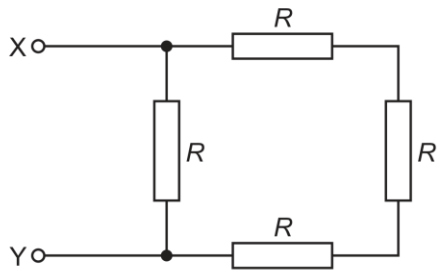
# 10. D.C. Circuits

## 10.2 Kirchhoff's laws

## Paper 1

Question Paper

**1** Four resistors, each of resistance $R$, are connected as shown.



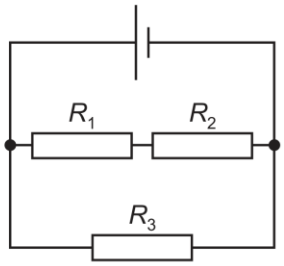

The total resistance between point X and point Y is 120 Ω.

What is the magnitude of the resistance $R$?

**A** 30 Ω **B** 90 Ω **C** 160 Ω **D** 480 Ω

**2** The diagram shows a circuit with a cell and three resistors with resistances $R_1$, $R_2$ and $R_3$.

The cell has negligible internal resistance.




The total resistance of the circuit is $R_T$.

Which equation for $R_T$ is correct?

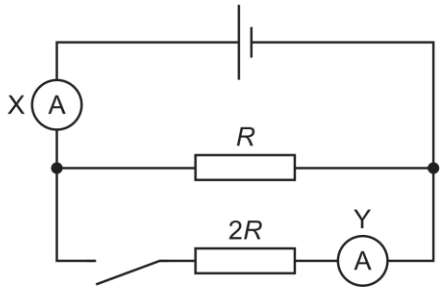
**A** $R_T = R_1 + R_2 + R_3$

**B** $R_T = \frac{1}{R_1 + R_2} + \frac{1}{R_3}$

**C** $\frac{1}{R_T} = \frac{1}{R_1 + R_2 + R_3}$

**D** $\frac{1}{R_T} = \frac{1}{R_1 + R_2} + \frac{1}{R_3}$

**3** The diagram shows a cell of negligible internal resistance connected to a switch and two resistors of resistances $R$ and $2R$.




The circuit also contains two ammeters X and Y.

The reading on X is 4.0 A when the switch is open.

What are the readings on X and Y after the switch is closed?

| | reading on X / A | reading on Y / A |
|---|---|---|
| **A** | 4.0 | 1.3 |
| **B** | 4.0 | 2.7 |
| **C** | 6.0 | 2.0 |
| **D** | 6.0 | 4.0 |

**4** Which description of Kirchhoff's first law is correct?

**A** It considers the currents at a junction in a circuit and is a consequence of the conservation of charge.

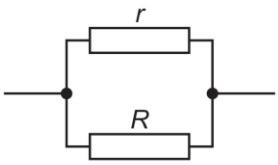
**B** It considers the currents at a junction in a circuit and is a consequence of the conservation of energy.

**C** It considers the electromotive forces and potential differences in a circuit loop and is a consequence of the conservation of charge.

**D** It considers the electromotive forces and potential differences in a circuit loop and is a consequence of the conservation of energy.

**5** Two resistors of resistances $r$ and $R$ are connected in parallel.

The value of $r$ is less than that of $R$.




Which statement about the combined resistance of the two resistors is correct?

**A** It is between $r$ and $R$.

**B** It is equal to $(r + R)$.

**C** It is greater than $(r + R)$.

**D** It is less than $r$.

**6** 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.

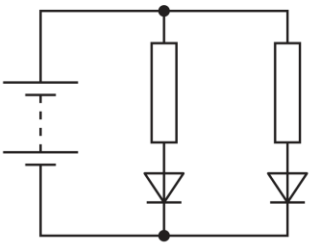
**C** The sum of the electric currents entering a point in an electric circuit is equal to the sum of the electric currents leaving that point.

**D** The sum of the potential differences in an electric circuit is equal to the sum of the products of the current and resistance.

