

**Current electricity - 2018**

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

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

$$I = Anvq$$

$I$  - current

$A$  - cross-sectional area

$n$  - number of  $e^-$  per unit volume

$v$  - drift velocity

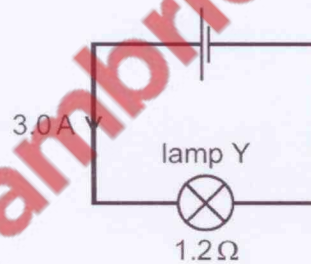
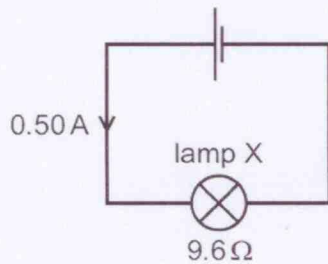
$q$  - charge in  $e^-$ 's.

What does the symbol  $n$  represent?

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

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

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



$$P = I^2 R$$

$$\frac{P_x}{P_y} = \frac{0.5^2 \times 9.6}{3.0^2 \times 1.2} = 0.2222$$

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

- A 0.22**
- B 0.75
- C 1.3
- D 4.5

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

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

What is its new resistance?

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

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

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

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

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

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

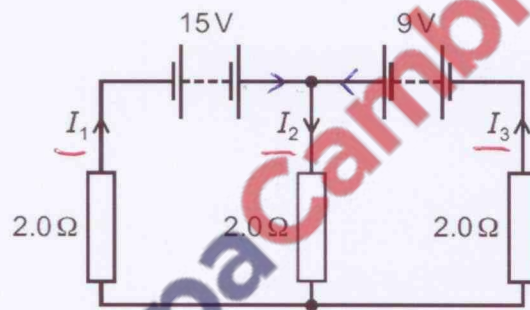
The sum of the electrical currents into a point in a circuit is equal to the sum of the currents out of the point.

Which statement is correct?

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

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

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



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

	$I_1/A$	$I_2/A$	$I_3/A$
A	-5.5	1.0	6.5
B	0.5	4.0	3.5
<input checked="" type="radio"/> C	3.5	4.0	0.5
D	6.5	1.0	-5.5

$$I_2 = I_1 + I_3$$

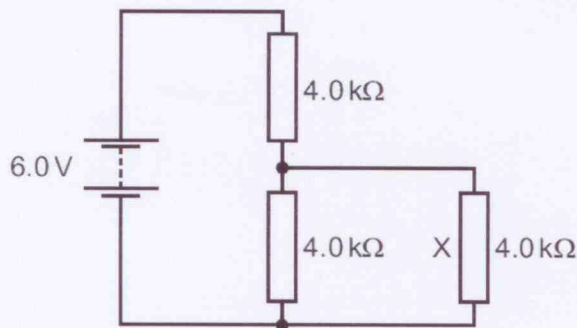
$$I_1 > I_3$$

$$I_2 > I_1$$

$$I_2 > I_3$$

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

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



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

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

$$I_x = \frac{V}{R} = \frac{2 \text{ V}}{4000 \Omega}$$

$$= 0.0005$$

$$= \underline{\underline{0.5 \text{ mA}}}$$

Each resistor has a resistance of 4.0 kΩ.

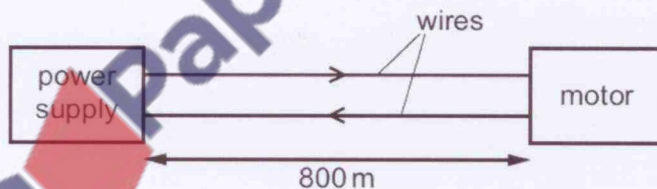
What is the current in resistor X?

