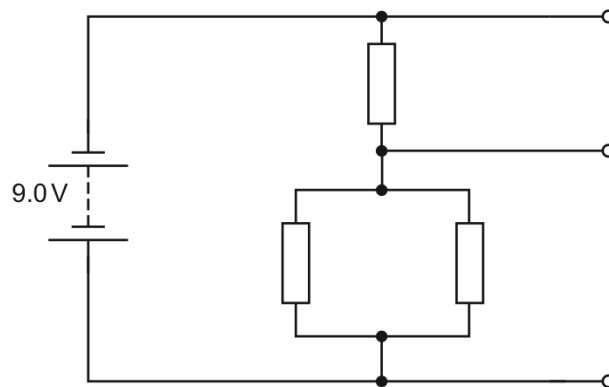


Fig. 6.2

On Fig. 6.2, label the resistances of all three resistors and the potential difference V_{OUT} .

[2]

[Total: 10]

216. 9702_s20_qp_23 Q: 5

(a) Define the *volt*.

.....
 [1]

(b) Fig. 5.1 shows a network of three resistors.

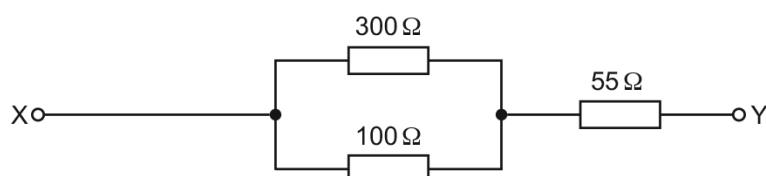


Fig. 5.1

Calculate:

(i) the combined resistance of the two resistors connected in parallel

combined resistance = ... Ω [1]

(ii) the total resistance between terminals X and Y.

total resistance = ... Ω [1]

(c) The network in (b) is connected to a power supply so that there is a potential difference between terminals X and Y. The power dissipated in the resistor of resistance 55 Ω is 0.20 W.

(i) Calculate the current in the resistor of resistance:

1. 55 Ω

current = ... A

2. 300 Ω.

current = ... A
[3]

- (ii) Calculate the potential difference between X and Y.

potential difference = ... V [1]

[Total: 7]

217. 9702_w20_qp_21 Q: 7

(a) Define the *ohm*.

.....
 [1]

(b) A uniform wire has resistance $3.2\ \Omega$. The wire has length 2.5 m and is made from metal of resistivity $460\text{ n}\Omega\text{ m}$.

Calculate the cross-sectional area of the wire.

cross-sectional area = ... m^2 [3]

(c) A cell of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R , as shown in Fig. 7.1.

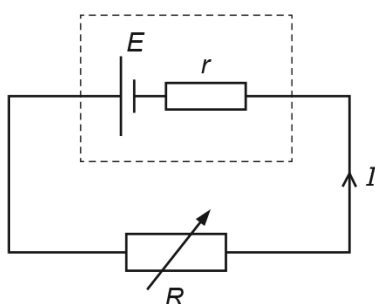


Fig. 7.1

The current in the circuit is I .

(i) State, in terms of energy, why the potential difference across the variable resistor is less than the e.m.f. of the cell.

.....
 [1]

- (ii) State an expression for E in terms of I , R and r .

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

- (iii) The resistance R of the variable resistor is changed so that it is equal to r .

Determine an expression, in terms of only E and r , for the power P dissipated in the variable resistor.

$$P = \dots\dots\dots [2]$$

[Total: 8]

218. 9702_w20_qp_22 Q: 6

- (a) A network of three resistors of resistances R_1 , R_2 and R_3 is shown in Fig. 6.1.

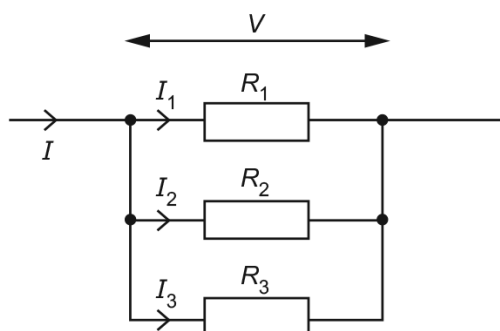


Fig. 6.1

The individual currents in the resistors are I_1 , I_2 and I_3 . The total current in the combination of resistors is I and the potential difference across the combination is V .

Show that the combined resistance R of the network is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

[2]

- (b) A battery of electromotive force (e.m.f.) 8.0V and internal resistance r is connected to three resistors X, Y and Z, as shown in Fig. 6.2.

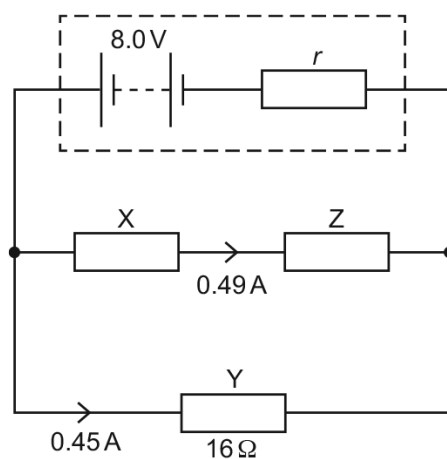


Fig. 6.2

Resistor Y has a resistance of $16\ \Omega$. The current in resistor X is 0.49 A and the current in resistor Y is 0.45 A .

Calculate:

- (i) the current in the battery

current = ... A [1]

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

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

- (c) Resistors X and Y in Fig. 6.2 are made from wires of the same material and cross-sectional area. The average drift speed of the free electrons in X is $2.1 \times 10^{-4}\text{ m s}^{-1}$.

Calculate the average drift speed v of the free electrons in Y.

$v = \dots\dots\dots\text{ m s}^{-1}$ [2]

- (d) Resistor Z in Fig. 6.2 is replaced by a new resistor of smaller resistance.

State and explain the effect, if any, on the terminal potential difference of the battery.

.....

 [2]

[Total: 9]

219. 9702_w20_qp_23 Q: 6

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

.....
 [1]

- (b) A wire of cross-sectional area A is made from metal of resistivity ρ . The wire is extended. Assume that the volume V of the wire remains constant as it extends.

Show that the resistance R of the extending wire is inversely proportional to A^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. 6.1.

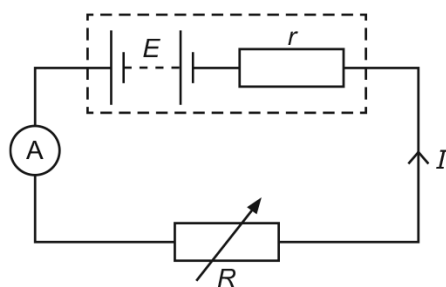


Fig. 6.1

The current in the circuit is I .

Use Kirchhoff's second law to show that

$$R = \left(\frac{E}{I} \right) - r.$$

- (d) An ammeter is used in the circuit in (c) to measure the current I as resistance R is varied. Fig. 6.2 is a graph of R against $\frac{1}{I}$.

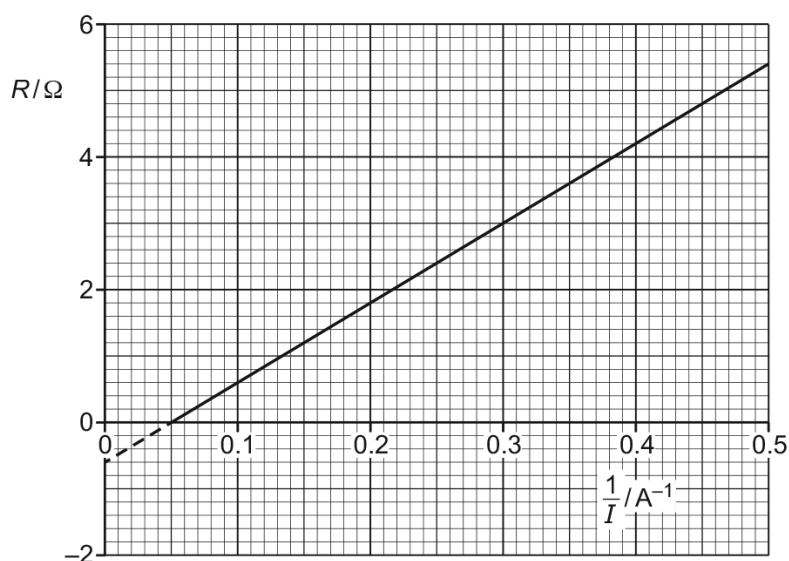


Fig. 6.2

- (i) Use Fig. 6.2 to determine the power dissipated in the variable resistor when there is a current of 2.0 A in the circuit.

power = ... W [3]

- (ii) Use Fig. 6.2 and the equation in (c) to:

1. state the internal resistance r of the battery

$r = \dots\dots\dots \Omega$

2. determine the e.m.f. E of the battery.

$E = \dots\dots\dots \text{V}$
[3]

[Total: 10]

220. 9702_m19_qp_22 Q: 6

- (a) Using energy transformations, describe the *electromotive force (e.m.f.)* of a battery and the *potential difference (p.d.)* across a resistor.

e.m.f.:

.....

p.d.:

.....[2]

- (b) A battery of e.m.f. 6.0V and negligible internal resistance is connected to a network of resistors and a voltmeter, as shown in Fig. 6.1.

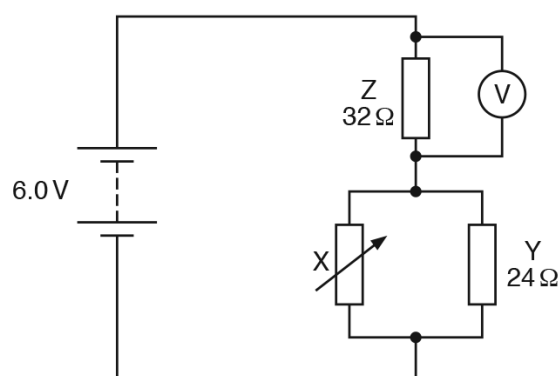


Fig. 6.1

Resistor Y has a resistance of 24Ω and resistor Z has a resistance of 32Ω .

- (i) The resistance R_X of the variable resistor X is adjusted until the voltmeter reads 4.8 V.

Calculate:

1. the current in resistor Z

current = ... A [1]

2. the total power provided by the battery

power = ... W [2]

3. the number of conduction electrons that move through the battery in a time interval of 25 s

number = ... [2]

4. the total resistance of X and Y connected in parallel

total resistance = ... Ω [2]

5. the resistance R_X .

R_X = ... Ω [2]

- (ii) The resistance R_X is now decreased.

State and explain the change, if any, to the reading on the voltmeter.

.....

 [2]

[Total: 13]

221. 9702_s19_qp_21 Q: 6

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. 6.1.

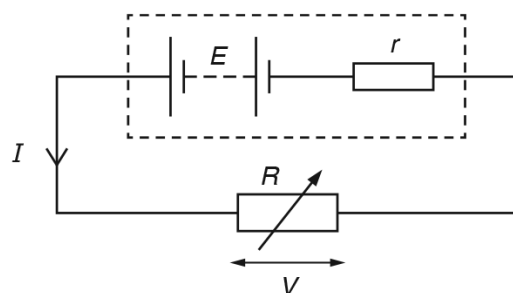


Fig. 6.1

The current in the circuit is I and the potential difference across the variable resistor is V .

(a) Explain, in terms of energy, why V is less than E .

.....
[1]

(b) State an equation relating E , I , r and V .

.....[1]

(c) The resistance R of the variable resistor is varied. The variation with I of V is shown in Fig. 6.2.

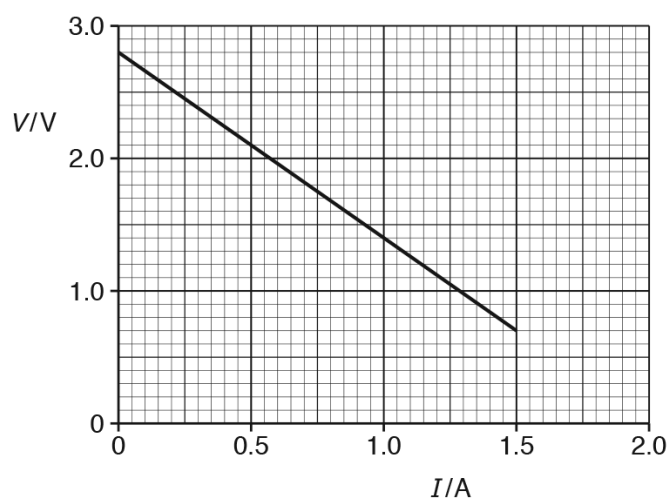


Fig. 6.2

Use Fig. 6.2 to:

- (i) explain how it may be deduced that the e.m.f. of the battery is 2.8 V

.....
[1]

- (ii) calculate the internal resistance r .

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

- (d) The battery stores 9.2 kJ of energy. The variable resistor is adjusted so that $V = 2.1$ V. Use Fig. 6.2 to:

- (i) calculate resistance R

$R = \dots\dots\dots \Omega$ [1]

- (ii) calculate the number of conduction electrons moving through the battery in a time of 1.0 s

number = $\dots\dots\dots$ [1]

- (iii) determine the time taken for the energy in the battery to become equal to 1.6 kJ.
 (Assume that the e.m.f. of the battery and the current in the battery remain constant.)

time taken = $\dots\dots\dots$ s [3]

[Total: 10]

222. 9702_s19_qp_22 Q: 5

(a) State Kirchhoff's second law.

.....

.....[2]

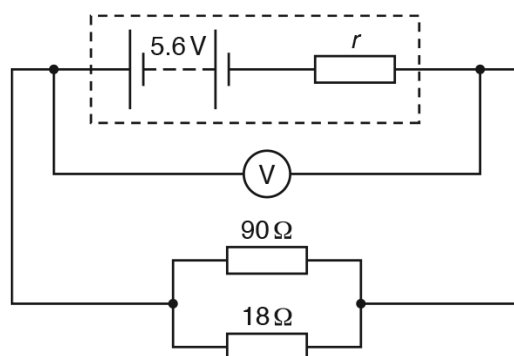
(b) A battery of electromotive force (e.m.f.) 5.6 V and internal resistance r is connected to two external resistors, as shown in Fig. 5.1.

Fig. 5.1

The reading on the voltmeter is 4.8 V.

