# Current Electricity – 2023 June AS Physics 9702

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

The electric current in a metal wire is 4.0 mA.

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

**A** $2.5 \times 10^{17}$ **B** $2.5 \times 10^{20}$ **C** $9.0 \times 10^{20}$ **D** $9.0 \times 10^{23}$

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

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

**A** the charge per unit time passing through the component

**B** the energy transferred per unit charge

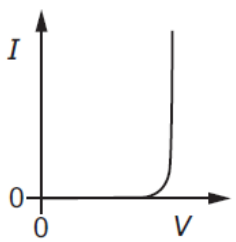
**C** the force per unit charge

**D** the resistance per unit current

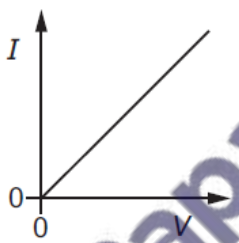
**3.** June/2023/Paper_ 9702/11/No.32

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

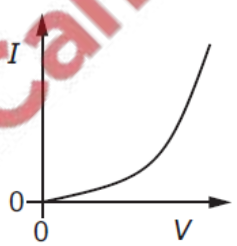
**A**



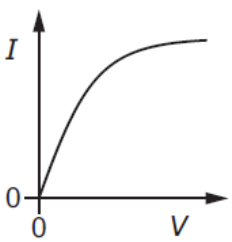

**B**




**C**




**D**




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

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

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

What is the change in the resistance of the wire?

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

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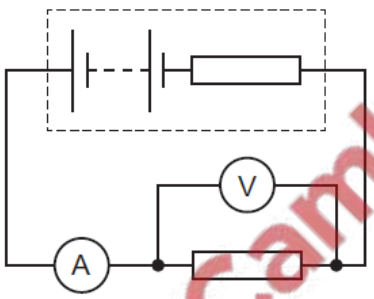
**5.** June/2023/Paper_ 9702/11/No.34

Which circuit symbol represents a microphone?


**6.** June/2023/Paper_ 9702/11/No.35

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




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

What happens to the readings on the ammeter and voltmeter?

| | ammeter reading | voltmeter reading |
|---|---|---|
| **A** | decreases | decreases |
| **B** | decreases | stays the same |
| **C** | stays the same | decreases |
| **D** | stays the same | stays the same |

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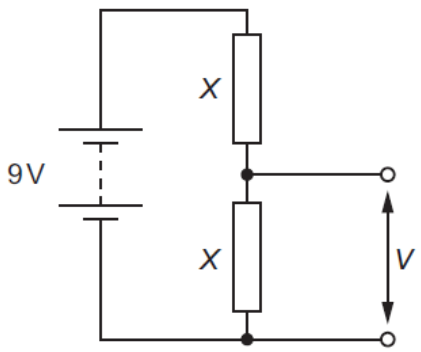
**7.** June/2023/Paper_ 9702/11/No.36

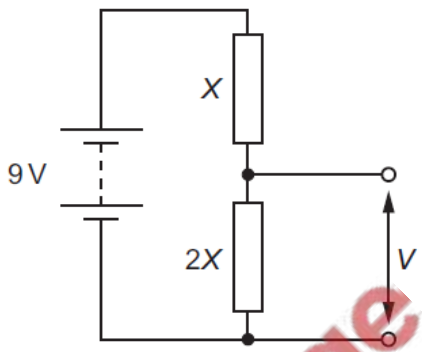
Four potential divider circuits each consist of a battery of electromotive force (e.m.f.) 9 V and negligible internal resistance connected to a combination of resistors. Each of the resistors in the circuits has a resistance of $X$ or $2X$.

Which circuit has the largest output voltage $V$?