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

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

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

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



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**

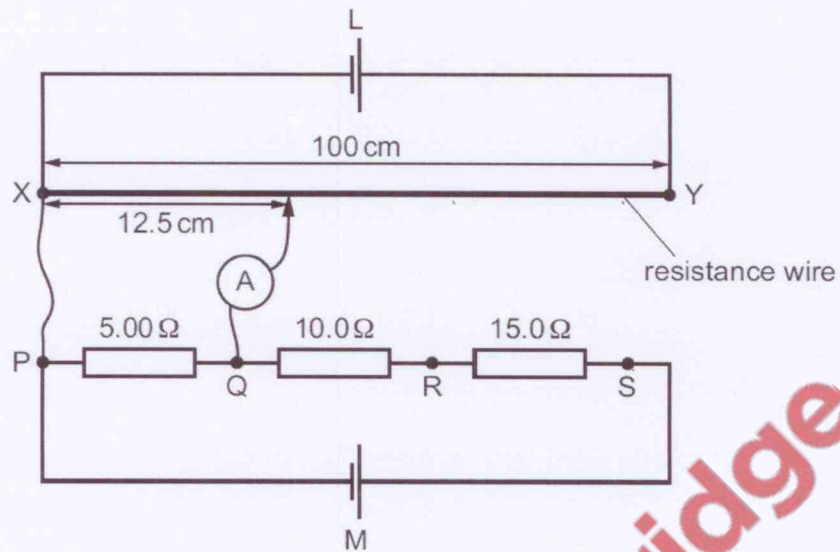
$$\begin{aligned} \text{Total Resistance} &= (0.005 \times 800) \times 2 \\ &= 8 \Omega \end{aligned}$$

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

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

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

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



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

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

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

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

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

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

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

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

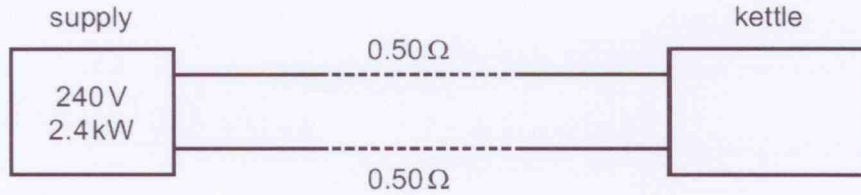
$$x = 62.5 \text{ cm}$$

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

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

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

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



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

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

Handwritten calculations:

$$P = VI$$

$$I = \frac{P}{V} = \frac{2400 \text{ W}}{240 \text{ V}} = 10 \text{ A}$$

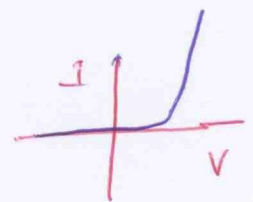
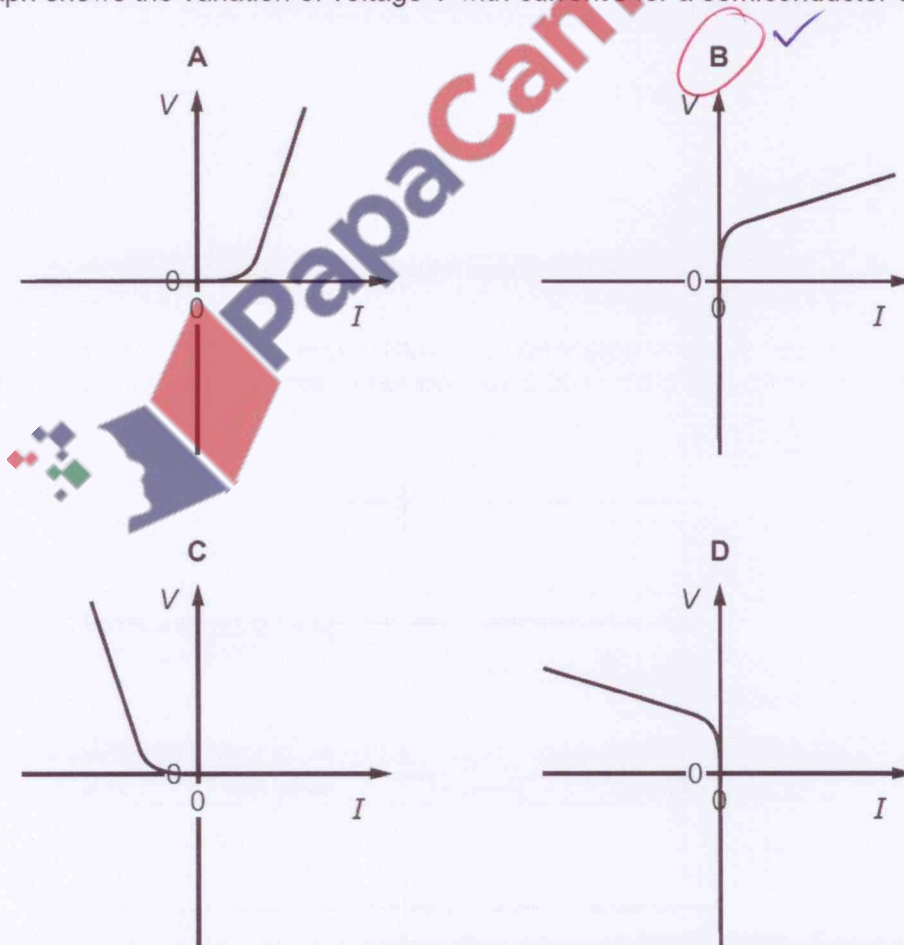
$$V_{\text{drop}} = 10 \text{ A} \times (0.5 \times 2) \Omega = 10 \text{ V}$$