(i) Calculate:

- the combined resistance of the two resistors connected in parallel

combined resistance = ... Ω [2]

- the current in the battery.

current = ... A [2]

(ii) Show that the internal resistance r is 2.5Ω .

[2]

(iii) Determine the ratio

$$\frac{\text{power dissipated by internal resistance } r}{\text{total power produced by battery}}.$$

ratio = ... [3]

(c) The battery in (b) is now connected to a battery of e.m.f. 7.2 V and internal resistance 3.5 Ω. The new circuit is shown in Fig. 5.2.

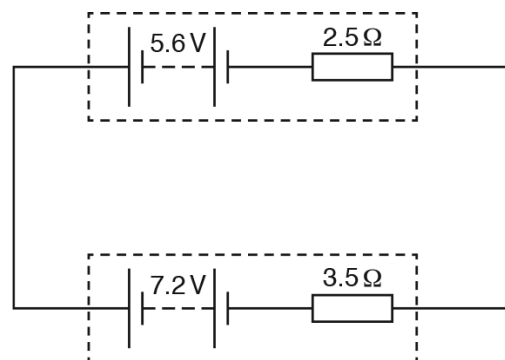


Fig. 5.2

Determine the current in the circuit.

current = ... A [2]

[Total: 13]

223. 9702_s19_qp_23 Q: 6

(a) Define the *ohm*.

.....[1]

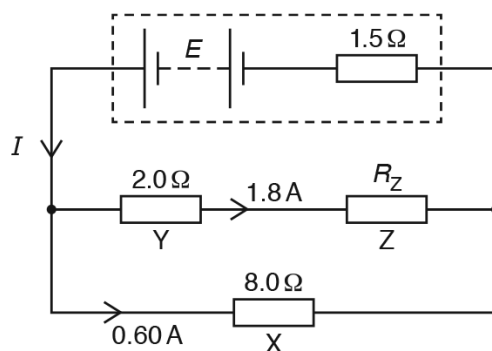
(b) A battery of electromotive force (e.m.f.) E and internal resistance 1.5Ω is connected to a network of resistors, as shown in Fig. 6.1.

Fig. 6.1

Resistor X has a resistance of 8.0Ω . Resistor Y has a resistance of 2.0Ω . Resistor Z has a resistance of R_Z . The current in X is 0.60A and the current in Y is 1.8A .

(i) Calculate:

1. the current I in the battery $I = \dots\dots\dots \text{A}$ [1]2. resistance R_Z $R_Z = \dots\dots\dots \Omega$ [2]3. e.m.f. E . $E = \dots\dots\dots \text{V}$ [2]

- (ii) Resistors X and Y are each made of wire. The two wires have the same length and are made of the same metal.

Determine the ratio:

1. $\frac{\text{cross-sectional area of wire X}}{\text{cross-sectional area of wire Y}}$

ratio = ... [2]

2. $\frac{\text{average drift speed of free electrons in X}}{\text{average drift speed of free electrons in Y}}$

ratio = ... [2]

[Total: 10]

224. 9702_w19_qp_21 Q: 6

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

.....
..... [1]

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

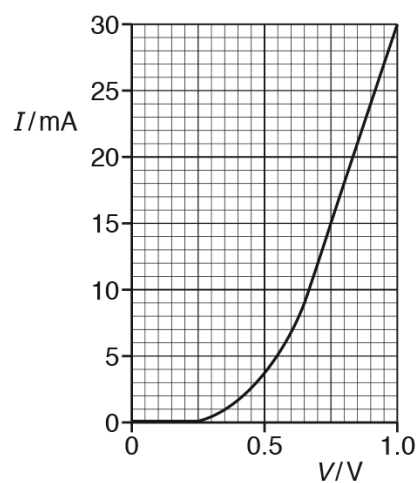


Fig. 6.1

Use Fig. 6.1 to describe qualitatively the variation of the resistance of the diode as V increases from 0 to 1.0 V.

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

- (c) The diode in (b) is part of the circuit shown in Fig. 6.2.

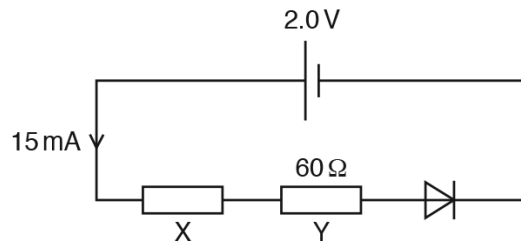


Fig. 6.2

The cell of electromotive force (e.m.f.) 2.0 V and negligible internal resistance is connected in series with the diode and resistors X and Y. The resistance of Y is $60\ \Omega$. The current in the cell is 15 mA.

- (i) Use Fig. 6.1 to determine the resistance of the diode.

resistance = ... Ω [3]

- (ii) Calculate:

1. the resistance of X

resistance = ... Ω [3]

2. the ratio

$$\frac{\text{power dissipated in resistor Y}}{\text{total power produced by the cell}}$$

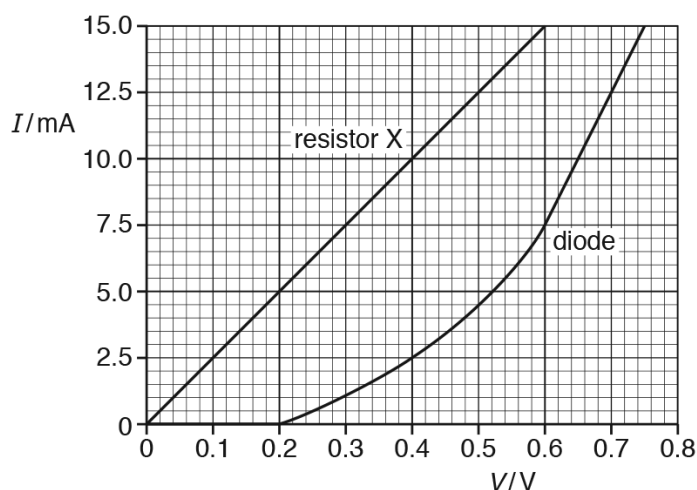
ratio = ... [2]

[Total: 11]

225. 9702_w19_qp_22 Q: 6

(a) State Kirchhoff's first law.

.....
 [1]

(b) The variations with potential difference V of the current I for a resistor X and for a semiconductor diode are shown in Fig. 6.1.**Fig. 6.1****(i)** Determine the resistance of the diode for a potential difference V of 0.60 V.

resistance = ... Ω [3]

(ii) Describe, qualitatively, the variation of the resistance of the diode as V increases from 0.60 V to 0.75 V.

..... [1]

- (c) The diode and the resistor X in (b) are connected into the circuit shown in Fig. 6.2.

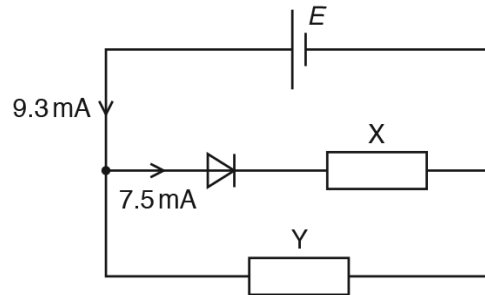


Fig. 6.2

The cell has electromotive force (e.m.f.) E and negligible internal resistance. Resistor Y is connected in parallel with resistor X and the diode. The current in the cell is 9.3 mA and the current in the diode is 7.5 mA .

- (i) Use Fig. 6.1 to determine E .

$$E = \dots\dots\dots\text{V} \quad [1]$$

- (ii) Determine the resistance of resistor Y.

$$\text{resistance} = \dots\dots\dots\Omega \quad [2]$$

- (iii) Calculate the power dissipated in the diode.

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

- (iv) The cell is now replaced by a new cell of e.m.f. 0.50 V and negligible internal resistance. Use Fig. 6.1 to determine the new current in the diode.

$$\text{current} = \dots\dots\dots\text{mA} \quad [1]$$

[Total: 11]

226. 9702_w19_qp_23 Q: 6

A battery of electromotive force (e.m.f.) 12V and negligible internal resistance is connected to a network of two lamps and two resistors, as shown in Fig. 6.1.

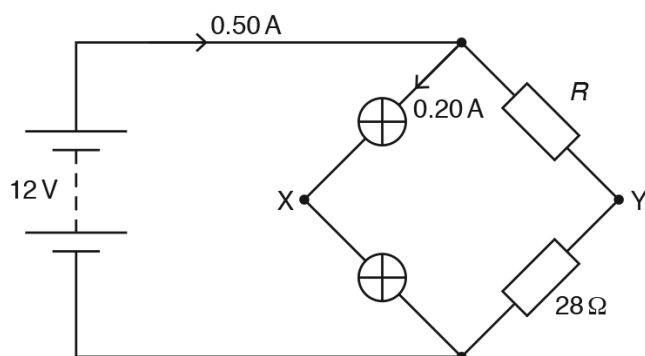


Fig. 6.1

The two lamps in the circuit have equal resistances. The two resistors have resistances R and 28Ω . The lamps are connected at junction X and the resistors are connected at junction Y. The current in the battery is 0.50A and the current in the lamps is 0.20A .

(a) Calculate:

(i) the resistance of each lamp

resistance = ... Ω [2]

(ii) resistance R .

$R =$ Ω [2]

(b) Determine the potential difference V_{XY} between points X and Y.

$V_{XY} =$ V [3]

- (c) Calculate the ratio

$$\frac{\text{total power dissipated by the lamps}}{\text{total power produced by the battery}}$$

ratio = ... [2]

- (d) The resistor of resistance R is now replaced by another resistor of lower resistance.

State and explain the effect, if any, of this change on the ratio in (c).

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

[Total: 11]

227. 9702_m18_qp_22 Q: 5

- (a) State Kirchhoff's second law.

.....
[2]

- (b) Two batteries, each of electromotive force (e.m.f.) 6.0 V and negligible internal resistance, are connected in series with three resistors, as shown in Fig. 5.1.

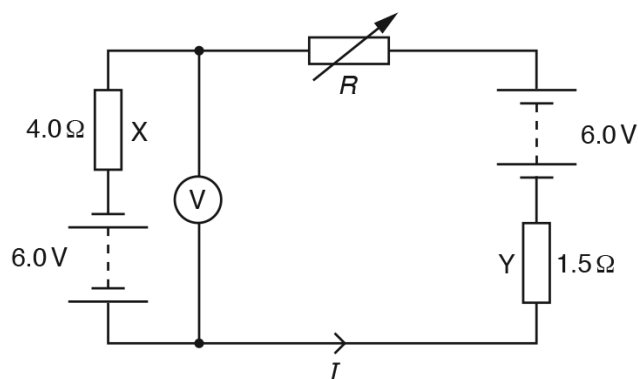


Fig. 5.1

Resistor X has resistance $4.0\ \Omega$ and resistor Y has resistance $1.5\ \Omega$.

- (i) The resistance R of the variable resistor is changed until the voltmeter in the circuit reads zero.

Calculate

1. the current I in the circuit,

$$I = \dots\dots\dots \text{ A [1]}$$

2. the resistance R .

$$R = \dots\dots\dots \ \Omega \text{ [2]}$$

- (ii) Resistors X and Y are wires made from the same material. The diameter of the wire of X is twice the diameter of the wire of Y.

Determine the ratio

$$\frac{\text{average drift speed of free electrons in X}}{\text{average drift speed of free electrons in Y}}.$$

ratio = ... [2]

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

State and explain the effect of the increase in R on the power transformed by each of the batteries.

.....

[3]

[Total: 10]

228. 9702_s18_qp_21 Q: 6

(a) Define the *volt*.

.....[1]

(b) A battery of electromotive force (e.m.f.) 4.5 V and negligible internal resistance is connected to two filament lamps P and Q and a resistor R, as shown in Fig. 6.1.

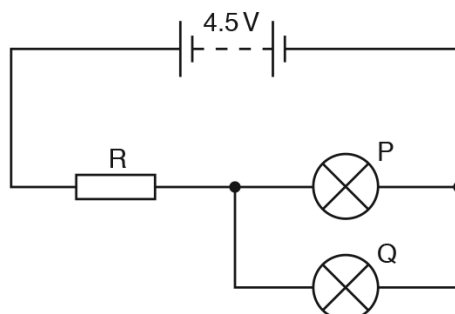


Fig. 6.1

The current in lamp P is 0.15 A.

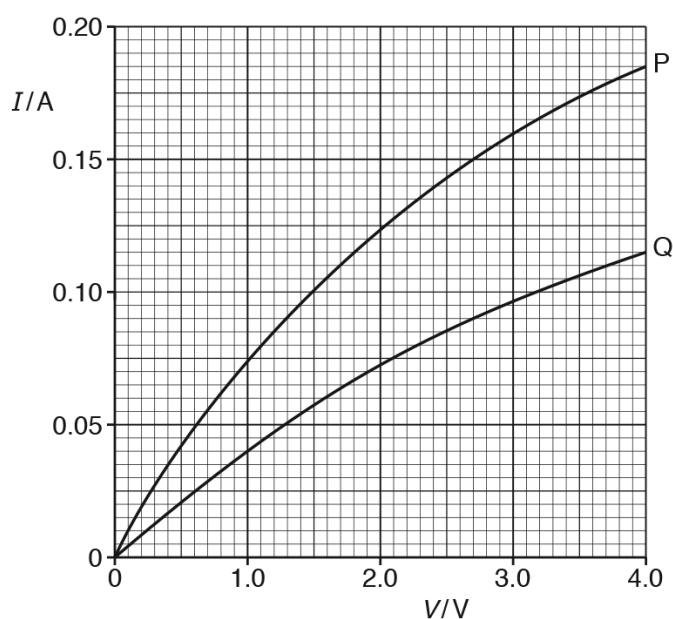
The I - V characteristics of the filament lamps are shown in Fig. 6.2.

Fig. 6.2

(i) Use Fig. 6.2 to determine the current in the battery. Explain your working.

current = ... A [2]

- (ii) Calculate the resistance of resistor R.

resistance = ... Ω [2]

- (iii) The filament wires of the two lamps are made from material with the same resistivity at their operating temperature in the circuit. The diameter of the wire of lamp P is twice the diameter of the wire of lamp Q.

Determine the ratio

$$\frac{\text{length of filament wire of lamp P}}{\text{length of filament wire of lamp Q}}$$

ratio = ... [3]

- (iv) The filament wire of lamp Q breaks and stops conducting.