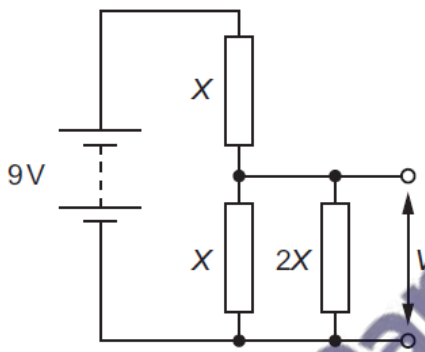
**A**



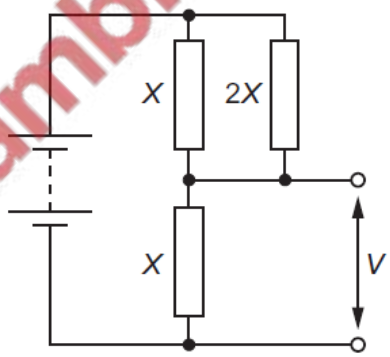

**B**




**C**




**D**

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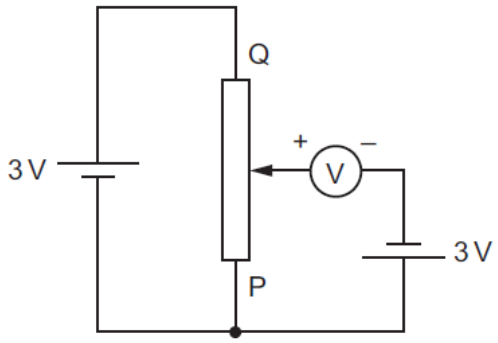
**8.** June/2023/Paper_ 9702/11/No.37

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




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

What are the two readings of the voltmeter?

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

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**9.** June/2023/Paper_ 9702/12/No.30

Which charge can be carried by a charge carrier?

**A** $1.1 \times 10^{-19}$ C

**B** $4.0 \times 10^{-19}$ C

**C** $4.8 \times 10^{-19}$ C

**D** $9.1 \times 10^{-19}$ C

**10.** June/2023/Paper_ 9702/12/No.31

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

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

**A** doubling the value of $E$

**B** doubling the value of $R$

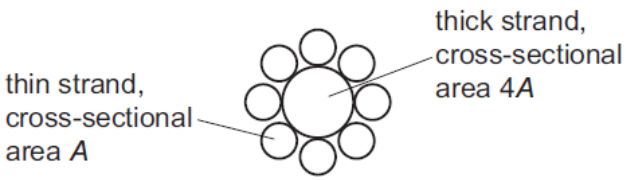
**C** halving the value of $E$

**D** halving the value of $R$

**11.** June/2023/Paper_ 9702/12/No.32

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

A cross-section of the cable is shown.




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

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

The cable has total resistance $R$.

Which expression gives the resistivity of copper?

**A** $\frac{4A}{33RL}$ **B** $\frac{12A}{RL}$ **C** $\frac{4AR}{L}$ **D** $\frac{12AR}{L}$

**12.** June/2023/Paper_ 9702/12/No.33

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

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

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

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

| | resistance of LDR | resistance of thermistor |
|---|---|---|
| **A** | increases | increases |
| **B** | increases | decreases |
| **C** | decreases | increases |
| **D** | decreases | decreases |

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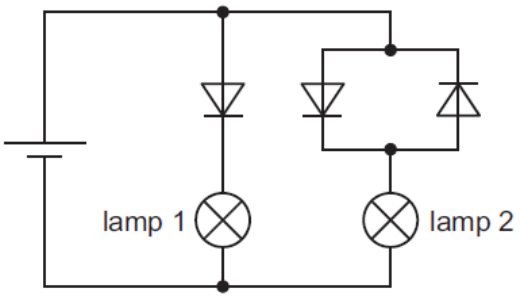
**13.** June/2023/Paper_ 9702/12/No.34

A student assembles the circuit shown.




Which row describes the state of the two lamps?

| | lamp 1 | lamp 2 |
|---|---|---|
| **A** | off | off |
| **B** | on | off |
| **C** | off | on |
| **D** | on | on |

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

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

**A** charge

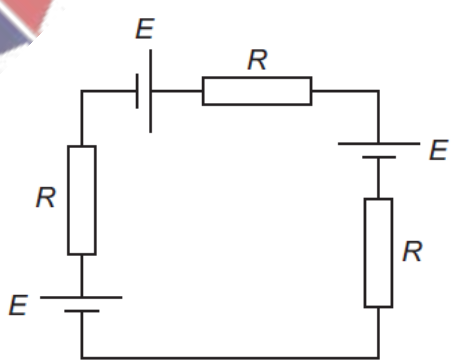
**B** energy

**C** momentum

**D** potential difference

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

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




What is the potential difference across one of the resistors?