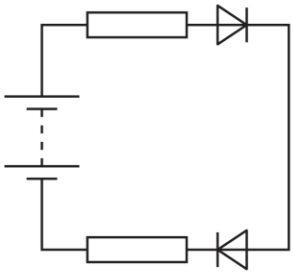
**7** In the circuits shown, the batteries are identical and all have negligible internal resistance. All of the resistors have the same resistance. The diodes have zero resistance when conducting and infinite resistance when not conducting.

In which circuit is the current in the battery greatest?

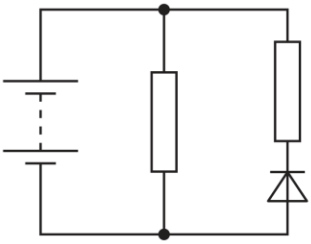
**A**



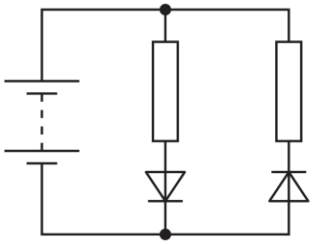
**B**



**C**



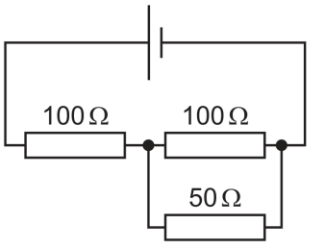
**D**



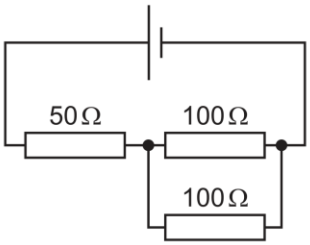
**8** Three resistors are connected to a cell of negligible internal resistance.

Which circuit has a combined resistance of 100 Ω?

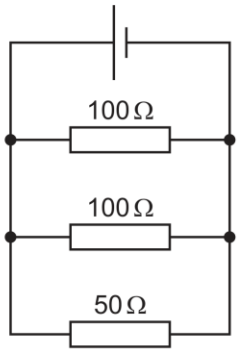
**A**



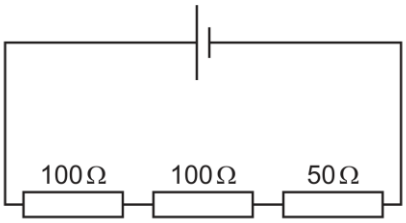

**B**




**C**




**D**




**9** Each of Kirchhoff's laws is a statement based on the conservation of a physical quantity.

Which quantity is conserved in each law?

| | Kirchhoff's first law | Kirchhoff's second law |
|---|---|---|
| **A** | charge | energy |
| **B** | energy | current |
| **C** | power | charge |
| **D** | resistance | power |

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

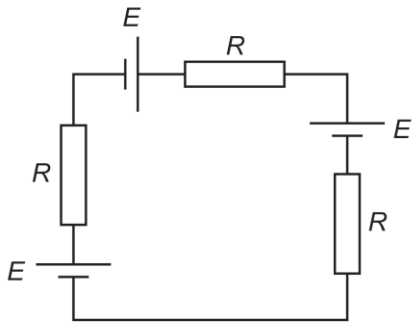
**A** charge

**B** energy

**C** momentum

**D** potential difference

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




What is the potential difference across one of the resistors?

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

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

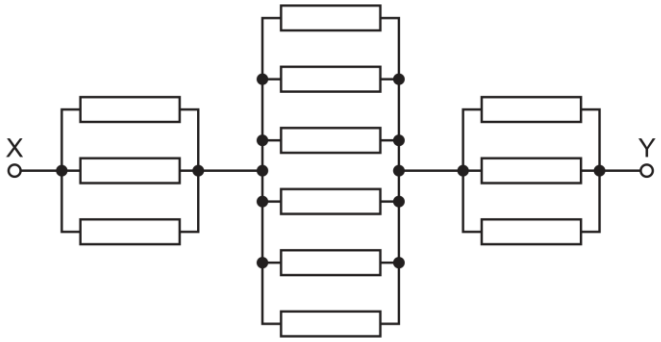
**A** charge and energy

**B** charge and resistance

**C** mass and energy

**D** mass and resistance

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




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

**A** 3.0 Ω **B** 5.0 Ω **C** 7.2 Ω **D** 18 Ω

**14** The sum of the currents entering a junction in an electrical circuit is always equal to the sum of the currents leaving the junction.