State and explain, qualitatively, the effect on the resistance of lamp P.

.....

[2]

[Total: 10]

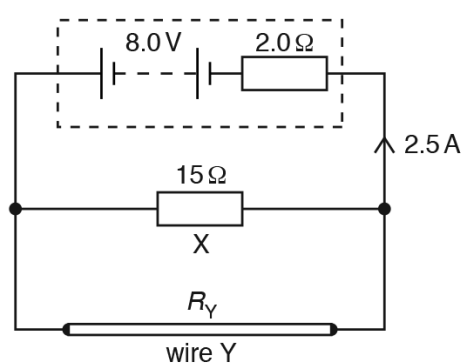
229. 9702_s18_qp_22 Q: 6

(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 battery of electromotive force (e.m.f.) 8.0 V and internal resistance 2.0Ω is connected to a resistor X and a wire Y, as shown in Fig. 6.1.**Fig. 6.1**

The resistance of X is 15Ω . The resistance of Y is R_Y . The current in the battery is 2.5 A .

(i) Calculate

- the thermal energy dissipated in the battery in a time of 5.0 minutes,

energy = ... J [2]

- the terminal potential difference of the battery.

terminal potential difference = ... V [1]

- (ii) Determine the resistance R_Y .

$$R_Y = \dots\dots\dots \Omega \text{ [3]}$$

- (iii) A new wire Z has the same length but less resistance than wire Y.

1. State two possible differences between wire Z and wire Y that would separately cause wire Z to have less resistance than wire Y.

first difference:

.....

second difference:

.....

[2]

2. Wire Y is replaced in the circuit by wire Z. By considering the current in the battery, state and explain the effect of changing the wires on the total power produced by the battery.

.....

.....

.....[2]

[Total: 12]

230. 9702_s18_qp_23 Q: 6

A wire X has a constant resistance per unit length of $3.0\,\Omega\,\text{m}^{-1}$ and a diameter of $0.48\,\text{mm}$.

(a) Calculate the resistivity of the metal of wire X.

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

(b) The wire X is connected into the circuit shown in Fig. 6.1.

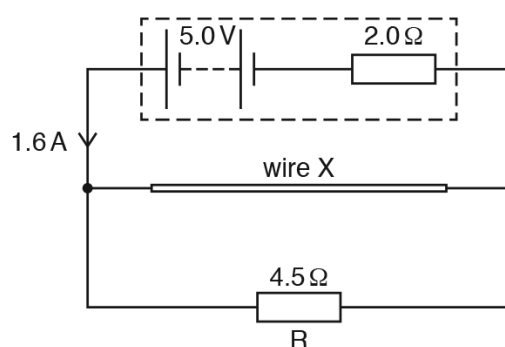


Fig. 6.1

The battery has an electromotive force (e.m.f.) of $5.0\,\text{V}$ and an internal resistance of $2.0\,\Omega$. The wire X and a resistor R of resistance $4.5\,\Omega$ are connected in parallel. The current in the battery is $1.6\,\text{A}$.

(i) Calculate the potential difference across resistor R.

potential difference = ... V [1]

(ii) Determine, for wire X,

1. its resistance,

resistance = ... Ω [3]

2. its length.

length = ... m [1]

[Total: 8]

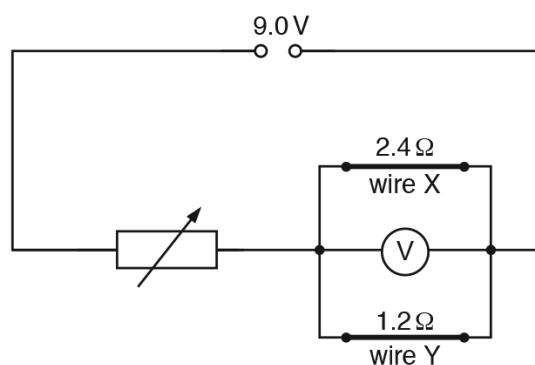
231. 9702_w18_qp_21 Q: 6

(a) State Kirchhoff's second law.

.....

.....

..... [2]

(b) An electric heater containing two heating wires X and Y is connected to a power supply of electromotive force (e.m.f.) 9.0 V and negligible internal resistance, as shown in Fig. 6.1.**Fig. 6.1**

Wire X has a resistance of $2.4\ \Omega$ and wire Y has a resistance of $1.2\ \Omega$. A voltmeter is connected in parallel with the wires. A variable resistor is used to adjust the power dissipated in wires X and Y.

The variable resistor is adjusted so that the voltmeter reads 6.0 V.

(i) Calculate the resistance of the variable resistor.

resistance = ... Ω [3]

(ii) Calculate the power dissipated in wire X.

power = ... W [2]

- (iii) The cross-sectional area of wire X is three times the cross-sectional area of wire Y. Assume that the resistivity and the number density of free electrons for the metal of both wires are the same.

Determine the ratio

1. $\frac{\text{length of wire X}}{\text{length of wire Y}},$

ratio = ... [2]

2. $\frac{\text{average drift velocity of free electrons in wire X}}{\text{average drift velocity of free electrons in wire Y}}.$

ratio = ... [2]

[Total: 11]

232. 9702_w18_qp_23 Q: 7

(a) State Kirchhoff's first law.

.....
[1]

(b) A potentiometer is connected to a battery of electromotive force (e.m.f.) 9.6 V and negligible internal resistance, as shown in Fig. 7.1.

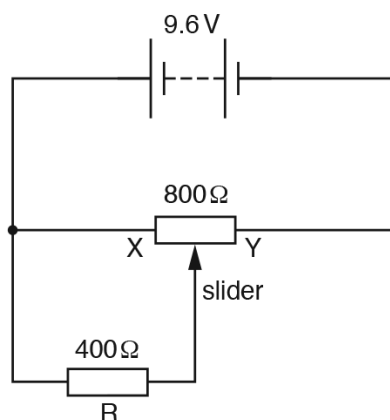


Fig. 7.1

The maximum resistance of the potentiometer is $800\ \Omega$. A resistor R of resistance $400\ \Omega$ is connected between the slider and end X of the potentiometer.

(i) State the potential difference across resistor R when the slider is positioned

1. at end X of the potentiometer,

potential difference = ... V

2. at end Y of the potentiometer.

potential difference = ... V
 [2]

- (ii) Calculate the potential difference across resistor R when the slider is positioned half-way between X and Y.

potential difference = ... V [3]

[Total: 6]

233. 9702_m17_qp_22 Q: 6

- (a) Three resistors of resistances R_1 , R_2 and R_3 are connected as shown in Fig. 6.1.

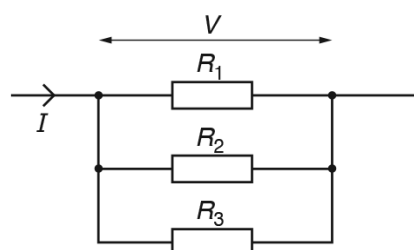


Fig. 6.1

The total current in the combination of resistors is I and the potential difference across the combination is V .

Show that the total resistance R of the combination is given by the equation

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

[2]

- (b) A battery of electromotive force (e.m.f.) 6.0V and internal resistance r is connected to a resistor of resistance 12Ω and a variable resistor X , as shown in Fig. 6.2.

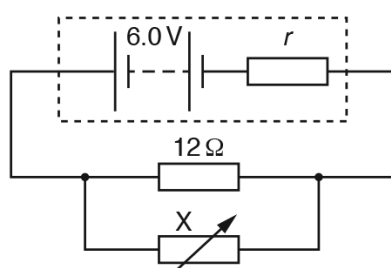


Fig. 6.2

- (i) By considering energy, explain why the potential difference across the battery's terminals is less than the e.m.f. of the battery.

.....

.....

.....

.....[2]

- (ii) A charge of 2.5 kC passes through the battery.

Calculate

1. the total energy transformed by the battery,

energy = ...J [2]

2. the number of electrons that pass through the battery.

number = ...[1]

- (iii) The combined resistance of the two resistors connected in parallel is 4.8 Ω .

Calculate the resistance of X.

resistance of X = ... Ω [1]

- (iv) Use your answer in (b)(iii) to determine the ratio

$$\frac{\text{power dissipated in X}}{\text{power dissipated in } 12\Omega \text{ resistor}}.$$

ratio = ...[2]

- (v) The resistance of X is now decreased. Explain why the power produced by the battery is increased.

.....

[1]

[Total: 11]

234. 9702_s17_qp_21 Q: 6

(a) Define the *ohm*.

.....

.....[1]

(b) A cell X of electromotive force (e.m.f.) 1.5 V and negligible internal resistance is connected in series to three resistors A, B and C, as shown in Fig. 6.1.

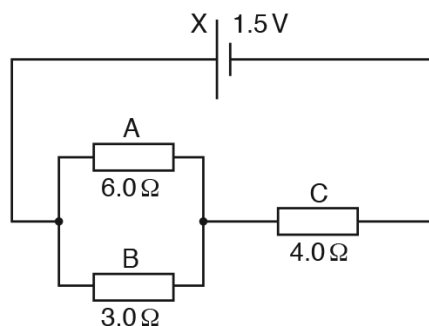


Fig. 6.1

Resistors A and B have resistances 6.0Ω and 3.0Ω respectively and are connected in parallel. Resistor C has resistance 4.0Ω and is connected in series with the parallel combination.

Calculate

(i) the current in the circuit,

current = ...A [3]

(ii) the current in resistor B,

current = ...A [1]

(iii) the ratio

$$\frac{\text{power dissipated in resistor B}}{\text{power dissipated in resistor C}}.$$

ratio = ...[2]

(c) The resistors A, B and C in (b) are wires of the same material and have the same length.

(i) Explain how the resistors may be made with different resistance values.

.....[1]

(ii) Calculate the ratio

$$\frac{\text{average drift speed of the charge carriers in resistor B}}{\text{average drift speed of the charge carriers in resistor C}}.$$

ratio = ...[2]

(d) A cell of e.m.f. 1.5V and negligible internal resistance is connected in parallel with cell X in Fig. 6.1 with their positive terminals together.

State the change, if any, to the current in

(i) cell X,

.....[1]

(ii) resistor C.

.....[1]

[Total: 12]

235. 9702_s17_qp_22 Q: 7

- (a) Define *electromotive force* (e.m.f.) of a cell.

.....
[1]

- (b) A cell C of e.m.f. 1.50 V and internal resistance $0.200\ \Omega$ is connected in series with resistors X and Y, as shown in Fig. 7.1.

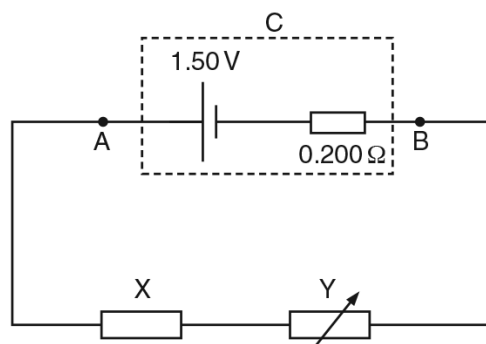


Fig. 7.1

The resistance of X is constant and the resistance of Y can be varied.

- (i) The resistance of Y is varied from 0 to $8.00\ \Omega$.

State and explain the variation in the potential difference (p.d.) between points A and B (terminal p.d. across C). Numerical values are not required.

.....

[3]

- (ii) The resistance of Y is set at $6.00\ \Omega$. The current in the circuit is 0.180 A .

Calculate

1. the resistance of X,

resistance = ... Ω [2]

2. the p.d. between points A and B,

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

3. the efficiency of the cell.

efficiency = ...[2]

[Total: 10]

236. 9702_s17_qp_23 Q: 6

(a) Describe the I - V characteristic of**(i)** a metallic conductor at constant temperature,

.....
[1]

(ii) a semiconductor diode.

.....

[2]

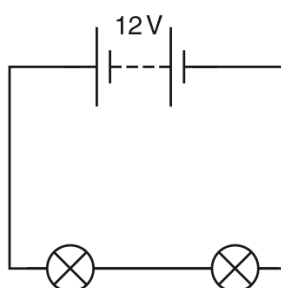
(b) Two identical filament lamps are connected in series and then in parallel to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance, as shown in Fig. 6.1a and Fig. 6.1b.

Fig. 6.1a

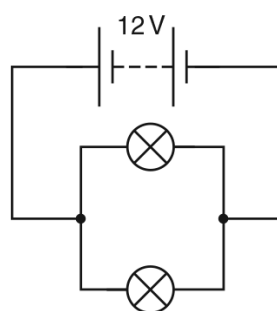


Fig. 6.1b

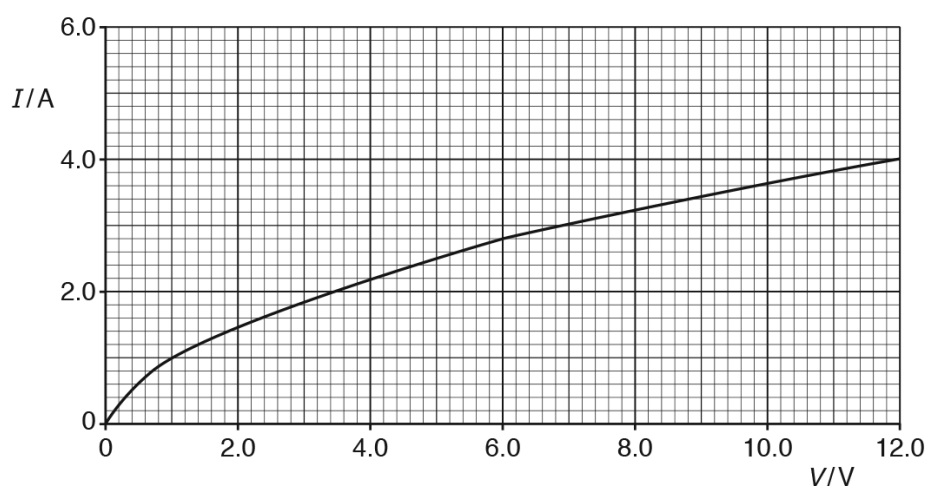
The I - V characteristic of each lamp is shown in Fig. 6.2.

