Current Electricity – 2022 Nov AS Physics 9702

1. Nov/2022/Paper_11/No.2

A voltmeter connected across a resistor in a circuit reads 3.6 V.

What could be the current in the resistor and the resistance of the resistor?

	current	resistance
A	150 mA	0.24 kΩ
B	15 mA	2.4 kΩ
C	1.5 mA	0.24 MΩ
D	15 μA	240 kΩ

$V = IR$

$150 \times 10^{-3} \times 0.24 \times 10^{3} = 36\,V$

$15 \times 10^{-3} \times 2.4 \times 10^{3} = 36\,V$

$1.5 \times 10^{-3} \times 0.24 \times 10^{6} = 360\,V$

$15 \times 10^{-6} \times 240 \times 10^{3} = 3.6\,V$ ✓

2. Nov/2022/Paper_11/No.31

A length of wire RS has a circular cross-section.

At end R of the wire, the cross-sectional area is A.

At end S of the wire, the cross-sectional area is $\frac{A}{2}$.

Charge Q takes time t to pass through end R of the wire. There is a constant electric current in the wire.

How much charge will pass through end S in a time interval of $\frac{t}{4}$?

A $\frac{Q}{8}$ **B** $\frac{Q}{4}$ **C** $\frac{Q}{2}$ **D** Q

$I = \frac{Q}{t}$

If Q takes t time

Then at $\frac{t}{4} = \frac{Q}{4}$ ✓

3. Nov/2022/Paper_11/No.32

A power supply is connected to a component by connecting wires of total resistance 4.9 Ω.

The power supply has an output power of 3.6 W and a terminal potential difference of 12 V.

How much thermal energy is dissipated in the connecting wires in a time of 1.0 hour? (3600 s)

A 0.44 J **B** 29 J **C** 1.6 kJ **D** 11 kJ

$P = IV$, $I = P/V$; $I = \frac{3.6}{12} = 0.3\,A$; $E = P \times t = I^2 R \times t$; $E = (0.3)^2 \times 4.9 \times 3600 = 1587.6\,J \approx 1.6\,kJ$

4. Nov/2022/Paper_11/No.33

A copper wire is to be replaced by an aluminium alloy wire of the same length and resistance. Copper has half the resistivity of the alloy.

What is the ratio $\dfrac{\text{diameter of alloy wire}}{\text{diameter of copper wire}}$?

A $\sqrt{2}$ ✓ **B** 2 **C** $2\sqrt{2}$ **D** 4

d_c – diameter of copper wire

d_A – diameter of Al alloy

$R = \dfrac{\rho l}{\pi (\frac{d}{2})^2}$

Copper:

$R = \dfrac{\frac{1}{2}\rho \times l}{\pi \times (\frac{d_c}{2})^2} = \dfrac{\frac{1}{2}\rho \times l}{\frac{\pi \times d_c^2}{4}}$

Alloy:

$R = \dfrac{\rho \times l}{\frac{\pi \times d_A^2}{4}}$

Equilise:

$\dfrac{\rho \times l}{\frac{\pi \times d_A^2}{4}} = \dfrac{\frac{1}{2}\rho \times l}{\frac{\pi \times d_c^2}{4}}$

$\dfrac{1}{d_A^2} = \dfrac{\frac{1}{2}}{d_c^2}$

$\dfrac{d_A^2}{1} = \dfrac{d_c^2}{\frac{1}{2}} = 2d_c^2$

$\dfrac{d_A^2}{d_c^2} = 2$

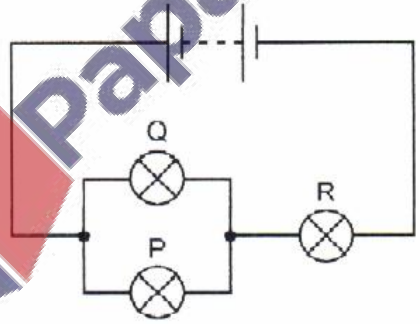
Take square root

$\sqrt{\dfrac{d_A^2}{d_c^2}} = \sqrt{2}$

$\dfrac{d_A}{d_c} = \sqrt{2}$

5. Nov/2022/Paper_11/No.34

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



- In parallel Q and P offer less resistance
- But when Q breaks resistance by P will increase to total circuit resistance

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

- Circuit becomes a series circuit when Q breaks.
- Since P and R are identical, then they share the battery voltage equally.
- So p-d for P increases, – brighter.
- p-d for R decreases – less brighter.