Why is this?

**A** It is a consequence of the conservation of charge.

**B** It is a consequence of the conservation of electromotive force.

**C** It is a consequence of the conservation of energy.

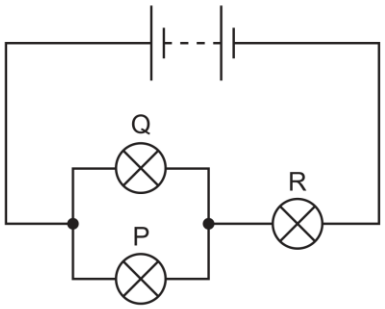
**D** It is a consequence of the conservation of potential difference.

**15** Kirchhoff's first and second laws are consequences of the conservation of different quantities.

What are those quantities?

| | Kirchhoff's first law | Kirchhoff's second law |
|---|---|---|
| **A** | charge | energy |
| **B** | energy | current |
| **C** | current | charge |
| **D** | energy | charge |

**16** Three identical filament lamps, P, Q and R, are connected to a battery of negligible internal resistance, as shown.

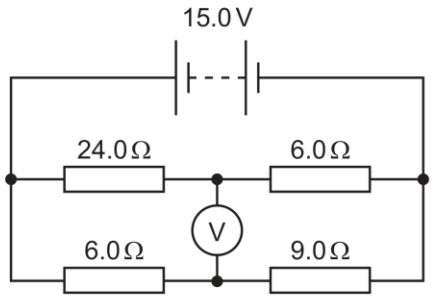



The filament wire in lamp Q breaks so that it no longer conducts.

What are the changes in the brightness of lamps P and R?

| | lamp P | lamp R |
|---|---|---|
| **A** | brighter | brighter |
| **B** | brighter | dimmer |
| **C** | dimmer | brighter |
| **D** | dimmer | dimmer |

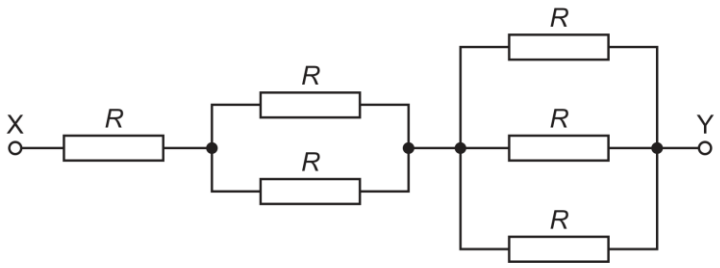
**17** A circuit consists of a battery, a high-resistance voltmeter and four fixed resistors, as shown. The battery has an electromotive force (e.m.f.) of 15.0 V and negligible internal resistance.




What is the reading on the voltmeter?

**A** 3.0 V **B** 6.0 V **C** 9.0 V **D** 12.0 V

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

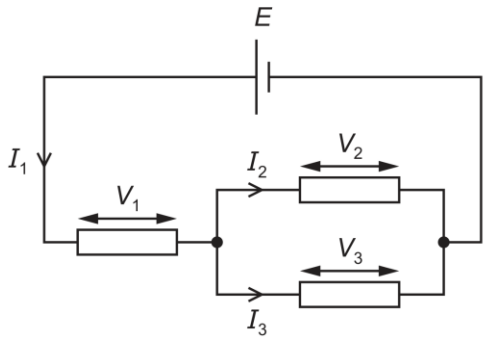



What is the total resistance of the network between points X and Y?

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

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

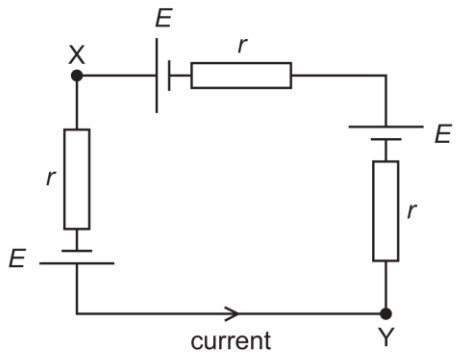
The circuit has currents $I_1$, $I_2$ and $I_3$, and potential differences $V_1$, $V_2$ and $V_3$, as shown.