$$V_{\text{kettle}} = 240 - 10 = 230 \text{ V}$$

$$P_{\text{kettle}} = 230 \times 10 = 2300 \text{ W} = 2.3 \text{ kW}$$

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

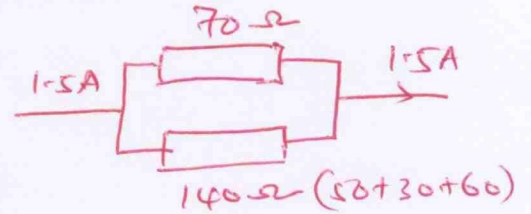
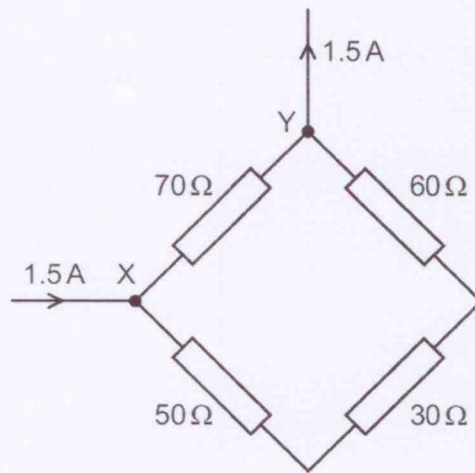
Which graph shows the variation of voltage  $V$  with current  $I$  for a semiconductor diode?



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

Four different resistors are arranged as shown.

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



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

$$V = IR = 1.5 \text{ A} \times 46.7 \Omega = 70 \text{ V}$$

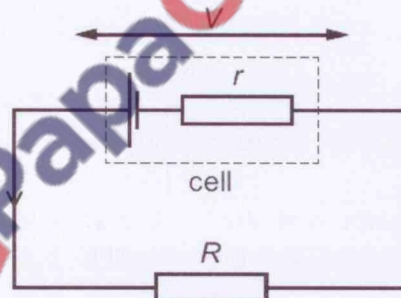
$$I = \frac{70 \text{ V}}{140 \Omega} = 0.5 \text{ A}$$