6. Nov/2022/Paper_11/No.35

Which ratio has the same units as electromotive force (e.m.f.)?

A charge per unit energy transferred

B charge per unit time

C energy transferred per unit charge

D energy transferred per unit time

e.m.f = V

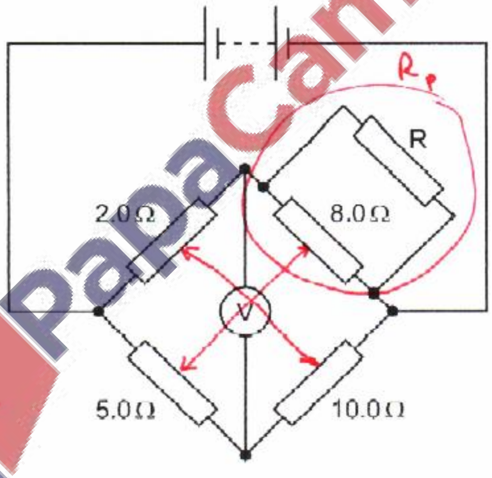
Voltage = Energy / Charge

V = J / C.

7. Nov/2022/Paper_11/No.36

A circuit consists of a battery, a voltmeter and five fixed resistors, as shown.

When voltmeter is zero, then the arrangement is called wheatstone bridge.
- So multiply opposite resistor and equalize them



$20 \times 10 = 5 \times R_p$

$20 = 5 R_p$

$R_p = \frac{20}{5} = 4\,\Omega$

but R_p is parallel.

$4 = \frac{8 \times R}{8 + R}$

$8R = 32 + 4R$

$8R - 4R = 32$

$4R = 32$

$R = 8\,\Omega$

The voltmeter reading is zero.

What is the resistance of resistor R?

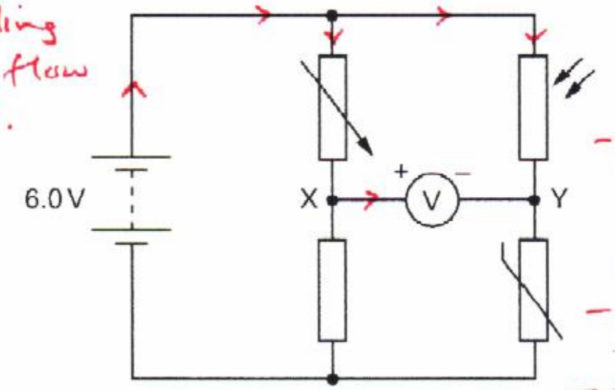
A 1.1Ω **B** 2.1Ω **C** 4.0Ω **D** 8.0Ω

8. Nov/2022/Paper_11/No.37

A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to a voltmeter and four other components, as shown.

The voltmeter is connected between points X and Y. The positive terminal of the voltmeter is connected to X and the negative terminal of the voltmeter is connected to Y.

For +ve reading current must flow from X to Y.



When LDR intensity decreases and its resistance increase.
- So more current will flow through variable resistor than the LDR
- So X will have more current than Y
- Hence current can flow from X to Y.

Initially, the resistance of each of the four components is 1.0 kΩ.

Which change, on its own, will cause the voltmeter to show a positive reading?

current need to move from X to Y.

A Decrease the temperature of the thermistor.

B Increase the resistance of the variable resistor.

(C) ✓ Reduce the intensity of light incident on the light-dependent resistor (LDR).

D Replace the fixed resistor with a 500 Ω resistor.

9. Nov/2022/Paper_12/No.31

A nichrome wire has a resistance of 15 Ω and a diameter of 3.0 mm. The number density of the free electrons in nichrome is $9.0 \times 10^{28}\,m^{-3}$.

A potential difference (p.d.) of 6.0 V is applied between the ends of the wire.

What is the average drift speed of the free electrons in the wire?