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

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

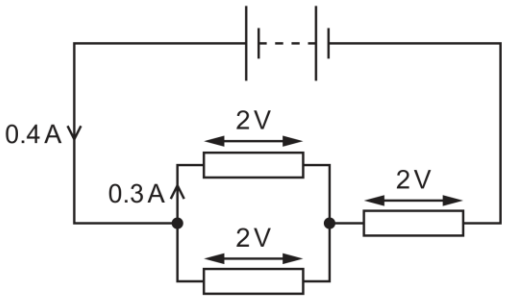
**20** Three identical cells, each of electromotive force (e.m.f.) $E$ and internal resistance $r$, are connected as shown.




What is the potential difference between points X and Y?

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

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




The potential difference across each resistor is 2 V.

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

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

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

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

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

What is the resistance of each individual resistor?

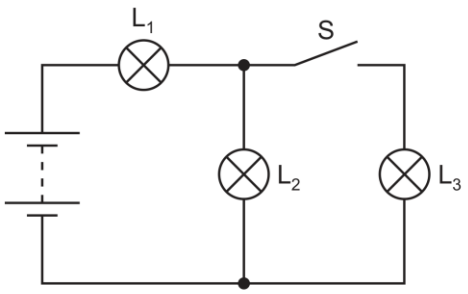
**A** 3.0 Ω **B** 6.0 Ω **C** 12 Ω **D** 18 Ω

**23** 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 |

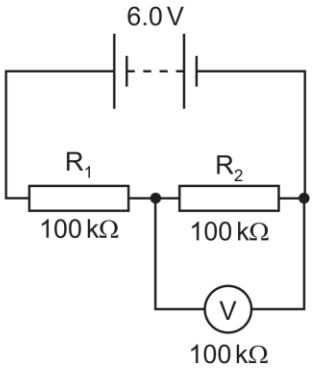
**24** Three identical lamps $L_1$, $L_2$ and $L_3$ are connected to a battery with negligible internal resistance, as shown.




What happens to the brightness of lamps $L_1$ and $L_2$ when the switch S is closed?

| | lamp $L_1$ | lamp $L_2$ |
|---|---|---|
| **A** | brighter | brighter |
| **B** | brighter | dimmer |
| **C** | dimmer | brighter |
| **D** | dimmer | dimmer |

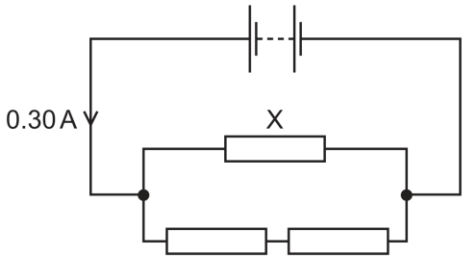
**25** In the circuit shown, the 6.0 V battery has negligible internal resistance. Resistors $R_1$ and $R_2$ and the voltmeter each have a resistance of 100 kΩ.




What is the current in the resistor $R_2$?