Fig. 6.2

(i) Use the information shown in Fig. 6.2 to determine the current through the battery in

1. the circuit of Fig. 6.1a,

current = ...A

2. the circuit of Fig. 6.1b.

current = ...A
[3]

(ii) Calculate the total resistance in

1. the circuit of Fig. 6.1a,

resistance = ... Ω

2. the circuit of Fig. 6.1b.

resistance = ... Ω
[3]

(iii) Calculate the ratio

$\frac{\text{power dissipated in a lamp in the circuit of Fig. 6.1a}}{\text{power dissipated in a lamp in the circuit of Fig. 6.1b}}$

ratio = ...[2]

[Total: 11]

237. 9702_w17_qp_21 Q: 5

Three cells of electromotive forces (e.m.f.) E_1 , E_2 and E_3 are connected into a circuit, as shown in Fig. 5.1.

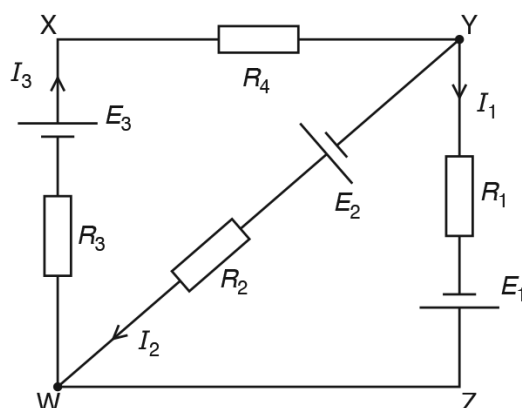


Fig. 5.1

The circuit contains resistors of resistances R_1 , R_2 , R_3 and R_4 . The currents in the different parts of the circuit are I_1 , I_2 and I_3 . The cells have negligible internal resistance.

Use Kirchhoff's laws to state an equation relating

(a) I_1 , I_2 and I_3 ,

.....[1]

(b) E_1 , E_3 , R_1 , R_3 , R_4 , I_1 and I_3 in loop WXYZW,

.....
[1]

(c) E_1 , E_2 , R_1 , R_2 , I_1 and I_2 in loop YZWY.

.....
[1]

[Total: 3]

238. 9702_m16_qp_22 Q: 5

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

.....
 [1]

- (ii) Define electric *potential difference* (*p.d.*).

.....
 [1]

- (b) A power supply of electromotive force (e.m.f.) 8.7 V and negligible internal resistance is connected by two identical wires to three filament lamps, as shown in Fig. 5.1.

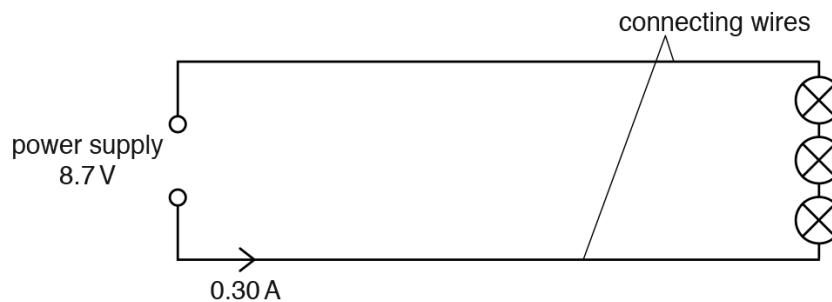


Fig. 5.1 (not to scale)

The power supply provides a current of 0.30 A to the circuit.
 The filament lamps are identical. The I – V characteristic for **one** of the lamps is shown in Fig. 5.2.

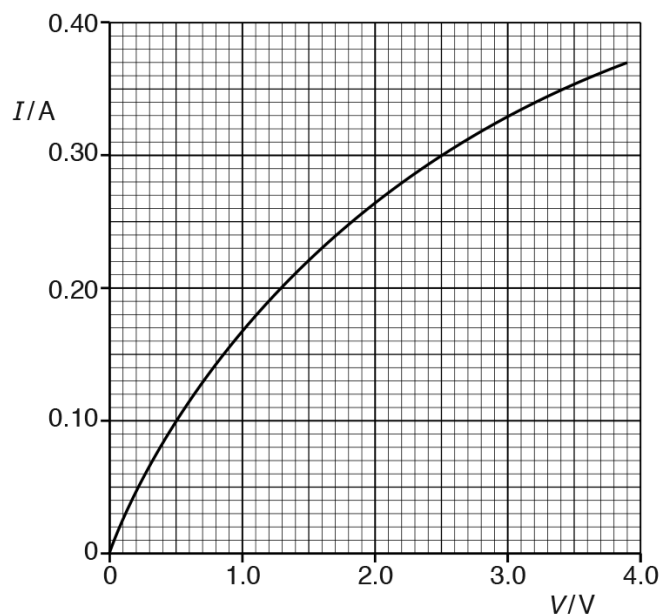


Fig. 5.2

- (i) Show that the resistance of each connecting wire is $2.0\ \Omega$.

[2]

- (ii) The resistivity of the metal of the connecting wires does not vary with temperature. On Fig. 5.2, sketch the I – V characteristic for **one** of the connecting wires. [2]

- (iii) Calculate the power loss in one of the connecting wires.

power = ... W [2]

- (iv) Some data for the connecting wires are given below.

cross-sectional area = 0.40 mm^2

resistivity = $1.7 \times 10^{-8}\ \Omega\text{ m}$

number density of free electrons = $8.5 \times 10^{28}\text{ m}^{-3}$

Calculate

1. the length of one of the connecting wires,

length = ... m [2]

2. the drift speed of a free electron in the connecting wires.

drift speed = ... ms^{-1} [2]

[Total: 12]

239. 9702_s16_qp_22 Q: 7

- (a) Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*.

.....[1]

- (b) A battery of electromotive force (e.m.f.) 9.0V and internal resistance 0.25Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

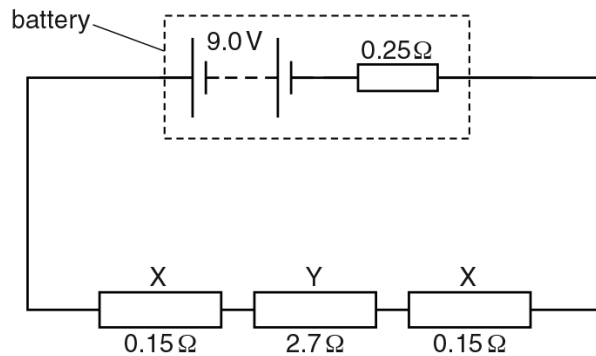


Fig. 7.1

The resistance of each resistor X is 0.15Ω and the resistance of resistor Y is 2.7Ω .

- (i) Show that the current in the circuit is 2.8A .

[3]

- (ii) Calculate the potential difference across the battery.

potential difference = ... V [2]

- (c) Each resistor X connected in the circuit in (b) is made from a wire with a cross-sectional area of 2.5 mm^2 . The number of free electrons per unit volume in the wire is $8.5 \times 10^{29} \text{ m}^{-3}$.
- (i) Calculate the average drift speed of the electrons in X.

drift speed = ... ms^{-1} [2]

- (ii) The two resistors X are replaced by two resistors Z made of the same material and length but with half the diameter.

Describe and explain the difference between the average drift speed in Z and that in X.

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

[Total: 10]

240. 9702_w16_qp_21 Q: 6

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

.....
[1]

- (b) A battery of electromotive force (e.m.f.) 14V and negligible internal resistance is connected to a resistor network, as shown in Fig. 6.1.

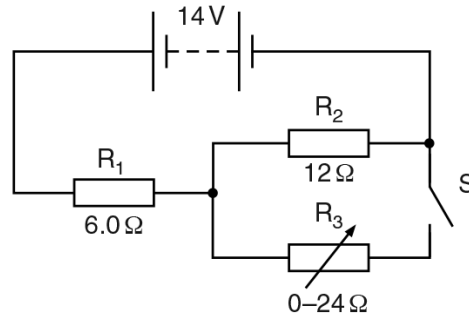


Fig. 6.1

R_1 and R_2 are fixed resistors of resistances 6.0Ω and 12Ω respectively. R_3 is a variable resistor.

Switch S is **closed**.

- (i) Calculate the current in the battery when the resistance of R_3 is set

1. at zero,

current = ... A [2]

2. at 24Ω .

current = ... A [2]

- (ii) Use your answers in (b)(i) to calculate the change in the total power produced by the battery when the resistance of R_3 is changed from zero to $24\ \Omega$.

change in power = ... W [2]

- (c) Switch S in Fig. 6.1 is now **opened**.

Resistors R_1 and R_2 are made from metal wires. Some data for these resistors are shown in Fig. 6.2.

	R_1	R_2
cross-sectional area of wire	A	$1.8A$
number of free electrons per unit volume in metal	n	$0.50n$

Fig. 6.2

Determine the ratio

$$\frac{\text{average drift speed of free electrons in } R_1}{\text{average drift speed of free electrons in } R_2}.$$

ratio = ... [2]

[Total: 9]

241. 9702_w16_qp_22 Q: 5

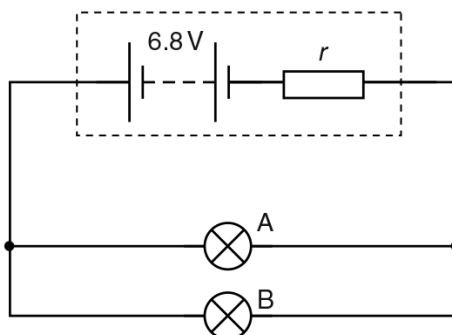
(a) State Kirchhoff's second law.

.....

.....

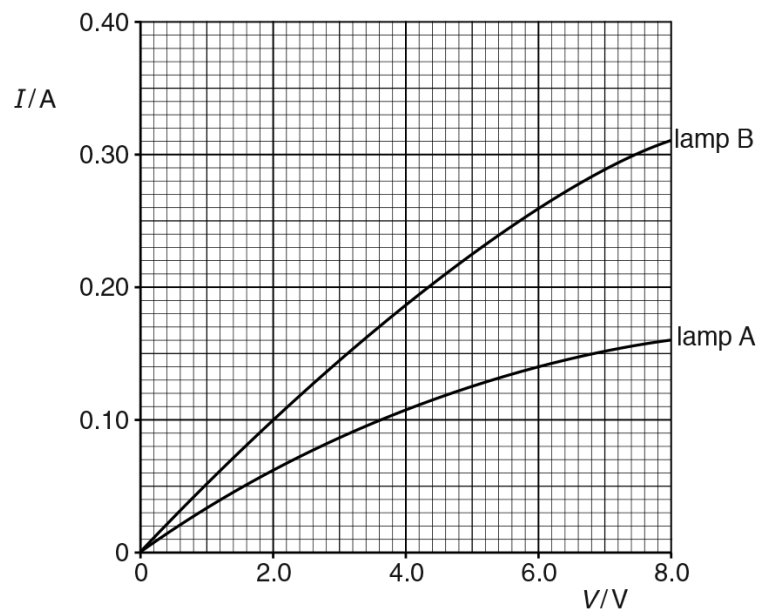
.....

.....[2]

(b) A battery is connected in parallel with two lamps A and B, as shown in Fig. 5.1.**Fig. 5.1**

The battery has electromotive force (e.m.f.) 6.8 V and internal resistance r .

The I - V characteristics of lamps A and B are shown in Fig. 5.2.

**Fig. 5.2**

The potential difference across the battery terminals is 6.0V.

- (i) Use Fig. 5.2 to show that the current in the battery is 0.40 A.

[2]

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

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

- (iii) Determine the ratio

$\frac{\text{resistance of lamp A}}{\text{resistance of lamp B}}$

ratio = $\dots\dots\dots$ [2]

(iv) Determine

1. the total power produced by the battery,

power = ... W [2]

2. the efficiency of the battery in the circuit.

efficiency = ... [2]

[Total: 12]

242. 9702_w16_qp_23 Q: 6

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

.....
[1]

(b) A battery of electromotive force (e.m.f.) 14V and negligible internal resistance is connected to a resistor network, as shown in Fig. 6.1.

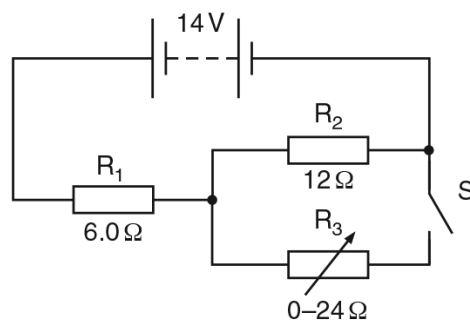


Fig. 6.1

R_1 and R_2 are fixed resistors of resistances $6.0\ \Omega$ and $12\ \Omega$ respectively. R_3 is a variable resistor.

Switch S is **closed**.(i) Calculate the current in the battery when the resistance of R_3 is set

1. at zero,

current = ... A [2]

2. at $24\ \Omega$.

current = ... A [2]

- (ii) Use your answers in (b)(i) to calculate the change in the total power produced by the battery when the resistance of R_3 is changed from zero to $24\ \Omega$.

change in power = ... W [2]

- (c) Switch S in Fig. 6.1 is now **opened**.

Resistors R_1 and R_2 are made from metal wires. Some data for these resistors are shown in Fig. 6.2.

	R_1	R_2
cross-sectional area of wire	A	$1.8A$
number of free electrons per unit volume in metal	n	$0.50n$

Fig. 6.2

Determine the ratio

$$\frac{\text{average drift speed of free electrons in } R_1}{\text{average drift speed of free electrons in } R_2}.$$

ratio = ... [2]

[Total: 9]

243. 9702_s15_qp_22 Q: 5

- (a) On Fig. 5.1, sketch the temperature characteristic of a thermistor.

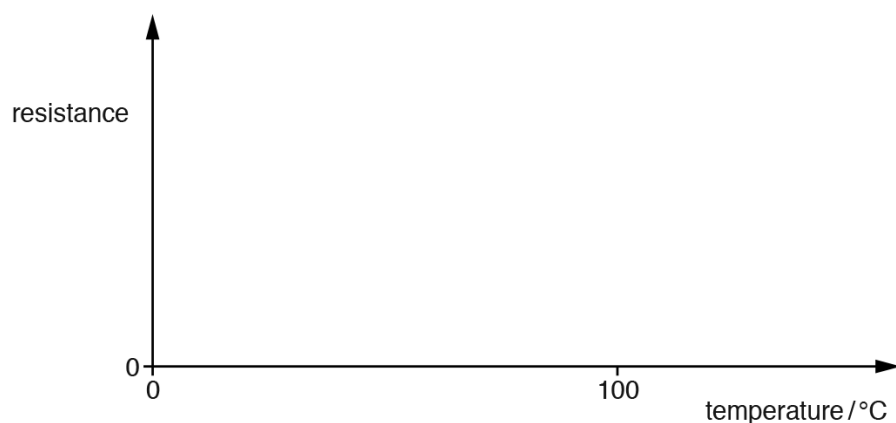


Fig. 5.1

[2]

- (b) A potential divider circuit is shown in Fig. 5.2.