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

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

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

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



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

	$V$	$I$
<b>A</b>	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

$$V = E - Ir$$

If  $r$  increases, the  $Ir$  increases  
So  $V$  decreases

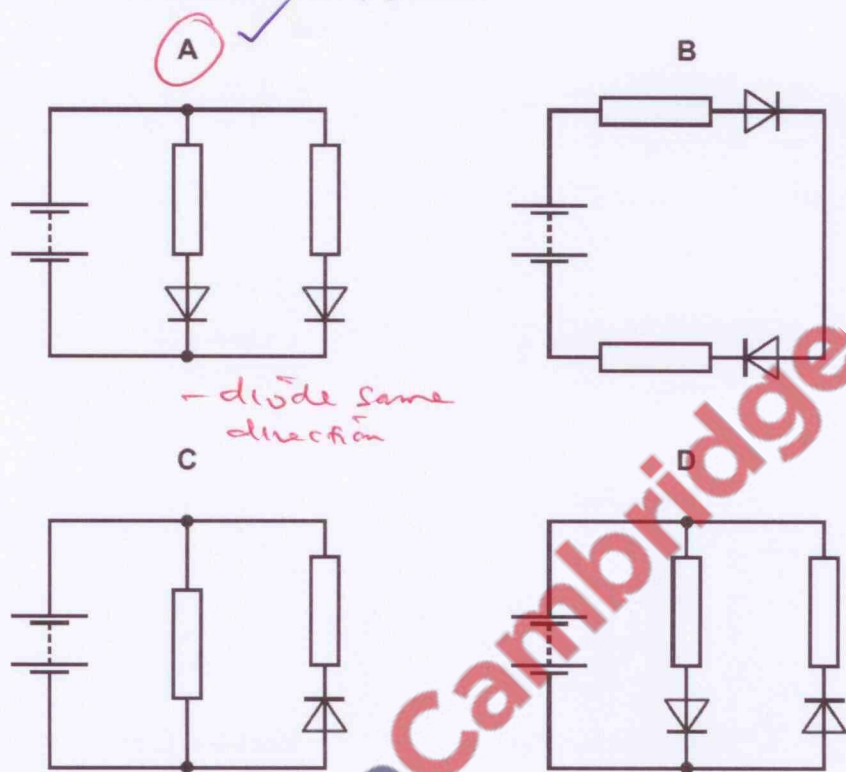
$$E = IR + Ir = I(R + r)$$

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

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

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

In which circuit is the current in the battery greatest?



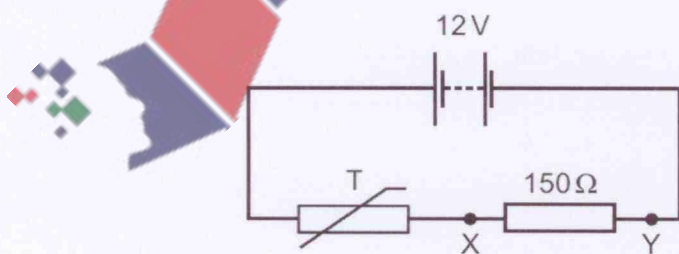
- diode same direction

- parallel resistors have a combined resistance which is lower.

- More I flows when resistance is small.

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

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



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

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

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

$$150 + T = 400$$

$$T = 400 - 150 = 250 \Omega$$

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

A 90  $\Omega$

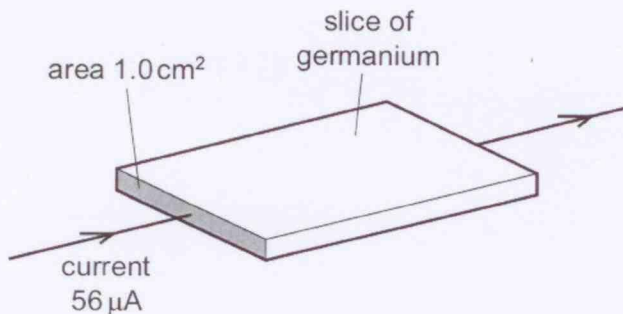
B 150  $\Omega$

C 250  $\Omega$

D 400  $\Omega$

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

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



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

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

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

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

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

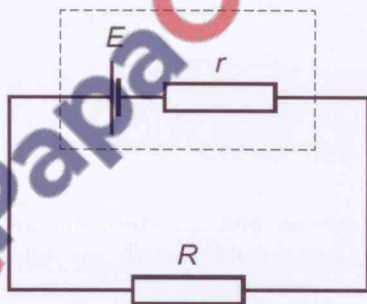
- A  $0.18\text{ ms}^{-1}$      B  $18\text{ ms}^{-1}$      C  $180\text{ ms}^{-1}$      D  $1800\text{ ms}^{-1}$

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

$$\approx \underline{\underline{0.18 \text{ m/s}}}$$

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

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



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

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

$$P = I^2 R$$

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

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

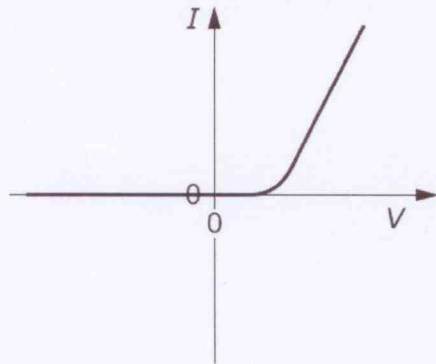
What is the power dissipated in the external resistor?