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

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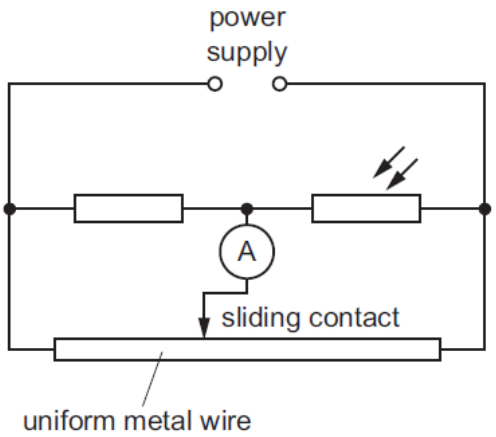
**16.** June/2023/Paper_ 9702/12/No.37

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




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

Which change could return the ammeter reading to zero?

**A** decreasing the supply voltage

**B** increasing the supply voltage

**C** moving the sliding contact to the left

**D** moving the sliding contact to the right

**17.** June/2023/Paper_ 9702/13/No.30

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

Which statement is correct?

**A** Negatively charged electrons in the wire move from the negative terminal to the positive terminal.

**B** Negatively charged nuclei in the wire move from the negative terminal to the positive terminal.

**C** Positively charged electrons in the wire move from the positive terminal to the negative terminal.

**D** Positively charged nuclei in the wire move from the positive terminal to the negative terminal.

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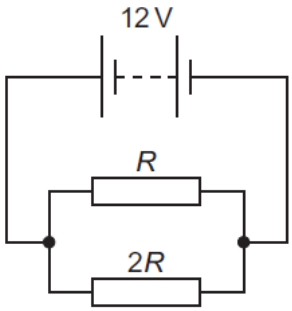
**18.** June/2023/Paper_ 9702/13/No.31

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




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

What is the value of $R$?

**A** 0.50 Ω **B** 2.7 Ω **C** 4.0 Ω **D** 6.0 Ω

**19.** June/2023/Paper_ 9702/13/No.32

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

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

What is the cross-sectional area of the wire?

**A** $1.2 \times 10^{-7}$ m$^2$

**B** $1.7 \times 10^{-7}$ m$^2$

**C** $1.1 \times 10^{-6}$ m$^2$

**D** $1.3 \times 10^{-5}$ m$^2$

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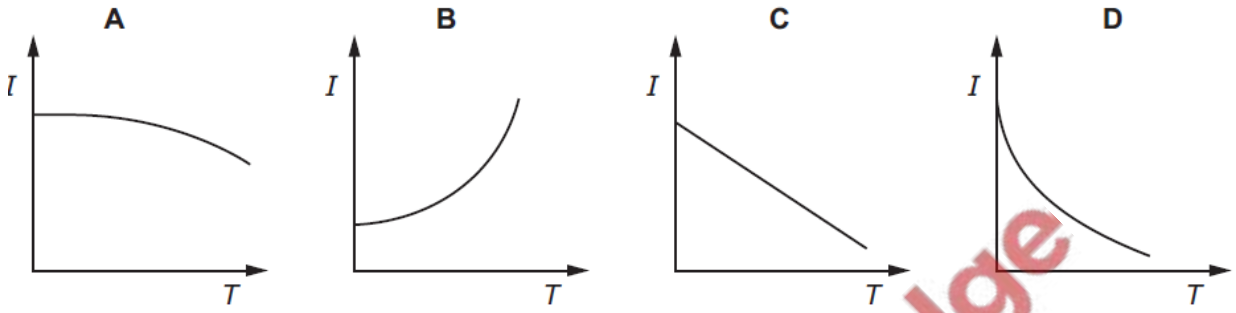
**20.** June/2023/Paper_ 9702/13/No.33

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

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

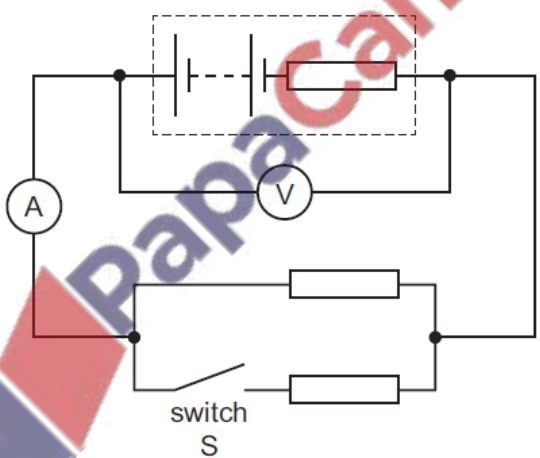
A graph of current $I$ against the temperature $T$ of the thermistor is plotted.

Which graph could show the variation of $I$ with $T$?