A $9.8 \times 10^{-7}\,m\,s^{-1}$

(B) ✓ $3.9 \times 10^{-6}\,m\,s^{-1}$

C $6.1 \times 10^{-6}\,m\,s^{-1}$

D $2.5 \times 10^{-5}\,m\,s^{-1}$

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

$I = \frac{V}{R} = \frac{6V}{15\Omega} = 0.4A$

$A = \pi r^2 = \pi \times (1.5 \times 10^{-3})^2$

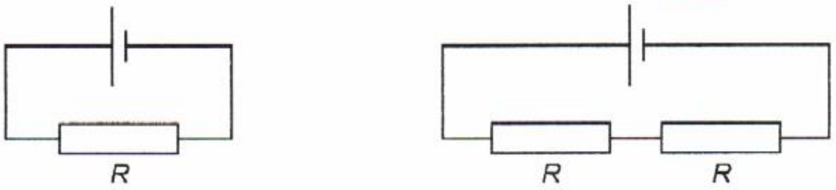
$v = \frac{0.4}{9.0 \times 10^{28} \times \pi \times (1.5 \times 10^{-3})^2 \times 1.6 \times 10^{-19}}$

$= 3.929 \times 10^{-6}\,ms^{-1}$

$= 3.9 \times 10^{-6}\,ms^{-1}$

10. Nov/2022/Paper_12/No.32

The diagrams show two different circuits.



The cells in each circuit have the same electromotive force (e.m.f.) and negligible 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** $2P$

11. Nov/2022/Paper_12/No.33

The potential difference (p.d.) across a filament lamp is increased.

Which statement is correct?

A The resistance of the lamp decreases because the temperature decreases.

B The resistance of the lamp decreases because the temperature increases.

C The resistance of the lamp increases because the temperature decreases.

D The resistance of the lamp increases because the temperature increases.

12. Nov/2022/Paper_12/No.34

A metal wire has resistance R.

The wire is stretched so that its diameter decreases to 94.0% of the original diameter.

The volume of the wire is unchanged.

What is the resistance of the stretched wire?

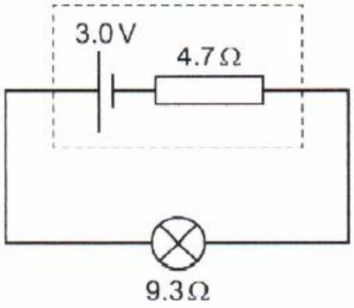
A 1.06R **B** 1.13R **C** 1.20R **D** 1.28R

13. Nov/2022/Paper_12/No.35

The diagram shows a cell of electromotive force (e.m.f.) 3.0 V and internal resistance 4.7 Ω connected across a lamp. The lamp has a resistance of 9.3 Ω.

$E = I(R + r)$

$I = \frac{E}{R + r} = \frac{3.0}{9.3 + 4.7} = 0.214\,A$



$P = I^2 R$

$= 0.214^2 \times 4.7$

$= 0.2152$

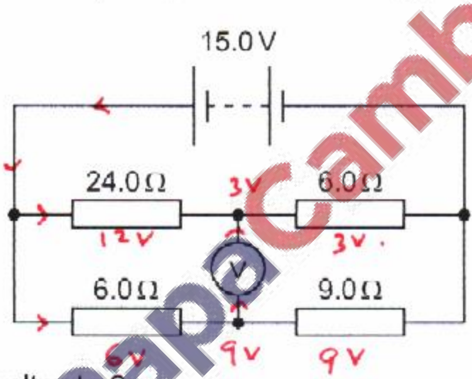
$\simeq 0.22\,W$

What is the power dissipated by the internal resistance of the cell?

A 0.22 W ✓ **B** 0.43 W **C** 0.64 W **D** 1.0 W

14. Nov/2022/Paper_12/No.36

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

Find voltage on each resistor using potential divider method.

$V = \frac{15 \times 24}{24 + 6} = 12\,V$

$15 - 12 = 3\,V$

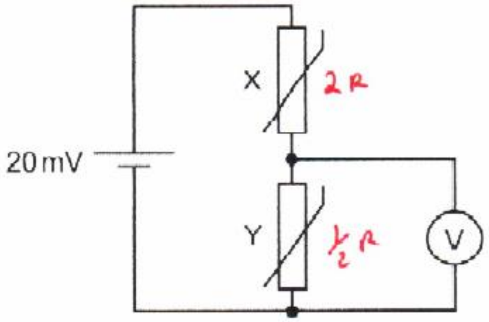
$V = \frac{6 \times 15}{6 + 9} = 6\,V$

$15 - 6 = 9\,V$

- The voltage at the junctions will be 3V and 9V respectively
- The different will be the voltmeter reading
  $9 - 3 = 6\,V$

15. Nov/2022/Paper_12/No.37

A potential divider circuit is designed to detect the difference in temperature between two different places.