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



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

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



What is the component?

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

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

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

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

What is the resistance of the wire?

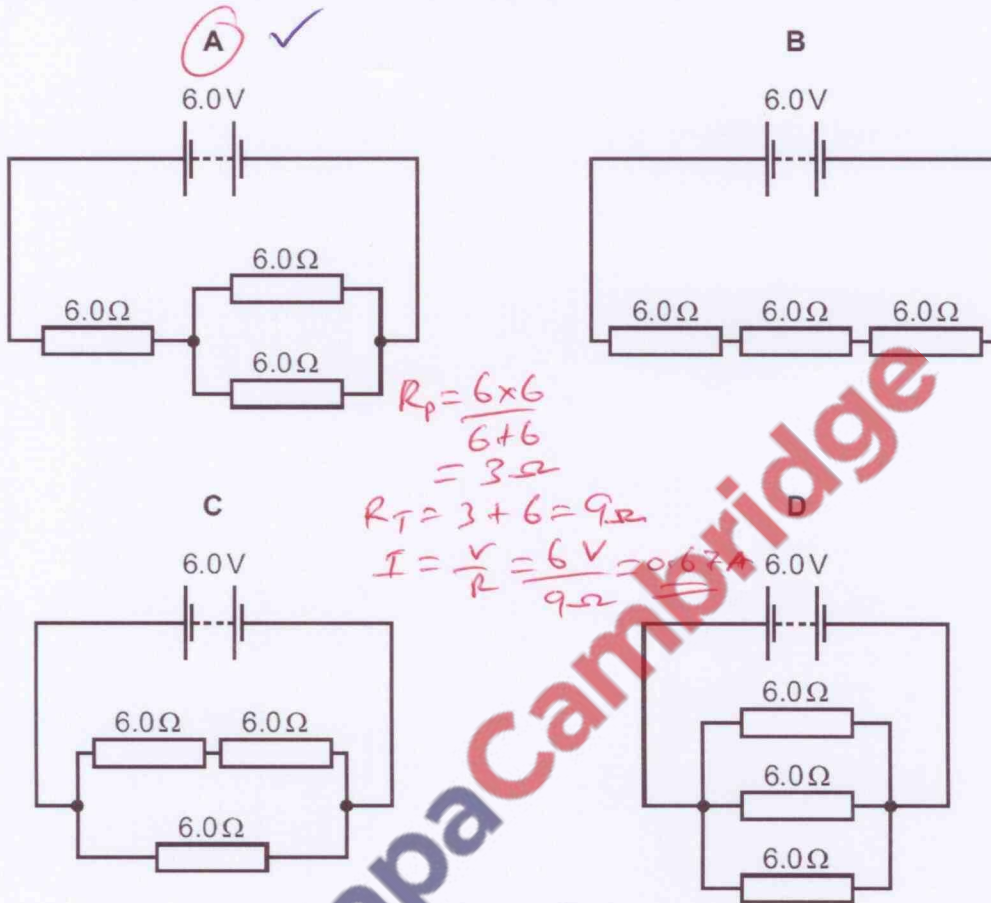
- A  $0.016 \Omega$
- B  $0.031 \Omega$
- C  $33 \Omega$
- D  $64 \Omega$

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

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

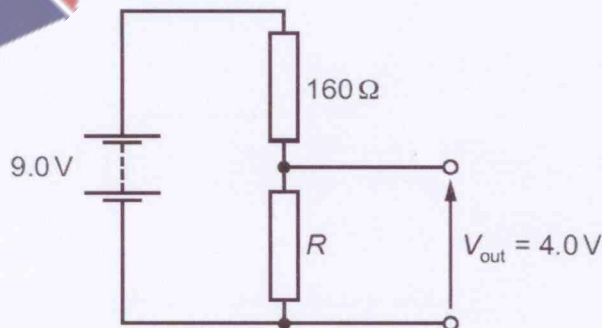
A battery of electromotive force (e.m.f.) 6.0V and negligible internal resistance is connected to three resistors each of resistance 6.0Ω.