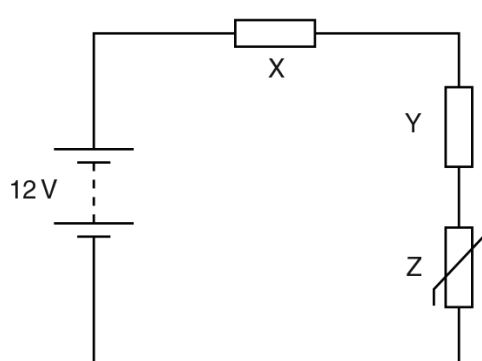


Fig. 5.2

The battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected in series with resistors X and Y and thermistor Z. The resistance of Y is $15\text{ k}\Omega$ and the resistance of Z at a particular temperature is $3.0\text{ k}\Omega$. The potential difference (p.d.) across Y is 8.0 V.

- (i) Explain why the power transformed in the battery equals the total power transformed in X, Y and Z.

..... [1]

- (ii) Calculate the current in the circuit.

current = ... A [2]

- (iii) Calculate the resistance of X.

resistance = ... Ω [3]

- (iv) The temperature of Z is increased.

State and explain the effect on the potential difference across Z.

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

244. 9702_w15_qp_21 Q: 6

- (a) Define electromotive force (e.m.f.) for a battery.

.....
 [1]

- (b) A battery of e.m.f. 6.0 V and internal resistance $0.50\ \Omega$ is connected in series with two resistors X and Y, as shown in Fig. 6.1.

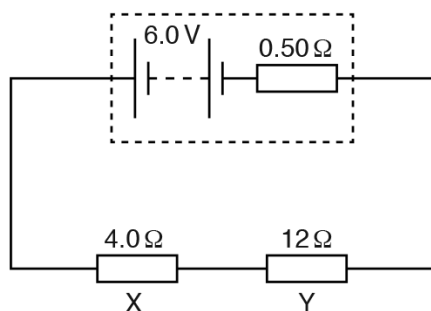


Fig. 6.1

The resistance of X is $4.0\ \Omega$ and the resistance of Y is $12\ \Omega$.

Calculate

- (i) the current in the circuit,

current = ... A [2]

- (ii) the terminal potential difference (p.d.) across the battery.

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

- (c) A resistor Z is now connected in parallel with resistor Y in the circuit in (b). The new arrangement is shown in Fig. 6.2.

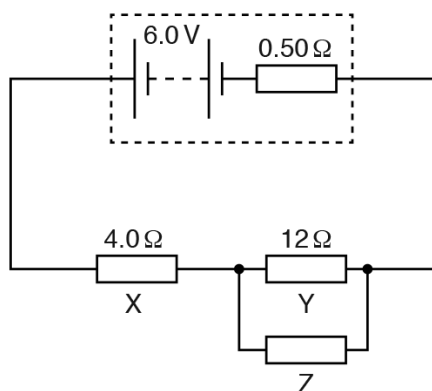


Fig. 6.2

Resistor Y is made from a wire of length l and diameter d . Resistor Z is a wire made from the same material as Y . The length of the wire for Z is $l/2$ and the diameter is $d/2$.

- (i) Calculate the resistance R of the combination of resistors Y and Z .

$$R = \dots\dots\dots \Omega \text{ [3]}$$

- (ii) State and explain the effect on the terminal p.d. across the battery.

A numerical value is not required.

.....

 [2]

(d) For the circuits given in (b) and (c), show that the ratio

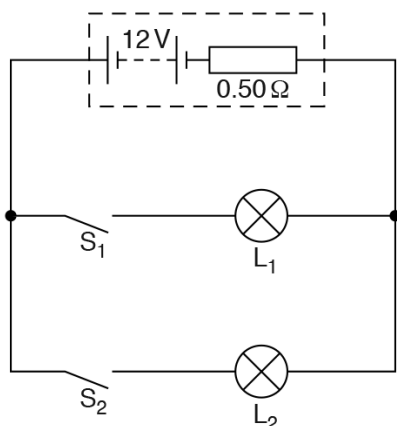
$$\frac{\text{power developed in the external circuit in Fig. 6.1}}{\text{power developed in the external circuit in Fig. 6.2}}$$

is approximately 0.8.

[3]

245. 9702_w15_qp_22 Q: 6

A 12V battery with internal resistance 0.50Ω is connected to two identical filament lamps L_1 and L_2 as shown in Fig. 6.1.

**Fig. 6.1**

The lamps are connected to the battery via switches S_1 and S_2 . The power rating of each lamp is 48W for a potential difference of 12V.

(a) S_1 is closed and S_2 open.

State and explain whether the power transformed in L_1 is 48W.

.....

[2]

(b) S_2 is now also closed.

(i) State and explain the effect on the current in L_1 .

.....

[1]

(ii) State and explain the effect on the resistance of L_1 .

.....

[1]

246. 9702_w15_qp_23 Q: 5

(a) The I - V characteristic of a semiconductor diode is shown in Fig. 5.1.

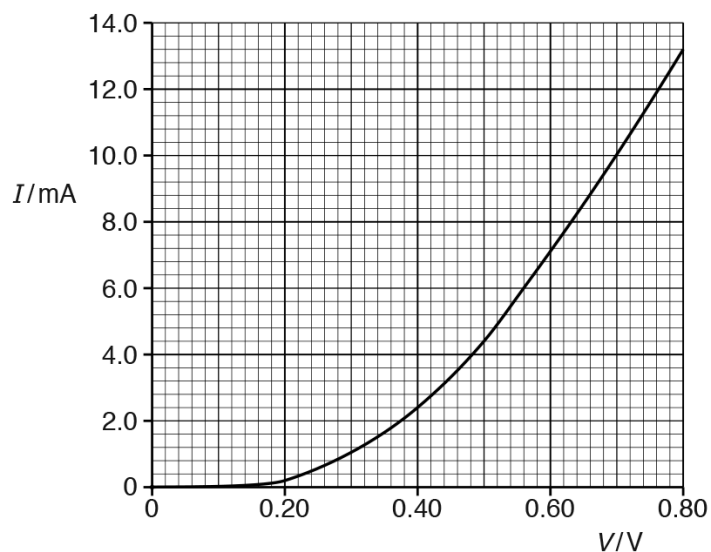


Fig. 5.1

(i) Use Fig. 5.1 to explain the variation of the resistance of the diode as V increases from zero to 0.8 V.

.....

[3]

(ii) Use Fig. 5.1 to determine the resistance of the diode for a current of 4.4 mA.

resistance = ... Ω [2]

- (b) A cell of e.m.f. 1.2V and negligible internal resistance is connected in series to a semiconductor diode and a resistor R_1 , as shown in Fig. 5.2.

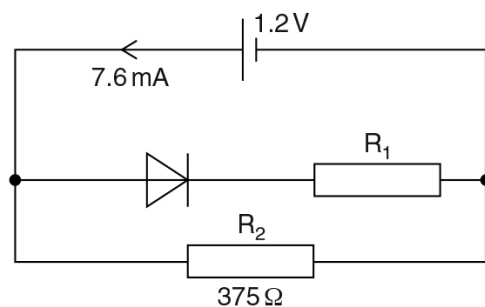


Fig. 5.2

A resistor R_2 of resistance 375Ω is connected across the cell. The diode has the characteristic shown in Fig. 5.1. The current supplied by the cell is 7.6mA .

Calculate

- (i) the current in R_2 ,

current = ... A [1]

- (ii) the resistance of R_1 ,

resistance = ... Ω [2]

- (iii) the ratio

$$\frac{\text{power dissipated in the diode}}{\text{power dissipated in } R_2}.$$

ratio = ... [2]

12.3 Potential dividers

247. 9702_s20_qp_21 Q: 5

- (a) Metal wire is used to connect a power supply to a lamp. The wire has a total resistance of $3.4\ \Omega$ and the metal has a resistivity of $2.6 \times 10^{-8}\ \Omega\text{m}$. The total length of the wire is 59 m .
- (i) Show that the wire has a cross-sectional area of $4.5 \times 10^{-7}\text{ m}^2$.

[2]

- (ii) The potential difference across the total length of wire is 1.8 V .

Calculate the current in the wire.

current = ... A [1]

- (iii) The number density of the free electrons in the wire is $6.1 \times 10^{28}\text{ m}^{-3}$.

Calculate the average drift speed of the free electrons in the wire.

average drift speed = ... ms^{-1} [2]

- (b) A different wire carries a current. This wire has a part that is thinner than the rest of the wire, as shown in Fig. 5.1.

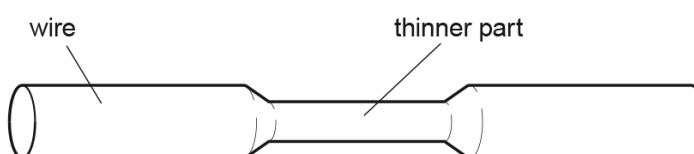


Fig. 5.1

- (i) State and explain qualitatively how the average drift speed of the free electrons in the thinner part compares with that in the rest of the wire.

.....

 [2]

- (ii) State and explain whether the power dissipated in the thinner part is the same, less or more than the power dissipated in an equal length of the rest of the wire.

.....

 [2]

- (c) Three resistors have resistances of $180\ \Omega$, $90\ \Omega$ and $30\ \Omega$.

- (i) Sketch a diagram showing how **two** of these three resistors may be connected together to give a combined resistance of $60\ \Omega$ between the terminals shown. Ensure you label the values of the resistances in your diagram.



[1]

- (ii) A potential divider circuit is produced by connecting the three resistors to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance. The potential divider circuit provides an output potential difference V_{OUT} of 8.0 V . Fig. 5.2 shows the circuit diagram.

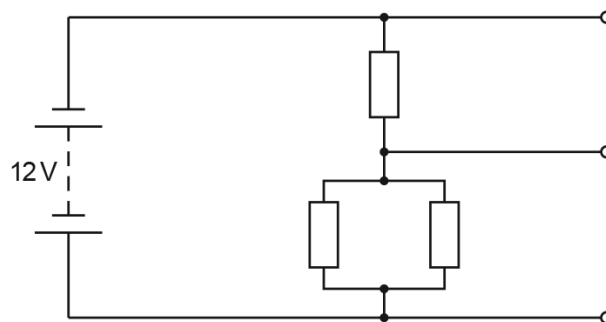


Fig. 5.2

On Fig. 5.2, label the resistances of all three resistors and the potential difference V_{OUT} .

[2]

[Total: 12]

248. 9702_s15_qp_23 Q: 5

A uniform resistance wire AB has length 50cm and diameter 0.36mm. The resistivity of the metal of the wire is $5.1 \times 10^{-7} \Omega \text{ m}$.

(a) Show that the resistance of the wire AB is 2.5Ω .

[2]

(b) The wire AB is connected in series with a power supply E and a resistor R as shown in Fig. 5.1.

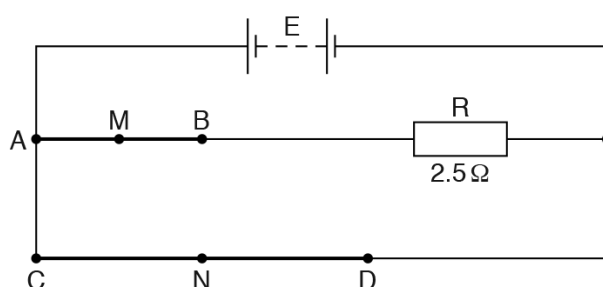


Fig. 5.1

The electromotive force (e.m.f.) of E is 6.0V and its internal resistance is negligible. The resistance of R is 2.5Ω . A second uniform wire CD is connected across the terminals of E. The wire CD has length 100cm, diameter 0.18mm and is made of the same metal as wire AB.

Calculate

(i) the current supplied by E,

current = ... A [4]

- (ii) the power transformed in wire AB,

power = ... W [2]

- (iii) the potential difference (p.d.) between the midpoint M of wire AB and the midpoint N of wire CD.

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

249. 9702_w15_qp_22 Q: 5

A 240V power supply S with negligible internal resistance is connected to four resistors, as shown in Fig. 5.1.

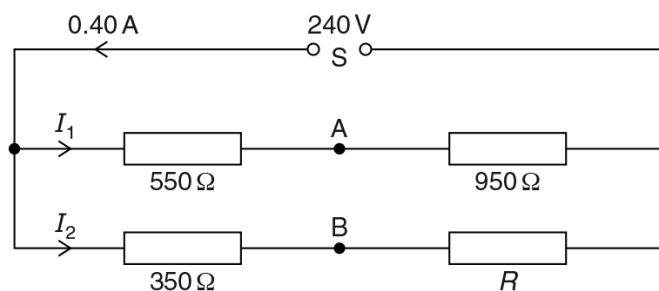


Fig. 5.1

Two resistors of resistance 550Ω and 950Ω are connected in series across S. Two resistors of resistance 350Ω and R are also connected in series across S.

The current supplied by S is 0.40 A .

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

(a) Calculate

(i) current I_1 ,

$$I_1 = \dots\dots\dots \text{ A [2]}$$

(ii) resistance R ,

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

(iii) the ratio

$$\frac{\text{power transformed in resistor of resistance } 350\Omega}{\text{power transformed in resistor of resistance } 550\Omega}.$$

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

- (b) Two points are labelled A and B, as shown in Fig. 5.1.
- (i) Calculate the potential difference V_{AB} between A and B.

$$V_{AB} = \dots\dots\dots \text{ V [2]}$$

- (ii) The resistance R is increased.

State and explain the effect on V_{AB} .