$V = \frac{20 \times \frac{1}{2}R}{2R + \frac{1}{2}R} = \frac{10R}{\frac{5}{2}R} = \frac{20}{5}$

$V = 4\text{ mV}$

The cell has electromotive force (e.m.f.) 20 mV and negligible internal resistance.

Initially, thermistors X and Y are at the same temperature and have the same resistance. The voltmeter reads 10 mV. X is then placed in a cold environment and its resistance doubles. Y is placed in a warm environment and its resistance halves.

What is the new reading on the voltmeter?

A 4 mV **B** 5 mV **C** 15 mV **D** 16 mV

16. Nov/2022/Paper_13/No.30

There is an electric current in a copper wire.

Which statement describing the average drift speed of the charge carriers in the wire is correct?

A It is nearly $3 \times 10^8\text{ m s}^{-1}$.

B It is proportional to the cross-sectional area of the wire.

C It is proportional to the length of the wire.

D It is proportional to the magnitude of the current.

$I = Anvq$

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

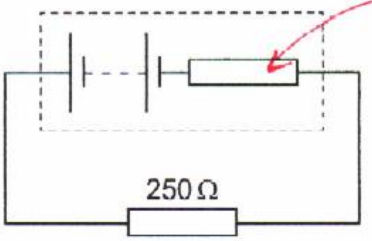
but nAq = constant

$\Rightarrow v = kI$

$\therefore v \propto I$

17. Nov/2022/Paper_13/No.31

A battery with a constant internal resistance is connected to a resistor of resistance 250 Ω, as shown.



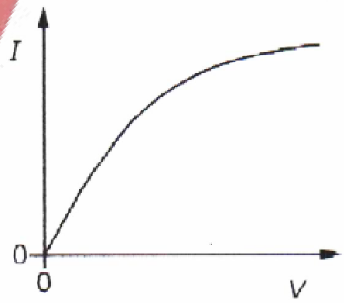
The current in the resistor is 40 mA for a time of 60 s. During this time 6.0 J of energy is dissipated by the internal resistance.

What is the energy supplied to the external resistor during the 60 s and the electromotive force (e.m.f.) of the battery?

	energy / J	e.m.f. / V
A	30	2.5
B	30	7.5
C	24	10.0
D	24	12.5

18. Nov/2022/Paper_13/No.32

Which component has the I–V graph shown?



A filament lamp

B metallic conductor at constant temperature

C resistor of fixed resistance

D semiconductor diode

19. Nov/2022/Paper_13/No.33

Two wires, P and Q, have the same resistance. Wire Q is made of material that has twice the resistivity of the material used to make wire P. The diameter of wire Q is twice the diameter of wire P.

What is the ratio $\dfrac{\text{length of wire P}}{\text{length of wire Q}}$?

A $\frac{1}{8}$ **B** $\frac{1}{4}$ **C** $\frac{1}{2}$ ✓ **D** $\frac{2}{1}$

$R_P = R_Q$.

$R_P = \dfrac{\rho \times l_P}{\pi \times \left(\frac{d}{2}\right)^2} = \dfrac{\rho \times l_P}{\pi \times \frac{d^2}{4}}$

$R_Q = \dfrac{2\rho \times l_Q}{\pi \times \left(\frac{2d}{2}\right)^2} = \dfrac{2\rho \times l_Q}{\pi \times d^2}$

$\dfrac{\rho \times l_P}{\pi \times \frac{d^2}{4}} = \dfrac{2\rho \times l_Q}{\pi \times d^2}$

$\dfrac{l_P}{1/4} = 2 l_Q$

$\dfrac{l_P}{l_Q} = 2 \times \dfrac{1}{4} = \dfrac{1}{2}$

20. Nov/2022/Paper_13/No.35

Each of Kirchhoff's laws is linked to the conservation of a physical quantity.

Which conserved physical quantities are used in the derivation of Kirchhoff's first law and of Kirchhoff's second law?

	Kirchhoff's first law	Kirchhoff's second law
A	energy	charge
B	energy	momentum
C ✓	charge	energy
D	momentum	energy

1st law:
Sum of currents into a junction is equal to sum of currents out of the junction.
Conservation of charge
charge not consumed.