**A** 20 μA **B** 30 μA **C** 40 μA **D** 60 μA

**26** 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

**27** 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?

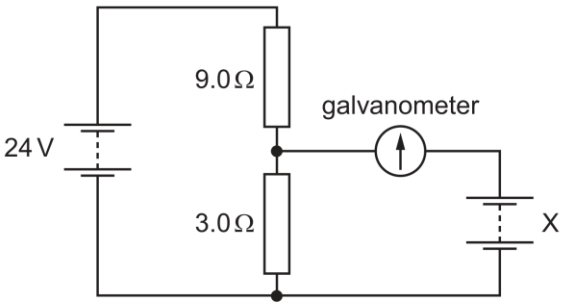
**A** charge

**B** energy

**C** mass

**D** momentum

**28** 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?

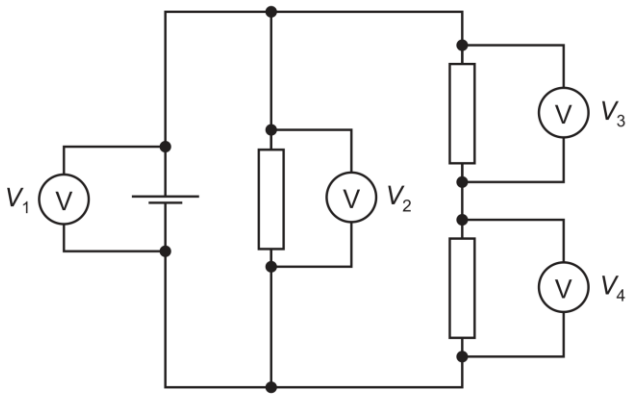
**A** 6.0 V **B** 8.0 V **C** 16.0 V **D** 18.0 V

**29** 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 |

**30** 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?

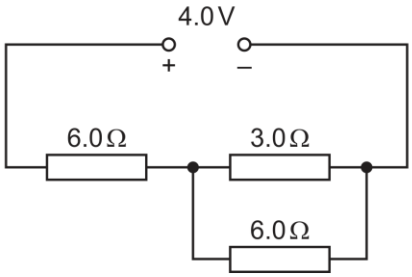
**A** $V_1 = V_2 + V_4$

**B** $V_1 = V_2 + V_3 + V_4$

**C** $V_2 + V_3 = V_4$

**D** $V_3 + V_4 - V_2 = 0$

**31** A network consists of a 3.0 Ω resistor and two 6.0 Ω resistors, as shown.

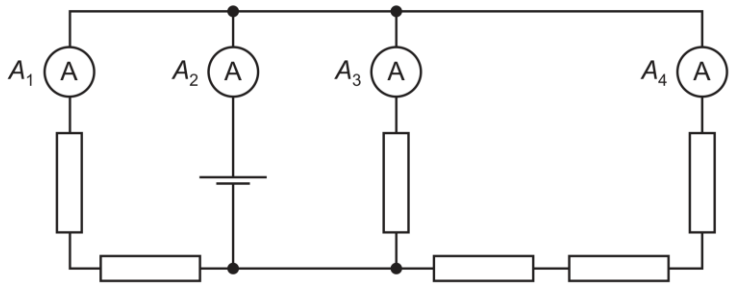



The potential difference (p.d.) across the network is 4.0 V.

What is the current through the 3.0 Ω resistor?

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

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

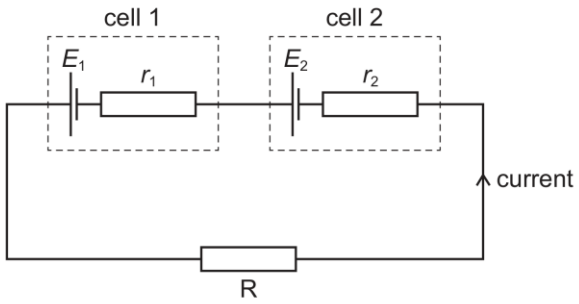



The reading $A_1$ is 0.6 A.

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 |

**33** 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.

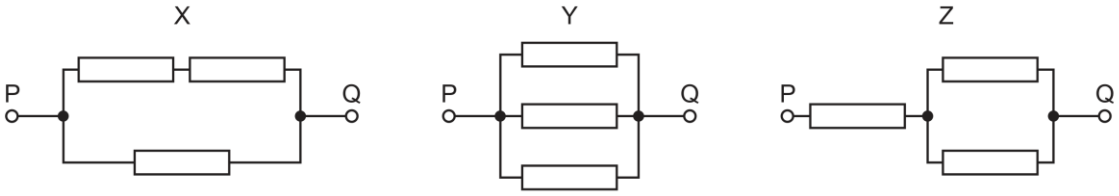



The terminal potential difference across cell 1 is zero.

Which expression gives the resistance of resistor R?