.....
.....
.....[1]

211. 9702_s16_qp_23 Q: 6

(a) ohm is volt per ampere or volt/ampere

B1 [1]

(b) (i) $R = \rho l / A$

B1

$$R_P = 4\rho(2l)/\pi d^2 \text{ or } 8\rho l/\pi d^2 \text{ or } R_Q = \rho l/\pi d^2$$

or

ratio idea e.g. length is halved hence R halved and diameter is halved hence R is $1/4$

C1

$$\begin{aligned} R_Q (= 4\rho l/\pi 4d^2) &= \rho l/\pi d^2 \\ &= R_P/8 \\ &= (12/8) = 1.5 \Omega \end{aligned}$$

A1 [3]

(ii) power = $I^2 R$ or V^2/R or VI

C1

$$= (1.25)^2 \times 12 + (10)^2 \times 1.5 \text{ or } (15)^2/12 + (15)^2/1.5 \text{ or } 15 \times 11.25$$

C1

$$= (18.75 + 150) = 170 \text{ (168.75) W}$$

A1 [3]

(iii) $I_P = (15/12) = 1.25 \text{ (A)}$ and $I_Q = (15/1.5) = 10 \text{ (A)}$

C1

$$V_P/V_Q = I_P n A_Q e / I_Q n A_P e \text{ or } (1.25 \times \pi d^2) / (10 \times \pi d^2/4)$$

C1

$$= 0.5$$

A1 [3]

212. 9702_m20_qp_22 Q: 6

	Answer	Mark
(a)	$E = V/d$ $d = 350 / 1.4 \times 10^4$	C1
	$= 0.025 \text{ m}$	A1
(b)(i)	$E = F/Q$	C1
	$Q = 6.7 \times 10^{-15} / 1.4 \times 10^4 (= 4.8 \times 10^{-19} \text{ C})$ $= (4.8 \times 10^{-19} / 1.6 \times 10^{-19}) e$	C1
	$= 3.0 e$	A1
(b)(ii)	mass $= 8.3 \times 10^{-27} / 1.66 \times 10^{-27}$ $= 5.0 \text{ u}$	A1
(b)(iii)	number $= 5 - 3$ $= 2$	A1

213. 9702_s15_qp_21 Q: 5

- (a) very high/infinite resistance for negative voltages up to about 0.4 V B1
 resistance decreases from 0.4 V B1 [2]
- (b) initial straight line from (0,0) into curve with decreasing gradient but not to horizontal M1
 repeated in negative quadrant A1 [2]
- (c) (i) $R = 12^2 / 36 = 4.0 \Omega$ A1
 or
 $I = P / V = 36 / 12 = 3.0 \text{ A}$ and $R = 12 / 3.0 = 4.0 \Omega$ (A1) [1]
- (ii) lost volts = $0.5 \times 2.8 = 1.4 \text{ (V)}$ or $E = 12 = 2.8 \times (R + r)$ C1
 $R = V / I = (12 - 1.4) / 2.8$ or $(R + r) = 4.29 \Omega$ C1
 $= 3.8 \text{ (3.79)} \Omega$ or $R = 3.8 \Omega$ A1 [3]
- (d) resistance of the lamp increases with increase of V or I B1 [1]

214. 9702_m20_qp_22 Q: 5

	Answer	Mark
(a)	volt / ampere	B1
(b)	$R = \rho L / A$	C1
	$L = (1.8 \times 0.38 \times 10^{-6}) / 9.6 \times 10^{-7}$	C1
	$= 0.71 \text{ m}$	A1
(c)(i)	thermal energy is dissipated in resistor Y	B1
(c)(ii)	$V / 1.2 = 1.8 / (1.8 + 0.6)$	C1
	$V = 0.90 \text{ V}$	A1
	or	
	$I = 1.2 / (1.8 + 0.6) (= 0.50)$	(C1)
	$V = 0.50 \times 1.8$ $= 0.90 \text{ V}$	(A1)
(d)(i)	remain the same	B1
(d)(ii)	decrease	B1
(e)(i)	$1 / R = 1 / 1.8 + 1 / 3.6$ $R = 1.2 \Omega$	A1

	Answer	Mark
(e)(ii)	$I = 1.2 / (1.2 + 0.60)$	C1
	$= 0.67 \text{ A}$	A1
	or	
	$V_Y = 1.2 \times 0.60 / (1.2 + 0.60) (= 0.40)$	(C1)
	$I = 0.40 / 0.60$ $= 0.67 \text{ A}$	(A1)

215. 9702_s20_qp_22 Q: 6

	Answer	Mark
(a)(i)	energy is dissipated in the internal resistance/ r	B1
(a)(ii)	1. $I = Q / t$	C1
	$= 750 / 1500$	A1
	$= 0.50 \text{ A}$	
	2. $V = W / Q$ or $V = W / It$	C1
	$= 5700 / 750$ or $5700 / (0.50 \times 1500)$	A1
	$= 7.6 \text{ V}$	
	or	
	$V = P / I$ and $P = W / t$	(C1)
	$V = 3.8 / 0.50$	(A1)
	$= 7.6 \text{ V}$	
(b)(i)	3. $r = (7.8 - 7.6) / 0.50$	C1
	$= 0.40 \Omega$	A1
(b)(i)	90 Ω and 45 Ω resistors shown connected in parallel	B1
(b)(ii)	the resistors connected in parallel labelled as 90 Ω and 45 Ω with the other resistor labelled as 20 Ω	M1
	V_{OUT} or 3.6 V labelled across the 20 Ω resistor	A1

216. 9702_s20_qp_23 Q: 5

	Answer	Mark
(a)	joule per coulomb	B1
(b)(i)	$1/R = 1/R_1 + 1/R_2$ $= 1/300 + 1/200$ $R = 75 \Omega$	A1
(b)(ii)	$R = 75 + 55$ $= 130 \Omega$	A1
(c)(i)	1. $P = I^2 R$ or $P = VI$ and $V = IR$	C1
	$I = (0.20/55)^{0.5}$ $= 0.060 \text{ A}$	A1
	2. $I = 0.060/4$ $= 0.015 \text{ A}$	A1
(c)(ii)	potential difference $= 130 \times 0.060$ $= 7.8 \text{ V}$	A1
	or	
	potential difference $= (300 \times 0.015) + (55 \times 0.060)$ $= 7.8 \text{ V (other valid methods are also possible)}$	(A1)

217. 9702_w20_qp_21 Q: 7

	Answer	Mark
(a)	volt / ampere	B1
(b)	$R = \rho L / A$	C1
	$A = 460 \times 10^{-9} \times 2.5 / 3.2$	C1
	$= 3.6 \times 10^{-7} \text{ m}^2$	A1
(c)(i)	energy is dissipated in the internal resistance/ r	B1
(c)(ii)	$E = IR + Ir$ or $E = I(R + r)$	B1
(c)(iii)	$P = I^2 R$ or $P = I^2 r$	C1
	$I = E / 2r$	A1
	(so) $P = E^2 / 4r$	

218. 9702_w20_qp_22 Q: 6

	Answer	Mark
(a)	$I = I_1 + I_2 + I_3$	B1
	$(V/R) = (V/R_1) + (V/R_2) + (V/R_3)$ or $(I/V) = (I_1/V) + (I_2/V) + (I_3/V)$	B1
	and $1/R = 1/R_1 + 1/R_2 + 1/R_3$	
(b)(i)	current = $0.49 + 0.45$ = 0.94 A	A1
(b)(ii)	$8.0 = (0.94 \times r) + (0.45 \times 16)$	C1
	$r = 0.85 \Omega$	A1
(c)	$I = Anvq$	C1
	$v = (0.45 / 0.49) \times 2.1 \times 10^{-4}$	
	= $1.9 \times 10^{-4} \text{ ms}^{-1}$	A1
(d)	total/combined resistance decreases	B1
	(current in battery increases so terminal) potential difference decreases	B1

219. 9702_w20_qp_23 Q: 6

	Answer	Mark
(a)	$\frac{\text{work (done)/energy (transferred from electrical to other forms)}}{\text{charge}}$	B1
(b)	$R = \rho L / A$	B1
	$V = LA$ and (so) $R = \rho V / A^2$ (with ρ and V constant)	B1
(c)	$E = IR + Ir$ or $E = I(R + r)$ or $E - Ir = IR$ and $R = (E/I) - r$	A1
(d)(i)	$P = I^2 R$ or $P = IV$ or $P = V^2 / R$	C1
	$R = 5.4 (\Omega)$ or $V = 10.8 (\text{V})$	C1
	$P = 2.0^2 \times 5.4$	A1
	= 22 W	
(d)(ii)	1. $r = 0.60 \Omega$	A1
	2. $E = \text{gradient}$	C1
	= e.g. $5.4 / 0.45$ = 12 V	A1

220. 9702_m19_qp_22 Q: 6

	Answer	Mark
(a)	e.m.f.: energy transferred from chemical to electrical (per unit charge)	B1
	p.d.: energy transferred from electrical to thermal (per unit charge)	B1

	Answer	Mark
(b)(i)	1 $I = 4.8 / 32$ $= 0.15 \text{ A}$	A1
	2 $P = EI$ or $P = VI$ or $P = I^2 R$ or $P = V^2 / R$ $= 6.0 \times 0.15$ or $0.15^2 \times 40$ or $6.0^2 / 40$	C1
	$= 0.90 \text{ W}$	A1
	3 number $= It / e$ $= [0.15 \times 25] / 1.6 \times 10^{-19}$	C1
	$= 2.3 \times 10^{19}$	A1
	or $Q = 0.15 \times 25 (= 3.75)$ number $= 3.75 / 1.6 \times 10^{-19}$	(C1)
	$= 2.3 \times 10^{19}$	(A1)
	4 $4.8 / 6.0 = 32 / (R_{XY} + 32)$ or $1.2 / 6.0 = R_{XY} / (R_{XY} + 32)$ or $4.8 / 1.2 = 32 / R_{XY}$	C1
	$R_{XY} = 8.0 \Omega$	A1
	Alternative methods:	
	$R_{XY} = (6.0 - 4.8) / 0.15$ or	(C1)
	$= 8.0 \Omega$	(A1)
	or $6.0 = 0.15 (32 + R_{XY})$	(C1)
	$R_{XY} = 40 - 32$ $= 8.0 \Omega$	(A1)
	Answer	Mark
(b)(i)	5 $1 / 8.0 = 1 / R_X + 1 / 24$	C1
	$R_X = 12 \Omega$	A1
	Alternative method:	
	$I_Z = 4.8 / 32 = 0.15$ and $I_Y = 1.2 / 24 = 0.05$ $I_X = 0.15 - 0.05 (= 0.10)$	(C1)
	$R_X = 1.2 / 0.10 = 12 \Omega$	(A1)
(b)(ii)	<u>total</u> resistance decreases	M1
	(so voltmeter) reading increases	A1

221. 9702_s19_qp_21 Q: 6

	Answer	Mark
(a)	energy is dissipated in the internal resistance	B1
(b)	$E = V + Ir$	B1
(c)(i)	(graph shows) maximum value of potential difference is 2.8 (V) or (graph shows) when current I (from battery) is zero, V is 2.8 (V) / E	B1
(c)(ii)	$r = (-)\text{gradient}$ or $r = (E - V) / I$ or substituted values from the graph for E , V and I	C1
	$r = 1.4 \Omega$	A1
(d)(i)	$R = 2.1 / 0.50$ $= 4.2 \Omega$	A1
(d)(ii)	number $= 0.50 / 1.60 \times 10^{-19}$ $= 3.1 \times 10^{18}$	A1
(d)(iii)	energy $= EIt$ or $P = EI$ and $P = W/t$ $(9.2 - 1.6) \times 10^3 = 2.8 \times 0.50 \times t$	C1
	$t = 5.4 \times 10^3 \text{ s}$	A1

222. 9702_s19_qp_22 Q: 5

	Answer	Mark
(a)	sum of e.m.f.(s) = sum of p.d.(s) around a loop/around a closed circuit	M1 A1
(b)(i)	1. $1/R = 1/R_1 + 1/R_2$ $1/R = 1/90 + 1/18$ $R = 15 \Omega$	C1 A1
	2. $I = V/R$ $I = 4.8/15$ or $I = 4.8/90 + 4.8/18$ $I = 0.32 \text{ A}$	C1 A1
(b)(ii)	$E = V + Ir$ or $E = I(R + r)$ $5.6 = 4.8 + 0.32 r$ so $r = 2.5 (\Omega)$ or $5.6 = 0.32 \times (15 + r)$ so $r = 2.5 (\Omega)$	C1 A1
(b)(iii)	$P = EI$ or $P = VI$ or $P = I^2 R$ or $P = V^2 / R$ ratio $= (0.32^2 \times 2.5) / (5.6 \times 0.32)$ or $0.256 / 1.792$ $= 0.14$	C1 C1 A1

	Answer	Mark
(c)	$7.2 - 5.6 - 2.5I - 3.5I = 0$ $I = 0.27 \text{ A}$	C1 A1

223. 9702_s19_qp_23 Q: 6

	Answer	Mark
(a)	volt / ampere	B1
(b)(i)	1. $I = 1.8 + 0.60$ $= 2.4 \text{ A}$	A1
	2. $(8.0 \times 0.60) = 1.8 \times (2.0 + R_2)$	C1
	$R_2 = 0.67 \Omega$	A1
	3. $E - (2.4 \times 1.5) = (0.60 \times 8.0)$ or $E - (2.4 \times 1.5) = 1.8 \times (2.0 + 0.67)$ or $E = 2.4 \times [1.5 + (8.0 \times 2.67) / (8.0 + 2.67)]$	C1
	$E = 8.4 \text{ V}$	A1
(b)(ii)	1. $R = \rho L / A$ or $R \propto 1 / A$	C1
	ratio $= R_Y / R_X = 2.0 / 8.0$ $= 0.25$	A1
	2. $I \propto A_V$ or $I_X / I_Y = A_X V_X / A_Y V_Y$	C1
	ratio $= (0.60 / 1.8) \times (1 / 0.25)$ $= 1.3$	A1

224. 9702_w19_qp_21 Q: 6

	Answer	Mark
(a)	work done / charge or energy (transferred from electrical to other forms) / charge	B1
(b)	for $V < 0.25 \text{ V}$ resistance is infinite/very high (as current is zero)	B1
	for $V > 0.25 \text{ V}$ resistance decreases (as V increases)	B1
(c)(i)	$R = V / I$	C1
	$= 0.75 / (15 \times 10^{-3})$	C1
	$= 50 \Omega$	A1