2nd law:
Sum of emfs in a closed circuit is equal to sum of p.ds in the circuit

21. Nov/2022/Paper_13/No.36

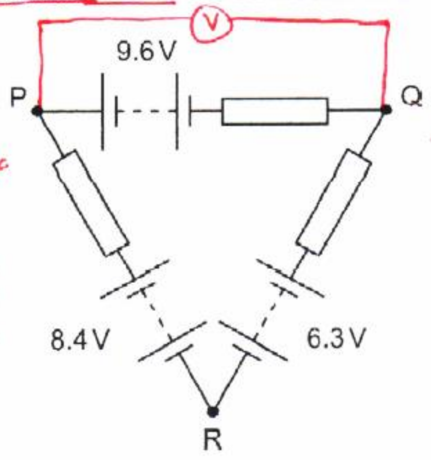
6 Three batteries and three identical resistors are connected in a circuit PQR, as shown.

Find the emf of battery

$e.m.f = 9.6 + 6.3 - 8.4$
$= 7.5\,V$

Since resistors are identical, find p.d across each resistor

$\frac{7.5}{3} = 2.5\,V$



If you connect a voltmeter across PQ, voltmeter reading will be

$9.6\,V - 2.5 = 7.1\,V$

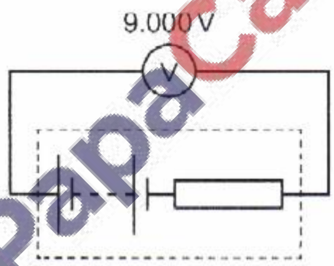
The batteries have negligible internal resistance.

What is the potential difference between points P and Q?

A 1.5 V **B** 2.1 V **C** 7.1 V **D** 12.1 V

22. Nov/2022/Paper_13/No.34

A voltmeter reads 9.000 V when it is connected across the terminals of a battery.



When a resistor of resistance 11.0 Ω is connected in parallel with the battery, the voltmeter reading changes to 8.800 V.

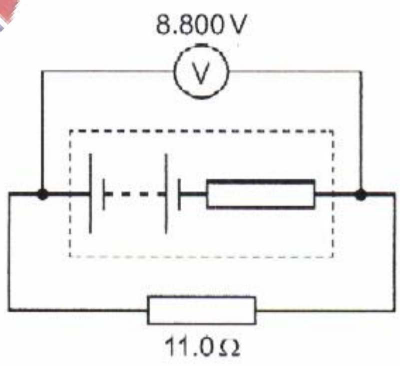
$E.m.f = 9.0\,V$

$E = IR + Ir$

$IR = V$

$E = V + Ir$

$\therefore V = 8.8\,V$



Calculate I in circuit

$I = \frac{V}{R}$
$= \frac{8.8}{11} = 0.8\,A$

$E = V + Ir$

$Ir = E - V$
$= 9 - 8.8$
$= 0.2\,V$

$r = \frac{V}{I} = \frac{0.2}{0.8}$
$= 0.25\,\Omega$

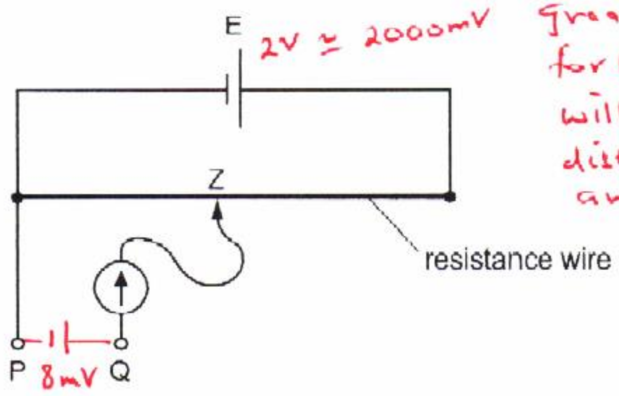
What is the internal resistance of the battery?

A 0.244 Ω **B** 0.250 Ω **C** 10.8 Ω **D** 11.3 Ω

23. Nov/2022/Paper_13/No.37

A cell E, of electromotive force (e.m.f.) 2 V and negligible internal resistance, is connected to a uniform resistance wire of resistance 10 Ω and length 1.0 m.

Since 2000mV is much greater than 8mV, for balance point will be a very small distance on the wire and difficult to measure precisely.



Z is a connection that may be made at any position along the resistance wire. A galvanometer is connected between Z and a point Q.

A new source of e.m.f. of approximately 8 mV is connected between points P and Q. The e.m.f. of the new source is determined by changing the position of Z until the reading on the galvanometer is zero.