**21.** June/2023/Paper_ 9702/13/No.34

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




Initially, switch S is open.

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

| | voltmeter reading | ammeter reading |
|---|---|---|
| **A** | decreases | increases |
| **B** | decreases | decreases |
| **C** | increases | increases |
| **D** | increases | decreases |

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**22.** June/2023/Paper_ 9702/13/No.35

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

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

What is this physical quantity?

**A** charge

**B** energy

**C** mass

**D** momentum

**23.** June/2023/Paper_ 9702/13/No.36

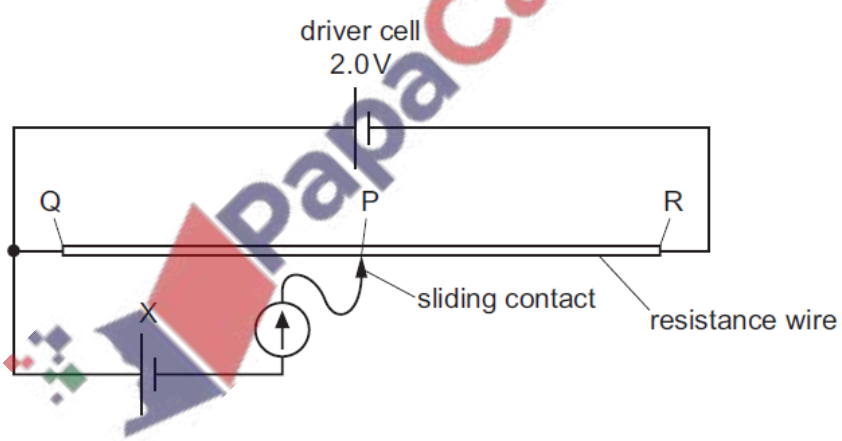
Two resistors have a combined resistance of 34 Ω when connected in series. The same resistors have a combined resistance of 7.4 Ω when connected in parallel.

What is the resistance of one of the resistors?

**A** 15 Ω **B** 17 Ω **C** 23 Ω **D** 27 Ω

**24.** June/2023/Paper_ 9702/13/No.37

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




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

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

What is an expression for the approximate length QP?

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

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**25.** June/2023/Paper_ 9702/21/No.6

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

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

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

[1]

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

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average drift speed = ..... $m\,s^{-1}$ [3]

[Total: 4]

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

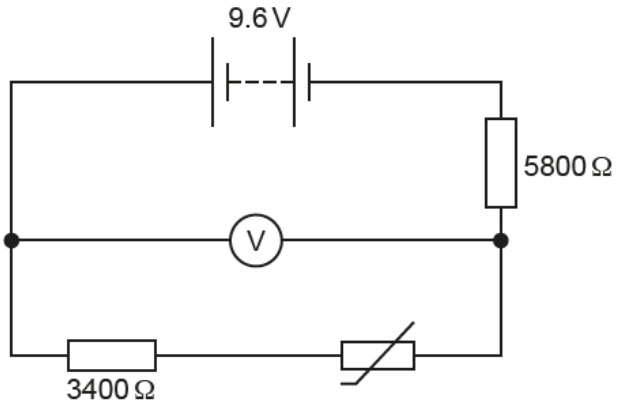


**Fig. 7.1**

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

**(a)** Calculate the current in the resistor of resistance 5800 Ω.

current = .....A [2]

**(b)** Calculate the resistance of the thermistor.

resistance = ..... Ω [2]

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

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

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

final stored energy = ..... J [2]

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

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

**(i)** the temperature of the thermistor

..... [1]

**(ii)** the current in the thermistor

..... [1]

**(iii)** the potential difference across the thermistor.

..... [1]

[Total: 9]

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

State and explain how the resistance of the lamp changes.

.....

..... [1]

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

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

**(i)** the current in the wire

current = ..... [1]

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

average drift speed = ..... [2]

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

time taken = ..... [1]

[Total: 5]

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

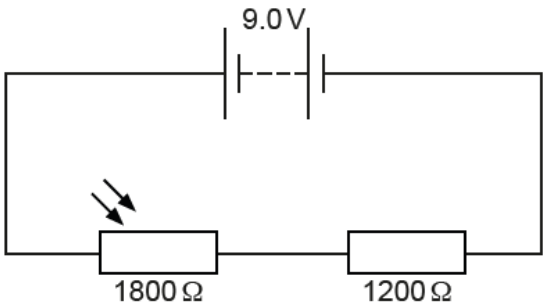


**Fig. 7.1**

The LDR and fixed resistor have resistances of 1800 Ω and 1200 Ω respectively.