	Answer	Mark
(c)(ii)	1. $V_Y = 15 \times 10^{-3} \times 60$ (= 0.90 V)	C1
	$V_X = 2.0 - 0.90 - 0.75$ (= 0.35 V)	C1
	$R_X = 0.35 / (15 \times 10^{-3})$ = 23 Ω	A1
	or	
	total $R = 60 + 50 + R_X$	(C1)
	$60 + 50 + R_X = 2.0 / (15 \times 10^{-3})$	(C1)
	$R_X = 23 \Omega$	(A1)
	2. $P = VI$ or $P = EI$ or $P = I^2 R$ or $P = V^2 / R$	C1
	ratio = $\frac{(15 \times 10^{-3})^2 \times 60}{2.0 \times 15 \times 10^{-3}}$ or $\frac{0.90 \times 15 \times 10^{-3}}{2.0 \times 15 \times 10^{-3}}$ or $\frac{(0.90^2 / 60)}{2.0 \times 15 \times 10^{-3}}$ = 0.45	A1

225. 9702_w19_qp_22 Q: 6

	Answer	Mark
(a)	<u>sum of</u> current(s) into junction = <u>sum of</u> current(s) out of junction or (algebraic) sum of current(s) at a junction is zero	B1
(b)(i)	$R = V / I$	C1
	= $0.60 / 7.5 \times 10^{-3}$	C1
	= 80 Ω	A1
(b)(ii)	resistance decreases	B1
(c)(i)	$E = 0.60 + 0.30$ = 0.90 V	A1
(c)(ii)	(I =) 9.3 – 7.5	C1
	$I = 1.8$ (mA) or 1.8×10^{-3} (A)	A1
	$R = 0.90 / 1.8 \times 10^{-3}$ = 500 Ω	
	or	
	total resistance = $0.90 / 9.3 \times 10^{-3} = 96.8$ (Ω) total resistance of diode and X = $0.90 / 7.5 \times 10^{-3} = 120$ (Ω) $1 / 96.8 = 1 / R + 1 / 120$	(C1)
	$R = 500 \Omega$	(A1)

	Answer	Mark
(c)(iii)	$P = VI$ or $I^2 R$ or V^2 / R	C1
	= $0.60 \times 7.5 \times 10^{-3}$ or $(7.5 \times 10^{-3})^2 \times 80$ or $0.60^2 / 80$ = 4.5×10^{-3} W	A1
(c)(iv)	current = 2.5 mA	A1

226. 9702_w19_qp_23 Q: 6

	Answer	Mark
(a)(i)	$R = V / I$	C1
	resistance = $(12 / 0.20) / 2$ or $6 / 0.20$ $= 30 \Omega$	A1
(a)(ii)	$I = 0.50 - 0.20$ (= 0.30 A)	C1
	$R + 28 = 12 / 0.30$ (= 40 Ω)	A1
	$R = 12 \Omega$	

	Answer	Mark
(b)	p.d. across lamp = 0.20×30 (= 6.0 V)	C1
	p.d. across $R = 0.30 \times 12$ (= 3.6 V)	C1
	$V_{XY} = 6.0 - 3.6$ $= 2.4 \text{ V}$	A1
	or	
	p.d. across lamp = 0.20×30 (= 6.0 V)	(C1)
	p.d. across 28Ω resistor = 0.30×28 (= 8.4 V)	(C1)
	$V_{XY} = 8.4 - 6.0$ $= 2.4 \text{ V}$	(A1)
(c)	$P = VI$ or $P = EI$ or $P = I^2 R$ or $P = V^2 / R$	C1
	ratio = $(6.0 \times 0.20) \times 2 / (12 \times 0.50)$ or $0.20 / 0.50$ $= 0.40$	A1
(d)	no change to V across lamps, so power in lamps unchanged or current in battery/total current increases (and e.m.f. the same) so power produced by battery increases	B1
	both the above statements and so the ratio decreases	B1

227. 9702_m18_qp_22 Q: 5

	Answer	Mark
(a)	sum of e.m.f.(s) = sum of p.d.(s)	M1
	around a loop / around a closed circuit	A1
(b)(i)	1 $6.0 - 4.0I = 0$ $I = 1.5 \text{ A}$	A1
	2 $6.0 + 6.0 = I(4.0 + R + 1.5)$ $12 = 1.5(4.0 + R + 1.5)$	C1
	$R = 2.5 \Omega$	A1
	or $6.0 = I(R + 1.5)$ $6.0 = 1.5(R + 1.5)$	(C1)
	$R = 2.5 \Omega$	(A1)
	or combines $6 = 4I$ and $6 = I(R + 1.5)$ to give $4 = R + 1.5$	(C1)
	$R = 2.5 \Omega$	(A1)

	Answer	Mark
(b)(ii)	$I = Anvg$ ratio = $1^2 / 2^2$	C1
	= 0.25	A1
(b)(iii)	total (circuit) resistance increases	B1
	current / I decreases or $P \propto I$ or $P \propto 1 / (\text{total resistance})$	M1
	power (transformed) decreases	A1

228. 9702_s18_qp_21 Q: 6

	Answer	Mark
(a)	joule/coulomb	B1
(b)(i)	lamps have same p.d./lamps have p.d. of 2.7 V	B1
	current = $0.15 + 0.090$ = 0.24 A	A1
(b)(ii)	$R = (4.5 - 2.7) / 0.24$	C1
	or	
	$R_P = 18(\Omega)$ and $R_Q = 30(\Omega)$ $1/R_T = 1/18 + 1/30$ and so $R_T = 11.25$ $4.5 = 0.24 \times (R + 11.25)$	
	$R = 7.5\Omega$	A1

	Answer	Mark
(b)(iii)	$R = \rho l / A$	C1
	$R_P / R_Q = [(2.7 / 0.15) / (2.7 / 0.09)] (= 0.60)$	C1
	ratio = 0.60×2^2 = 2.4	A1
(b)(iv)	less p.d. across resistor/greater p.d. across P	B1
	greater current through P and so resistance (of P) increases	B1

229. 9702_s18_qp_22 Q: 6

	Answer	Mark
(a)(i)	<u>sum of</u> current(s) into junction = <u>sum of</u> current(s) out of junction or (algebraic) sum of current(s) at a junction is zero	B1
(a)(ii)	charge	B1
(b)(i)1.	$E = I^2 R t$ or $E = V I t$ or $E = (V^2 / R) t$	C1
	$E = 2.5^2 \times 2.0 \times 5.0 \times 60$ or $5.0 \times 2.5 \times 5.0 \times 60$ or $(5.0^2 / 2.0) \times 5.0 \times 60$ $= 3800 \text{ J}$	A1
(b)(i)2.	p.d. = $8.0 - (2.0 \times 2.5)$ $= 3.0 \text{ V}$	A1
(b)(ii)	$I_x = 3.0 / 15 = 0.20 \text{ (A)}$	C1
	$I_y = 2.5 - 0.20 = 2.3 \text{ (A)}$	C1
	$R_y = 3.0 / 2.3$ $= 1.3 \Omega$	A1
	or	
	$R_T = 3.0 / 2.5 = 1.2 (\Omega)$ or $(8.0 / 2.5) - 2.0 = 1.2 (\Omega)$	(C1)
	$1 / 1.2 = 1 / 15 + 1 / R_y$	(C1)
	$R_y = 1.3 \Omega$	(A1)

	Answer	Mark
(b)(iii)1.	Z has larger radius/diameter/(cross-sectional) area	B1
	Z has (material of) smaller resistivity/greater conductivity	B1
(b)(iii)2.	current/I (in battery) increases	M1
	($P = EI$ so) power/P (produced by battery) increases	A1

230. 9702_s18_qp_23 Q: 6

	Answer	Mark
(a)	$R = \rho L / A$	C1
	$3.0 = \rho / [\pi \times (0.48 \times 10^{-3} / 2)^2]$	C1
	$\rho = 5.4 \times 10^{-7} \Omega \text{ m}$	A1
(b)(i)	p.d. = $5.0 - (2.0 \times 1.6)$ $= 1.8 \text{ V}$	A1
(b)(ii)1.	current in resistor = $1.8 / 4.5 (= 0.40 \text{ A})$	C1
	current in wire = $1.6 - 0.40 (= 1.2 \text{ A})$	C1
	$R_x = 1.8 / 1.2$ $= 1.5 \Omega$	A1
	or	
	$R_T = 1.8 / 1.6$ or $(5.0 / 1.6) - 2.0 (= 1.125 \Omega)$	(C1)
	$(1 / 1.125) = (1 / 4.5) + (1 / R_x)$	(C1)
	$R_x = 1.5 \Omega$	(A1)
(b)(ii)2.	length = $1.5 / 3.0$ or $1.5 \times 1.8 \times 10^{-7} / (5.4 \times 10^{-7})$ $= 0.50 \text{ m}$	A1

231. 9702_w18_qp_21 Q: 6

	Answer	Mark
(a)	<u>sum of</u> e.m.f.(s) equal to <u>sum of</u> p.d.(s)	M1
	around a loop/around a closed circuit	A1
(b)(i)	current in variable resistor = $(6.0/2.4) + (6.0/1.2)$ (= 7.5 A)	C1
	p.d. across variable resistor = $9.0 - 6.0$ (= 3.0 V)	C1
	$R = 3.0/7.5$ = 0.40 Ω	A1
	or	
	$\frac{1}{R_T} = \frac{1}{2.4} + \frac{1}{1.2}$ $R_T = 0.80$ (Ω)	(C1)
	$\frac{3}{9} = \frac{R}{(R + 0.80)}$ or $\frac{3}{R} = \frac{6}{0.8}$	(C1)
	$R = 0.40 \Omega$	(A1)
(b)(ii)	$P = V^2/R$ or $P = I^2 R$ or $P = IV$	C1
	$P = 6.0^2/24$ or $2.5^2 \times 2.4$ or 6.0×2.5 = 15 W	A1

	Answer	Mark
(b)(iii)	1. $R = \frac{\rho L}{A}$	C1
	ratio = $(2.4/1.2) \times (3/1)$ = 6.0	A1
	2. ($I = nAvq$) $I_X/I_Y = 2.5/5.0$ or $1.2/2.4$ or 0.5	C1
	ratio = $(2.5/5.0) \times (1/3)$ or $(1.2/2.4) \times (1/3)$ = 0.17	A1

232. 9702_w18_qp_23 Q: 7

	Answer	Mark
(a)	<u>sum of</u> current(s) in(to) junction = <u>sum of</u> current(s) out of junction or (algebraic) sum of current(s) at a junction is zero	B1
(b)(i)	1. potential difference = 0	A1
	2. potential difference = 9.6 V	A1
(b)(ii)	for resistance in parallel: $(1/R_T) = (1/400) + (1/400)$ $R_T = 200$ (Ω)	C1
	$V/9.6 = 200/600$	C1
	$V = 3.2$ V	A1

233. 9702_m17_qp_22 Q: 6

	Answer	Mark
(a)	$I = I_1 + I_2 + I_3$	B1
	$(V/R) = (V/R_1) + (V/R_2) + (V/R_3)$ or $(I/V) = (I_1/V) + (I_2/V) + (I_3/V)$ and (so) $1/R = 1/R_1 + 1/R_2 + 1/R_3$	A1
(b)(i)	e.m.f. is total energy available per unit charge	B1
	energy is dissipated in the internal resistance/resistor/ r	B1
(b)(ii)1	Energy = EQ	C1
	$= 6.0 \times 2.5 \times 10^3$ $= 1.5 \times 10^4 \text{ J}$	A1
(b)(ii)2	number = $2.5 \times 10^3 / 1.6 \times 10^{-19}$ $= 1.6 \times 10^{22}$ (1.56×10^{22})	A1
(b)(iii)	$1/4.8 = 1/12 + 1/R_X$ $R_X = 8.0 \Omega$	A1
(b)(iv)	$P = V^2/R$ or $P = VI$ and $V = IR$	C1
	ratio = $(V^2/8)/(V^2/12) = 12/8$ $= 1.5$	A1
(b)(v)	(total) current, or I , increases and $P = EI$ or $P = 6I$ or $P \propto I$ or total (circuit) resistance decreases and $P = E^2/R$ or $P = 36/R$ or $P \propto 1/R$	B1

234. 9702_s17_qp_21 Q: 6

	Answer	Mark
(a)	volt / ampere	B1
(b)(i)	$R_T = [1/3.0 + 1/6.0]^{-1} + 4.0 (= 6.0 \Omega)$	C1
	$I = 1.5/6.0$	C1
	$= 0.25 \text{ A}$	A1
(b)(ii)	$V_B = 0.5 \text{ V}$	A1
	$I = 0.5/3.0$	
	$= 0.17$ (0.167) A	
(b)(iii)	$P = I^2 R$ or VI or V^2/R	C1
	ratio = $(0.167^2 \times 3.0)/(0.25^2 \times 4.0)$	A1
	$= 0.33$	
(c)(i)	vary/change/different radius/diameter/cross-sectional area (of wire)	B1
(c)(ii)	$v = I/Ane$	C1
	ratio = $\frac{(I_B/A_B)}{(I_C/A_C)}$ or $\frac{I_B}{I_C} \times \frac{A_C}{A_B}$	
	$(R \propto 1/A \text{ so})$ ratio = $\frac{I_B}{I_C} \times \frac{R_B}{R_C} = \frac{0.167}{0.25} \times \frac{3.0}{4.0}$ $= 0.50$	
(d)(i)	0.25 A to 0.13 (0.125) A or halved	A1
(d)(ii)	no change	A1

235. 9702_s17_qp_22 Q: 7

	Answer	Mark
(a)	energy transformed from <u>chemical to electrical</u> /unit charge (driven around a complete circuit)	B1
(b)(i)	the current decreases (as resistance of Y increases)	M1
	lost volts go down (as resistance of Y increases)	M1
	p.d. AB increases (as resistance of Y increases)	A1
(b)(ii)1.	$1.50 = 0.180 \times (6.00 + 0.200 + R_x)$	C1
	$R_x = 2.1(3) \Omega$	A1
(b)(ii)2.	p.d. AB = $1.5 - (0.180 \times 0.200)$ or $0.18 \times (2.13 + 6.00)$	C1
	= $1.46(4) V$	A1
(b)(ii)3.	efficiency = (useful) power output / (total) power input or IV/IE	C1
	(= $1.46 / 1.5$) = 0.97 [0.98 if full figures used]	A1