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



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



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

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

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

$$640 + 4R = 9R$$

$$640 = 9R - 4R$$

$$640 = 5R$$

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

What is the resistance R?

A 32Ω

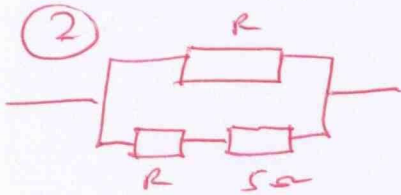
B 49Ω

C 71Ω

D 128Ω

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

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



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

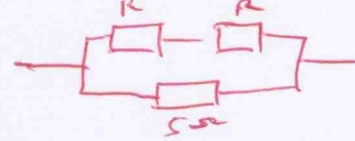
$$= \frac{2.5^2 \times (5 \times 2.5)}{(2 \times 2.5) + 5} = \frac{18.75}{10}$$

$$= 1.875 \Omega$$

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

① - draw parallel resistors of the arrangement

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



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

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

$$10R = 5R + 12.5$$

$$5R = 12.5$$

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

The resistance between Y and Z is found to be  $2.5\Omega$ .

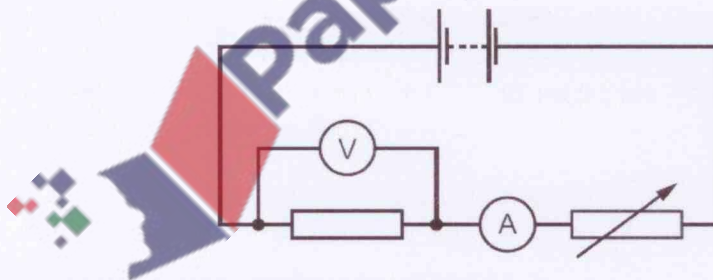
What is the resistance between X and Y?

- A  $0.30\Omega$       B  $0.53\Omega$       **C  $1.9\Omega$**       D  $3.3\Omega$

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

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

A voltmeter is connected across the fixed resistor.



The resistance of the variable resistor is reduced.

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

	ammeter	voltmeter
A	decrease	decrease
B	decrease	increase
C	increase	decrease
<b>D</b>	increase	increase

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

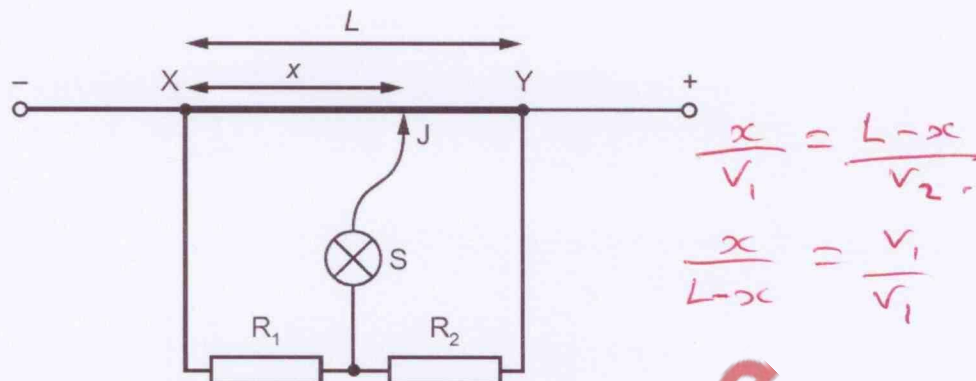
- so current increases

$$V \propto I$$

- so voltage also increases.

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

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



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

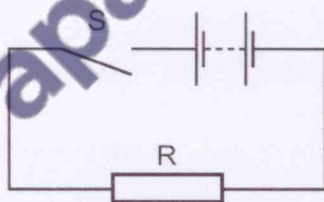
The potential difference across  $R_1$  is  $V_1$  and the potential difference across  $R_2$  is  $V_2$ .