Calculate the potential difference across the LDR.

potential difference = ..... V [2]

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

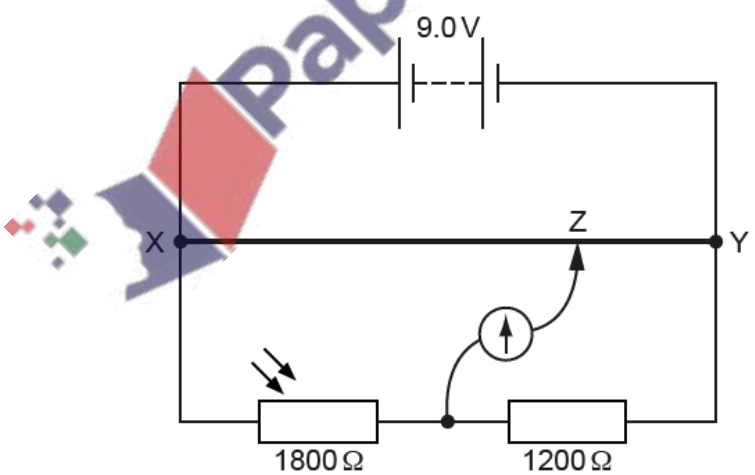


**Fig. 7.2** (not to scale)

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

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

length XZ = ..... m [2]

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

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

- the intensity of the light illuminating the LDR

.....

- the total power produced by the battery

.....

- the length XZ so that the galvanometer reads zero.

.....

[3]

[Total: 7]

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**29.** June/2023/Paper_ 9702/23/No.5

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

The battery has negligible internal resistance.

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

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

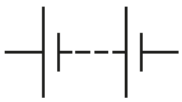

**Fig. 5.1**

[3]

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

The reading on the voltmeter is 4.8 V.

Calculate:

**(i)** the resistance of the heater

resistance = ..... Ω [2]

**(ii)** the reading on the ammeter.

reading on ammeter = ..... A [1]

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

The resistance of the LDR remains constant.

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

.....

.....

..... [2]

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

.....

.....

..... [2]

[Total: 10]

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**30.** March/2023/Paper_ 9702/12/No.30

A wire carries a current of 0.10 μA. The potential difference across the wire is 10 mV.

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

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

**31.** March/2023/Paper_ 9702/12/No.31

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

**A** energy transferred per unit charge

**B** energy transferred per unit current

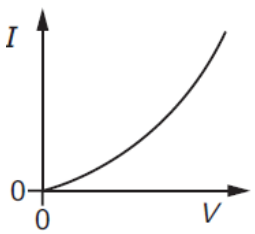
**C** energy transferred per unit resistance

**D** energy transferred per unit time

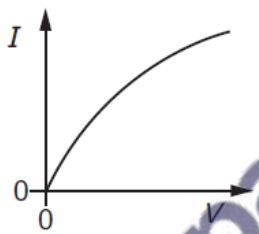
**32.** March/2023/Paper_ 9702/12/No.32

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

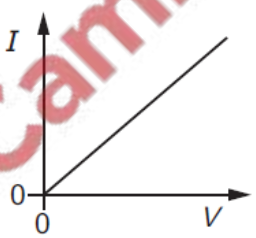
**A**



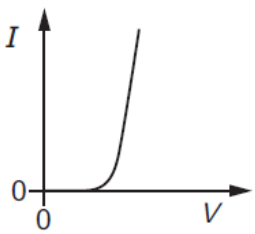

**B**




**C**




**D**




**33.** March/2023/Paper_ 9702/12/No.33

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

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

Wire P has a cross-section of diameter $d$.

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

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

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**34.** March/2023/Paper_ 9702/12/No.34

A cell has a constant electromotive force.

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

The resistance of the variable resistor is decreased.

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

**A** The terminal p.d. is decreased because more work is done moving unit charge through the internal resistance of the cell.

**B** The terminal p.d. is decreased because the current in the variable resistor is decreased.

**C** The terminal p.d. is increased because more work is done moving unit charge through the variable resistor.

**D** The terminal p.d. is increased because the current in the variable resistor is increased.

**35.** March/2023/Paper_ 9702/12/No.35

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

On which conservation laws do Kirchhoff's laws depend?