Which change to the circuit allows a much more precise value for the e.m.f. of the new source to be obtained?

A Add a resistor of resistance 0.1 Ω in series with cell E.

B Add a resistor of resistance 1000 Ω in series with cell E. ✓

C Add a resistor of resistance 10 Ω in series with the new source.

D Add a resistor of resistance 800 Ω in series with the new source.

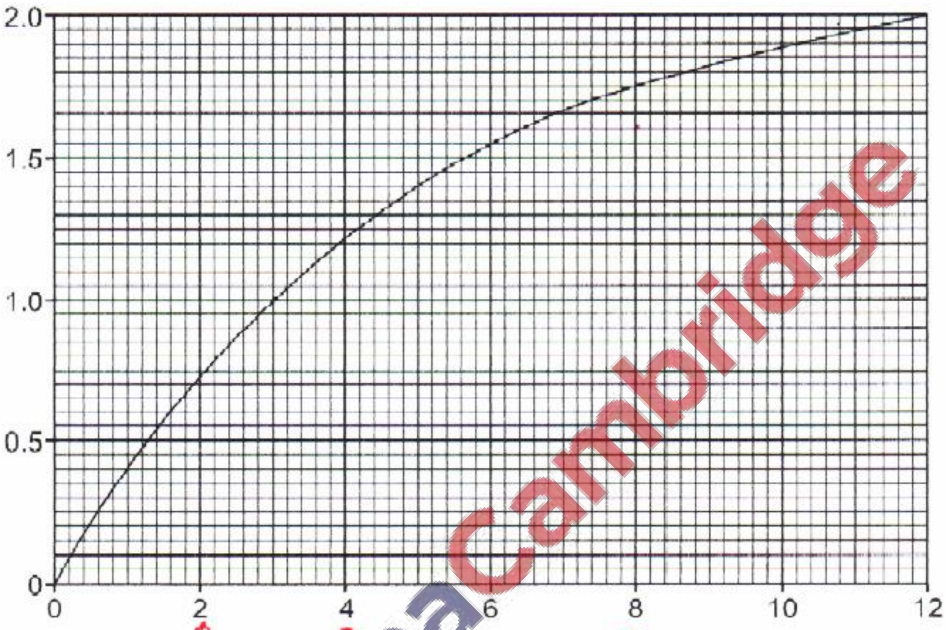
Adding a 1000Ω in series with cell E will reduce the voltage 2000mV closer to 8mV, hence comparable. – So distance will be longer on the wire to measure precisely.

24. Nov/2022/Paper_21/No.5

(a) State Ohm's law. $R = \frac{V}{I}$ $V = IR$ $V \propto I$, R constant.

Current through a conductor is directly proportional to potential difference across it provided temperature remains constant. [2]

(b) The variation of current I with potential difference V for a filament lamp is shown in Fig. 5.1.



$R = \frac{2}{0.7} = 2.857\,\Omega$ $R = \frac{4}{1.2} = 3.3\,\Omega$ $R = \frac{8}{1.75} = 4.57\,\Omega$

Fig. 5.1

The resistance of the filament lamp increases with potential difference. $R = \frac{V}{I}$

(i) State how Fig. 5.1 shows this.

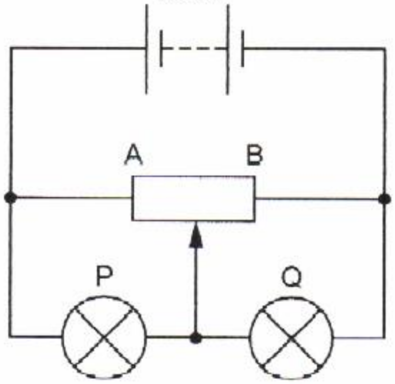
- the ratio of V/I increases as p.d increases.
- V/I = Resistance [1]

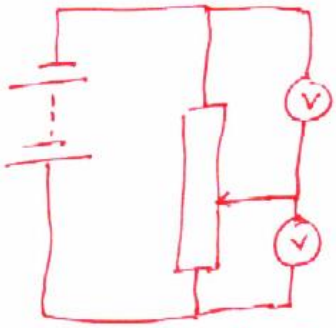
(ii) Explain why the resistance varies in this way.

- As p.d increase, current increases as well.
- This causes temperature to increase [1]
- Resistance will increase when temperature increases.