236. 9702_s17_qp_23 Q: 6

	Answer	Mark
(a)(i)	straight line <u>through the origin</u>	B1
(a)(ii)	zero current for one direction (–ve V) up to zero or a few tenths of volt (+ve V)	B1
	straight line positive gradient/increasing gradient (+ve V)	B1
(b)(i)	1. current = 2.8 A	A1
	2. 4(.0) A for each lamp	C1
	current in circuit = 8(.0) A	A1
(b)(ii)	use of $R = V/I$ with correct values of V from graph for each arrangement	C1
	1. series resistance (= $2.1 + 2.1$) = 4.2 or 4.3 Ω or ($12 / 2.8$) = 4.3 Ω	A1
	2. parallel resistance 1.5 Ω (each lamp 3.0 Ω) or ($12 / 8.0$) = 1.5 Ω	A1
(b)(iii)	power = IV or V^2/R or I^2R	C1
	ratio = $(2.8 \times 6.0) / (4.0 \times 12) = 0.35$	A1

237. 9702_w17_qp_21 Q: 5

	Answer	Mark
(a)	$I_1 + I_2 = I_3$ [any subject]	B1
(b)	$E_1 + E_3 = I_1 R_1 + I_3 R_3 + I_3 R_4$ [any subject]	B1
(c)	$E_1 - E_2 = I_1 R_1 - I_2 R_2$ [any subject]	B1

238. 9702_m16_qp_22 Q: 5

- (a) (i) movement/flow of charge carriers B1
- (ii) $\frac{\text{work (done) or energy (transformed)}(\text{from electrical to other forms})}{\text{charge}}$ B1
- (b) (i) p.d. across one lamp = 2.5 V C1
 resistance = $[(8.7 - 7.5)/0.3]/2 = 2.0 (\Omega)$ A1
- (ii) straight line through the origin M1
 with gradient of 0.5 A1
- (iii) $P = I^2 R$ or $P = VI$ and $V = IR$ or $P = V^2 / R$ and $V = IR$ C1
 $= 0.30^2 \times 2.0 = 0.60 \times 0.30 = 0.60^2 / 2.0$
 $= 0.18 \text{ (W)}$ A1
- (iv) 1 $R = \rho l / A$ C1
 $l = (2.0 \times 0.40 \times 10^{-6}) / 1.7 \times 10^{-8}$
 $= 47 \text{ (m)}$ A1
- 2 $I = Anvq$
 $v = 0.30 / (0.40 \times 10^{-6} \times 8.5 \times 10^{28} \times 1.6 \times 10^{-19})$ C1
 $= 5.5 \times 10^{-5} \text{ (m s}^{-1}\text{)}$ A1
-

239. 9702_s16_qp_22 Q: 7

(a) charge exists only in discrete amounts B1 [1]

(b) (i) $E = I(R + r)$ or $V = IR$ C1

(total resistance =) $2.7 + 0.30 + 0.25 (= 3.25 \Omega)$ M1

$I = 9.0 / (2.7 + 0.30 + 0.25)$ or $9.0 / 3.25 = 2.8 \text{ A}$ A1 [3]

(ii) $V = IR_{\text{ext}}$ C1
 $= 2.77 \times 3.0$ or 2.8×3.0

or

$V = E - Ir$ (C1)
 $= 9.0 - 2.77 \times 0.25$ or $9.0 - 2.8 \times 0.25$

$V = 8.3$ (8.31) V or 8.4 V A1 [2]

(c) (i) $I = nevA$

$v = 2.77 / (8.5 \times 10^{29} \times 1.6 \times 10^{-19} \times 2.5 \times 10^{-6})$ M1

$= 8.1$ (8.147) $\times 10^{-6} \text{ ms}^{-1}$ or $8.2 \times 10^{-6} \text{ ms}^{-1}$ A1 [2]

(ii) A reduces by a factor 4 (1/4 less) or resistance of Z goes up by 4× M1

current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up A1 [2]

240. 9702_w16_qp_21 Q: 6

- (a) $\frac{\text{work done or energy (transformed) (from electrical to other forms)}}{\text{charge}}$ B1 [1]
- (b) (i) 1. $V = IR$ or $E = IR$ C1
- $I = 14/6.0$
 $= 2.3$ (2.33) A A1 [2]
2. total resistance of parallel resistors = 8.0Ω C1
- current = $14/(6.0 + 8.0)$
 $= 1.0$ A A1 [2]
- (ii) $P = EI$ (allow $P = VI$) or $P = V^2/R$ or $P = I^2R$ C1
- change in power = $(14 \times 2.33) - (14 \times 1.0)$
 or $(14^2/6.0) - (14^2/14)$
 or $(2.33^2 \times 6.0) - (1.0^2 \times 14)$
 $= 19$ W (18 W if 2.3 A used) A1 [2]
- (c) $I = Anvq$
- ratio = $(0.50n/n) \times (1.8\text{ A}/\text{A})$ or ratio = 0.50×1.8 C1
- $= 0.90$ A1 [2]
-

242. 9702_w16_qp_23 Q: 6

- (a) $\frac{\text{work done or energy (transformed) (from electrical to other forms)}}{\text{charge}}$ B1 [1]
- (b) (i) 1. $V = IR$ or $E = IR$ C1
- $I = 14/6.0$
 $= 2.3$ (2.33) A A1 [2]
2. total resistance of parallel resistors $= 8.0\Omega$ C1
- current $= 14/(6.0 + 8.0)$
 $= 1.0$ A A1 [2]
- (ii) $P = EI$ (allow $P = VI$) or $P = V^2/R$ or $P = I^2R$ C1
- change in power $= (14 \times 2.33) - (14 \times 1.0)$
 or $(14^2/6.0) - (14^2/14)$
 or $(2.33^2 \times 6.0) - (1.0^2 \times 14)$
 $= 19$ W (18 W if 2.3 A used) A1 [2]
- (c) $I = Anvq$
- ratio $= (0.50n/n) \times (1.8\text{ A}/\text{A})$ or ratio $= 0.50 \times 1.8$ C1
- $= 0.90$ A1 [2]

243. 9702_s15_qp_22 Q: 5

- (a) curved line showing decreasing gradient with temperature rise M1
- smooth line not touching temperature axis, not horizontal or vertical anywhere A1 [2]
- (b) (i) (no energy lost in battery because) no/negligible internal resistance B1 [1]

- (ii) $I = V/R$
 $= 8/15 \times 10^3$ or $1.6/3.0 \times 10^3$ or $2.4/4.5 \times 10^3$ or $12/22.5 \times 10^3$ C1
 $= 0.53 \times 10^{-3} \text{ A}$ A1 [2]
- (iii) p.d. across X = $12 - 8.0 - 3.0 \times 10^3 \times 0.53 \times 10^{-3}$ (= 2.4 V) C1
 $R_X = 2.4/(0.53 \times 10^{-3})$ C1
 or
 $R_{\text{tot}} = 12/0.53 \times 10^{-3}$ (= $22.5 \times 10^3 \Omega$) (C1)
 $R_X = (22.5 - 15.0 - 3.0) \times 10^3$ (C1)
 $4.5(2) \times 10^3 \Omega$ A1 [3]
- (iv) resistance decreases hence current (in circuit) is greater M1
 p.d. across X and Y is greater hence p.d across Z decreases A1
 or explanation in terms of potential divider:
 R_Z decreases so $R_Z/(R_X + R_Y + R_Z)$ is less (M1)
 therefore p.d. across Z decreases (A1) [2]

244. 9702_w15_qp_21 Q: 6

- (a) energy converted from chemical to electrical per unit charge B1 [1]
- (b) (i) current = $E/(R + r)$ C1
 $= 6.0/(16 + 0.5)$
 $= 0.36$ (0.364) A A1 [2]
- (ii) terminal p.d. = $(0.36 \times 16) = 5.8 \text{ V}$ or $(6 - 0.36 \times 0.5)$
 $= 5.8 \text{ V}$ A1 [1]
- (c) (i) use of $R = \rho l/A$ or proportionality with length and inverse proportionality with area or d^2 C1
 $d/2$ and $l/2$ gives resistance of Z = $2R_Y = 24 (\Omega)$ C1
 R = resistance of parallel combination = $[1/24 + 1/12]^{-1}$
 $= 8(0) (\Omega)$ A1 [3]
- (ii) resistance of circuit less therefore current larger B1
 lost volts greater therefore terminal p.d. less B1 [2]
- (d) power = $I^2 R$ or VI or V^2/R C1
 current in second circuit (= $6.0/12.5$) = 0.48 (A) B1
 ratio = $[(0.36)^2 \times 16] / [(0.48)^2 \times 12] = 0.75$ [0.77 if full s.f. used] B1 [3]

245. 9702_w15_qp_22 Q: 6

- (a) internal resistance causes lost volts B1
 p.d. across lamp is less than 12V, power is less than 48W B1 [2]
- (b) (i) greater lost volts or p.d. across cell/lamp reduced, less current in lamp B1 [1]
 (ii) p.d. across lamp/current in lamp decreases, hence resistance decreases B1 [1]

246. 9702_w15_qp_23 Q: 5

- (a) (i) resistance = V/I B1
 very high/infinite resistance at low voltages B1
 resistance decreases as V increases B1 [3]
- (ii) p.d. from graph 0.50(V) C1
 resistance = $0.5/(4.4 \times 10^{-3})$
 = 110 (114) Ω A1 [2]
- (b) (i) current (= $1.2/375$) = 3.2×10^{-3} A A1 [1]
- (ii) current in diode = 4.4×10^{-3} (A)
 total resistance = $1.2/4.4 \times 10^{-3} = 272.7$ (Ω) C1
 resistance of $R_1 = 272.7 - 113.6 = 160$ (159) Ω A1
- or
- p.d. across diode = 0.5V and p.d. across $R_1 = 0.7$ V (C1)
 resistance of $R_1 = 0.7/4.4 \times 10^{-3}$
 = 160 (159) Ω (A1) [2]
- (iii) power = IV or I^2R or V^2/R C1
 ratio = $(4.4 \times 0.5)/(3.2 \times 1.2)$
 or $[(4.4)^2 \times 114]/[(3.2)^2 \times 375]$
 or $[(0.5)^2 \times 375]/[114 \times (1.2)^2]$
 = 0.57 A1 [2]

247. 9702_s20_qp_21 Q: 5

	Answer	Mark
(a)(i)	$R = \rho L / A$	C1
	$A = (2.6 \times 10^{-8} \times 59) / 3.4 = 4.5 \times 10^{-7} \text{ m}^2$	A1
(a)(ii)	$I = 1.8 / 3.4$	A1
	$= 0.53 \text{ A}$	
(a)(iii)	$I = Anvq$	C1
	$v = 0.53 / (4.5 \times 10^{-7} \times 6.1 \times 10^{28} \times 1.60 \times 10^{-19})$	A1
	$= 1.2 \times 10^{-4} \text{ m s}^{-1}$	
(b)(i)	(cross-sectional) area/A is less	M1
	(I, n, e the same so) average drift speed is greater	A1
(b)(ii)	(area is less so) more resistance/R	M1
	(I is the same, so) more power/P	A1
	or	
	$(P = I^2 \rho L / A \text{ so}) P \propto 1 / A$	(M1)
	(A is less so) more P	(A1)
(c)(i)	180 Ω and 90 Ω resistors shown connected in parallel	B1
(c)(ii)	resistors connected in parallel labelled as 180 Ω and 90 Ω and the other resistor labelled as 30 Ω	M1
	V_{OUT} or 8.0 V labelled across the two resistors in parallel	A1

248. 9702_s15_qp_23 Q: 5

(a)	$R = \rho l / A$		C1	
	$= (5.1 \times 10^{-7} \times 0.50) / \pi(0.18 \times 10^{-3})^2 = 2.5 (2.51) \Omega$		M1	[2]
(b) (i)	resistance of CD = 8 $\times$ resistance of AB = 20 (Ω)		C1	
	circuit resistance = $[1/5.0 + 1/20]^{-1} = 4.0 (\Omega)$		C1	
	current = $V/R = 6.0/4.0$		C1	
	$= 1.5 \text{ A}$		A1	[4]
(ii)	power in AB = $I^2 R$	or power = V^2 / R	C1	
	$= (1.2)^2 \times 2.5 = 3.6 \text{ W}$	$= (3.0)^2 / 2.5 = 3.6 \text{ W}$	A1	[2]
(iii)	potential drop A to M = $1.25 \times 1.2 = 1.5 \text{ V}$		M1	
	potential drop C to N = 3.0 V			
	p.d. MN = 1.5 V		A1	[2]

249. 9702_w15_qp_22 Q: 5

- (a) (i) $I = V/R$ C1
 $(= 240/1500 =) 0.16\text{ A}$ A1 [2]
- (ii) $I_2 = 0.40 - 0.16 (= 0.24)$ C1
 $0.24(350 + R) = 240$
 $R = 650\Omega$ A1 [2]
- (iii) power = IV or I^2R or V^2/R C1
ratio = $(84 \times 0.24)/(88 \times 0.16)$
or $[(0.24)^2 \times 350]/[(0.16)^2 \times 550]$
or $(84^2/350)/(88^2/550)$
or $20.16/14.08$
 $= 1.4(3)$ A1 [2]
- (b) (i) p.d. across 350Ω resistor = 0.24×350
or p.d. across 550Ω resistor = 0.16×550 C1
 $V_{350} = 84\text{ (V)}$ and $V_{550} = 88\text{ (V)}$ gives $V_{AB} = 4.0\text{ V}$
or $V_{950} = 152\text{ (V)}$ and $V_R = 156\text{ V}$ gives $V_{AB} = 4.0\text{ V}$ A1 [2]
- (ii) p.d. across R increases or potential at B increases or V_{350} decreases hence V_{AB} increases B1 [1]

250. 9702_s20_qp_21 Q: 6

	Answer	Mark
(a)(i)	$E = \Delta V / \Delta d$	C1
	$E = (180 + 120) / (2.0 \times 10^{-2})$	A1
	$= 1.5 \times 10^4 \text{ N C}^{-1}$	
(a)(ii)	vertically downwards	B1
(b)(i)	number of protons = 92	A1
	number of neutrons = 146	A1
	number of electrons = 90	A1
(b)(ii)	$F = EQ$	C1
	$= 1.5 \times 10^4 \times 2 \times 1.60 \times 10^{-19}$	A1
	$= 4.8 \times 10^{-15} \text{ N}$	
(b)(iii)	number of α -particles = 2	A1
	number of β^- particles = 2	A1