**A** $\frac{E_2r_1 - E_1r_2}{E_1}$ **B** $\frac{E_2r_1 - E_1r_2}{E_2}$ **C** $\frac{E_1r_2 - E_2r_1}{E_1}$ **D** $\frac{E_1r_2 - E_2r_1}{E_2}$

**34** 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 → Y → Z

**B** X → Z → Y

**C** Y → X → Z

**D** Y → Z → X

**35** 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?

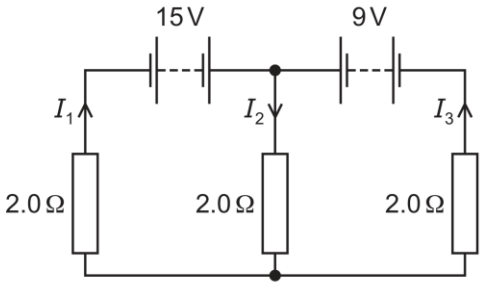
**A** This is Kirchhoff's first law, which results from the conservation of charge.

**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.

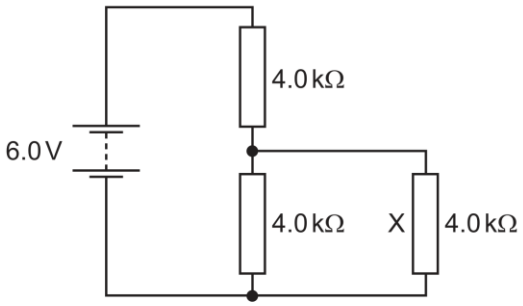
**36** In the circuit shown, the batteries have negligible internal resistance.




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 |

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



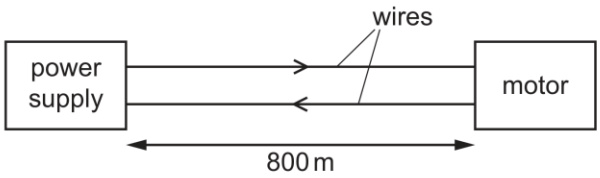

Each resistor has a resistance of 4.0 kΩ.

What is the current in resistor X?

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

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

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



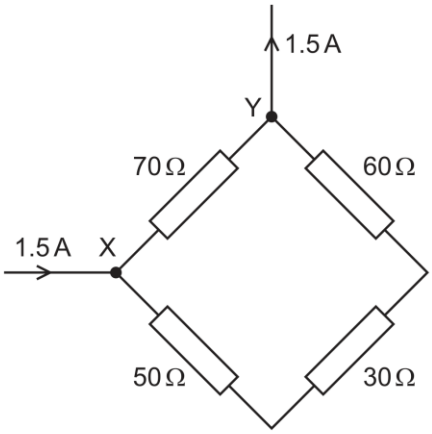

The resistance of each of these wires is 0.0050 Ω per metre.

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

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

**39** Four different resistors are arranged as shown.

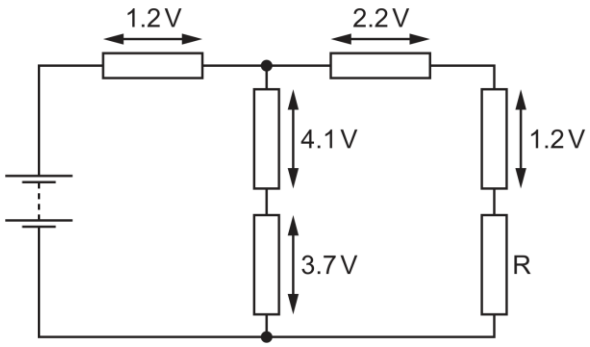
A current of 1.5 A enters the network at junction X and leaves through junction Y.




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

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

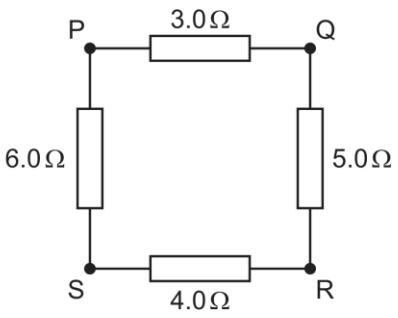



The potential differences across five of the resistors are labelled on the diagram.

What is the potential difference across resistor R?

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

**41** 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 |