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

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

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

The diagram shows a simple circuit.



Which statement is correct?

- A When switch S is closed, the e.m.f. of the battery falls because work is done against the internal resistance of the battery.
- B When switch S is closed, the e.m.f. of the battery falls because work is done against the resistance of R.
- C When switch S is closed, the potential difference across the battery falls because work is done against the internal resistance of the battery.
- D When switch S is closed, the potential difference across the battery falls because work is done against the resistance of R.

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

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

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

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

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

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

D  $R = \frac{V}{P}$

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

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

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

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

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

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

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

What is the length of the wire?

A 1.20 m

B 4.80 m

C 19.0 m

D 76.8 m

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

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

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

$\approx 1.200088394$

$\approx 1.20 \text{ m}$

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

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

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

A current per unit of cross-sectional area

B potential difference per unit of length

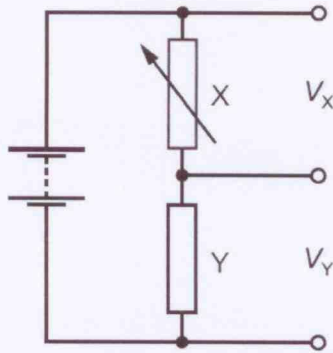
C resistance and cross-sectional area

D resistivity and length

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

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

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



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

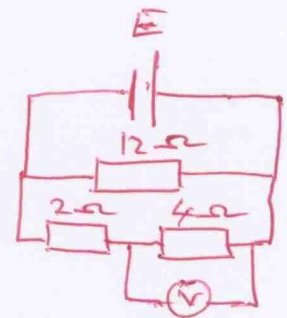
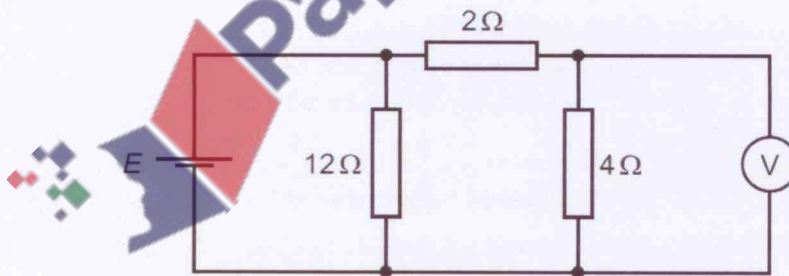
As the resistance of X is increased, what happens to  $V_X$  and to  $V_Y$ ?

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

*- high resistance has high  $V_{out}$*

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

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



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

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

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

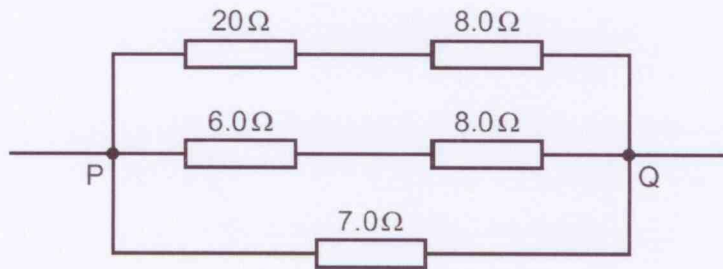
*- voltage (p.d) across parallel resistors is same as the p.d of cell (E).*

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

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

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

Five resistors are connected as shown.



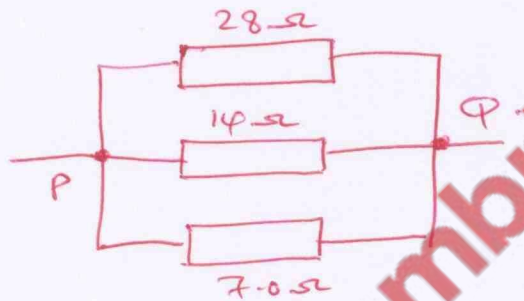
What is the total resistance between points P and Q?

A  $0.25\Omega$

B  $0.61\Omega$

C  $4.0\Omega$

D  $16\Omega$



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

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

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

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