(c) Fig. 5.2 shows a circuit with a battery of electromotive force (e.m.f.) 12.0 V connected to a linear potentiometer AB and two identical filament lamps P and Q.

divide p.d btw the 2 lamps





Interpreted circuit.

Fig. 5.2

The battery has negligible internal resistance and the lamps each have the same I–V characteristic shown in Fig. 5.1.

When the slider of the potentiometer is at its midpoint, as shown in Fig. 5.2, the current I in the battery is 1.78 A.

Determine:

(i) the current in lamp P

At midpoint p.d across potentiometer = 6 V.

At p.d = 6.0 V, the current, I = 1.55 A

current = ... 1.55 .... A [1]

(ii) the total power dissipated in lamps P and Q

$P = V \times I$

$= (6 \times 1.55) \times 2$ (two lamps P & Q).

$= 19$ W

total power = ... 19 .... W [2]

(iii) the resistance of the potentiometer between its ends A and B.

$I = 1.78 - 1.55$

$= 0.23$ A

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

Voltage across the potentiometer = 12 V from end A to B.

$R = \frac{12\text{ V}}{0.23\text{ A}} = 52\ \Omega$

resistance = ... 52. .... Ω [2]

(d) The slider of the potentiometer in **(c)** is moved to end A.

State and explain the effect on the brightness of lamps P and Q.

lamp P: p.d across the lamp decreases to zero, so the lamp will go off.

lamp Q: p.d across the lamp increases to 12 V so lamp get brigter.

[2]

[Total: 11]

25. Nov/2022/Paper_22/No.6

(a) Define electric potential difference.

Is energy transferred per unit charge from electrical to other forms of energy. [1]

(b) A battery is connected to two resistors X and Y, as shown in Fig. 6.1.

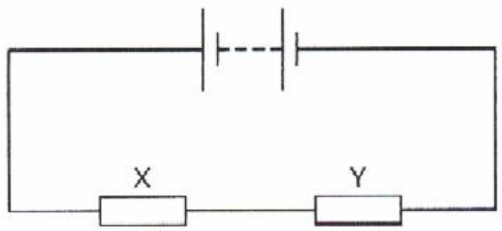


Fig. 6.1

$R_x > R_y$

The resistance of resistor X is greater than the resistance of resistor Y.

State and explain which resistor dissipates more power.

- Both resistors are in series, so same current flow through both.
- Power $= I^2 R$, and since R_x is greater than R_y, then more power will be dissipated on resistor X [3]

(c) A battery of electromotive force (e.m.f.) 9.0 V and internal resistance *r* is connected to two resistors P and Q, as shown in Fig. 6.2.

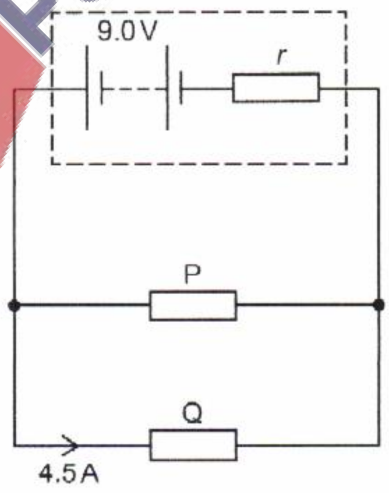


Fig. 6.2

A total charge of 650 C moves through resistor P in a time interval of 540 s. During this time resistor P dissipates 4800 J of energy. The current in resistor Q is 4.5A. Assume that the e.m.f. of the battery remains constant.

Calculate:

(i) the current in resistor P

$I = \frac{Q}{t}$

$= \frac{650\,C}{540\,s}$

$= 1.2\,A$

current = ...1.2...... A [2]

(ii) the potential difference across resistor P

Voltage = $\frac{\text{Energy}}{\text{charge}}$

$= \frac{4800\,J}{650\,C}$

$= 7.3846$

$\simeq 7.4\,V$

potential difference = ...7.4...... V [2]

(iii) the internal resistance *r* of the battery.

Find current, I through the cell

External = 4.5A + 1.2

= 5.7A

$E = I(R + r)$

$E = IR + Ir$

but $IR = V = 7.4$

$9.0 = 7.4 + (5.7 \times r)$

$5.7r = 9.0 - 7.4$

$= 1.6$

$r = \frac{1.6}{5.7} = 0.2807$

$\simeq 0.28\,\Omega$

r = ...0.28...... Ω [2]

[Total: 10]

26. Nov/2022/Paper_23/No.5

(a) State Kirchhoff's second law.