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

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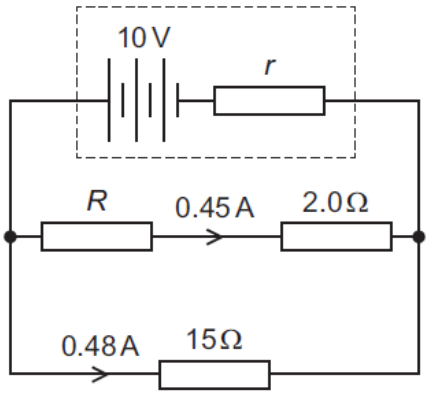
**36.** March/2023/Paper_ 9702/12/No.36

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




What are the values of $r$ and $R$?

| | $r$/Ω | $R$/Ω |
|---|---|---|
| **A** | 3.0 | 14 |
| **B** | 3.0 | 20 |
| **C** | 5.8 | 14 |
| **D** | 5.8 | 20 |

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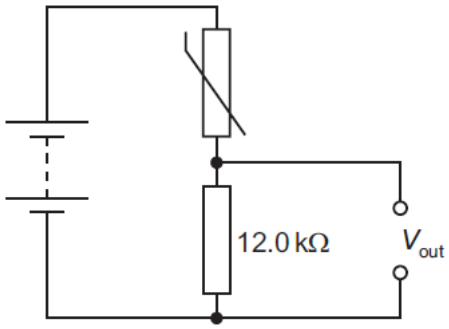
**37.** March/2023/Paper_ 9702/12/No.37

A battery of negligible internal resistance is connected in series with a thermistor and a fixed resistor of resistance 12.0 kΩ, as shown.




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

| temperature /°C | resistance of thermistor / kΩ |
|---|---|
| 20.0 | 12.0 |
| 50.0 | 5.00 |

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

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

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

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**38.** March/2023/Paper_ 9702/22/No.6

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

.....

..... [1]

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

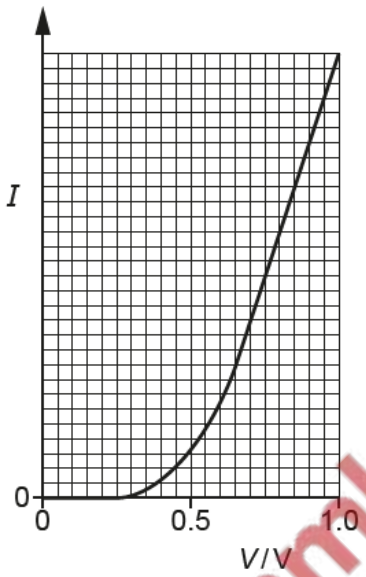


**Fig. 6.1**

Use Fig. 6.1 to describe qualitatively:

**(i)** the resistance of the diode in the range $V = 0$ to $V = 0.25\,V$

..... [1]

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

..... [1]

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

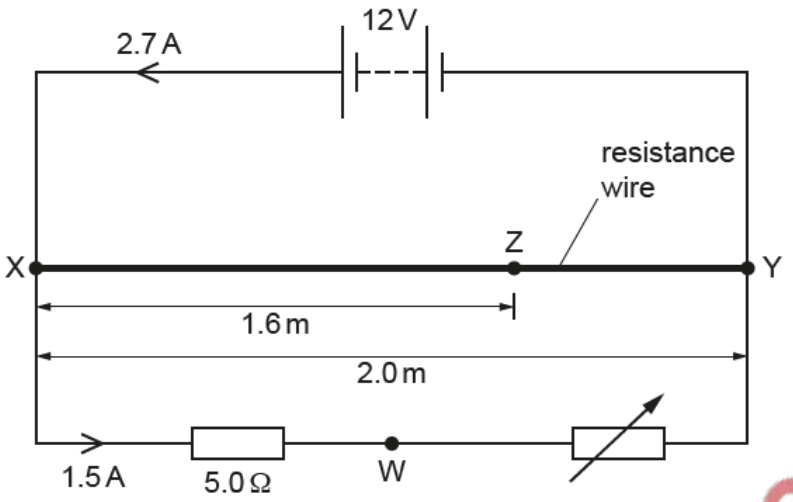


**Fig. 6.2** (not to scale)

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

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

current = .....A [1]

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

resistance = ..... Ω [2]

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

Determine the potential difference between points W and Z.

potential difference = ..... V [3]

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

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

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

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