In a closed loop the sum of emf's is equal to the sum of p.d's.
(or algebraic sum of emf's and p.ds is zero). [2]

(b) Three identical cells, each of electromotive force (e.m.f.) 1.5 V and internal resistance 590 mΩ, are connected in parallel across a conductor, as shown in Fig. 5.1.

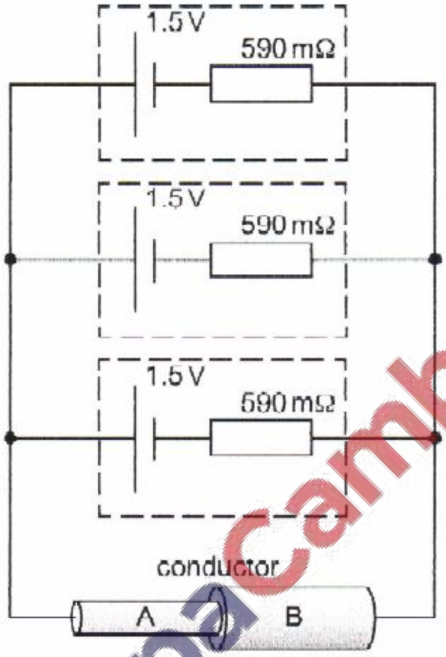


Fig. 5.1

The conductor is composed of two cylindrical sections A and B.
The total resistance of the circuit is 2.2 Ω.

(i) Show that the resistance of the conductor is 2.0 Ω.

$590\,m\Omega = 590 \times 10^{-3}\,\Omega = 0.59\,\Omega$.

$\frac{1}{r_T} = \frac{1}{590} + \frac{1}{590} + \frac{1}{590}$

$= \frac{1}{0.59} + \frac{1}{0.59} + \frac{1}{0.59}$

$\frac{1}{r_T} = 5.0847$

$r_T = \frac{1}{5.0847}$

$= 0.1966$

$\simeq 0.197\,\Omega$

$R_c = 2.2 - 0.197$

$= 2.0033$

$\simeq 2.0\,\Omega$ ✓

[2]

(ii) Calculate the current in the conductor.

$I = \frac{V}{R}$ Cells in parallel give p.d equal to that of one cell.

$= \frac{1.5}{2.2}$

$= 0.68\ A$

current = 0.68 A [2]

(c) The two cylindrical sections A and B of the conductor in Fig. 5.1 are made from the same material and have the same length.
The diameter of section A is 4.3 mm and the diameter of section B is 7.6 mm.
The resistance of section A is R_A and the resistance of section B is R_B.

(i) Calculate the ratio $\frac{R_A}{R_B}$.

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

Same length and resistivity

$\rho l = RA$

$R_A A_A = R_B A_B$

$\frac{R_A}{R_B} = \frac{A_B}{A_A}$

$A = \pi\left(\frac{d}{2}\right)^2$

$\therefore \frac{R_A}{R_B} = \frac{\pi \times \left(\frac{7.6}{2}\right)^2}{\pi \times \left(\frac{4.3}{2}\right)^2}$

$= 3.123$

$\simeq 3.1$

$\frac{R_A}{R_B}$ = 3.1 [3]

(ii) Calculate the ratio

$$\frac{\text{average drift speed of free electrons in section A}}{\text{average drift speed of free electrons in section B}}.$$

Explain your reasoning.

$I = nAvq$

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

but I, n, q are same in both sections

$\Rightarrow v = \frac{K}{A}$

$v_A = \frac{K}{A_A}$

$v_A A_A = k$

$v_B A_B = k$

$A = \pi r^2$

$\Rightarrow v_A A_A = v_B A_B$

$\frac{v_A}{v_B} = \frac{A_B}{A_A} = \frac{\pi \times \left(\frac{7.6}{2}\right)^2}{\pi \times \left(\frac{4.3}{2}\right)^2} = 3.1$

ratio = 3.1 [2]

(d) The circuit of Fig. 5.1 is altered by removing one of the cells.

State and explain the effect, if any, of this change on the potential difference across the conductor.

- The combined resistance of the two cell will be greater than previous 3 cells.
- There will be more lost volts (Ir) in the Cells so the p.d across the resistor conductor will be less.

[3]

[Total: 14]

[2]