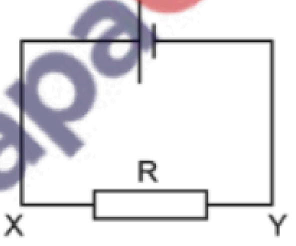
1.

The current in the circuit shown is 3.2 mA.



What are the direction of flow and the rate of flow of electrons through the resistor R?

	direction of flow	rate of flow / s^{-1}
A	X to Y	2.0×10^{16}
B	X to Y	5.1×10^{-22}
C	Y to X	2.0×10^{16}
D	Y to X	5.1×10^{-22}

Ans: C

Rate of flow of electrons = current / charge on 1 electron

2.

The number density of free electrons in copper is $8.0 \times 10^{28}\,m^{-3}$.

A copper wire has diameter 0.42 mm.

What is the average drift speed of the free electrons in the wire when the current in the wire is 0.57 A?

A $8.0 \times 10^{-11}\,m\,s^{-1}$

B $3.2 \times 10^{-10}\,m\,s^{-1}$

C $8.0 \times 10^{-5}\,m\,s^{-1}$

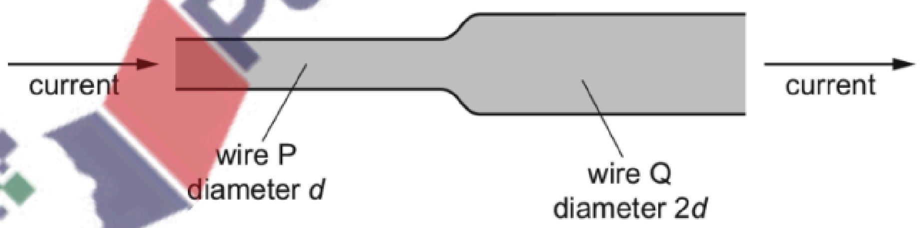
D $3.2 \times 10^{-4}\,m\,s^{-1}$

$$\frac{0.57}{8 \times 10^{28} \times \pi \left(\frac{0.42}{2} \times 10^{-3}\right)^2 \times 1.6 \times 10^{-19}} = 3.2 \times 10^{-4}$$

NOTE: coulomb = the charge passing a point in 1 second when there is a current of 1 ampere.

3.

Two copper wires are joined together and carry a current, as shown.



Wire P has diameter d and wire Q has diameter $2d$.

What is the ratio $\dfrac{\text{average drift speed of the free electrons in wire P}}{\text{average drift speed of the free electrons in wire Q}}$?

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

Ans: D

- When area increases, drift speed decreases
- Diameter is doubled so area is quadrupled

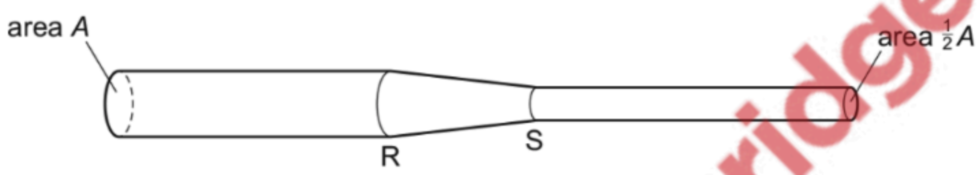
NOTE:

n = number of charge carriers <u>per unit volume</u> of wire

nA = number of charge carriers <u>per unit length</u> of wire

4.

A length of wire is connected into a circuit.



The area of the cross-section of the wire changes from A at R to $\frac{1}{2}A$ at S.

There is a constant current in the wire. Charge Q passes R in time t.

What is the charge passing point S in the same time t?

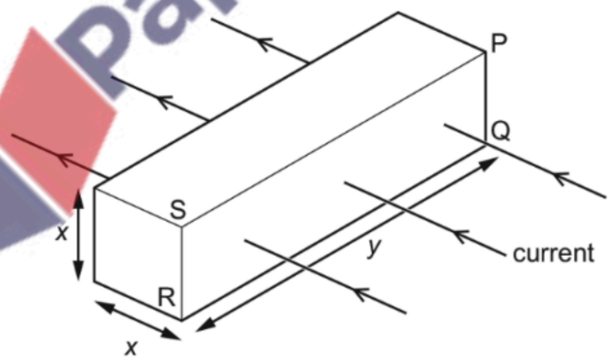
A $\frac{1}{2}Q$ **B** Q **C** $Q\sqrt{2}$ **D** $2Q$

Ans: B

- Constant current and constant time
- Q = It, so Q must also be constant

5.

The diagram shows the direction of the current in a metal block. The charge carriers enter the block through the face PQRS and leave the block through the opposite face.



The number density of charge carriers is n. Each charge carrier has charge e. The average drift speed of the charge carriers is v.

Which expression gives the current in the block?

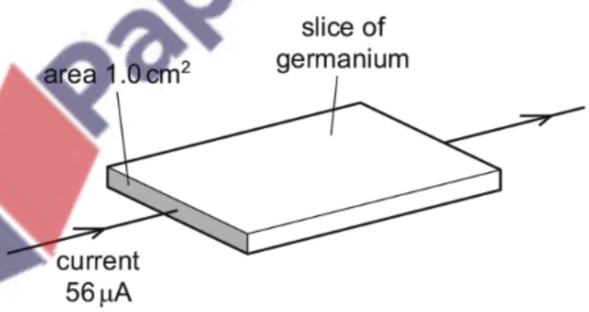
A $envx^2$ **B** $envxy$ **C** $envx^3y^2$ **D** $envx^4y$

Ans: B

NOTE: charge carriers in a metal wire = <u>free electrons</u>
n = number of charge carriers per unit volume of wire = number of <u>free electrons</u> per unit volume of wire

6.

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



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

A $0.18\,m\,s^{-1}$ **B** $18\,m\,s^{-1}$ **C** $180\,m\,s^{-1}$ **D** $1800\,m\,s^{-1}$

Ans: A

7.

When there is a current of 5.0 A in a copper wire, the average drift velocity of the free electrons is $8.0 \times 10^{-4}\,m\,s^{-1}$.

What is the average drift velocity in a different copper wire that has twice the diameter and a current of 10.0 A?

A $4.0 \times 10^{-4}\,m\,s^{-1}$

B $8.0 \times 10^{-4}\,m\,s^{-1}$

C $1.6 \times 10^{-3}\,m\,s^{-1}$

D $3.2 \times 10^{-3}\,m\,s^{-1}$

Ans: A

8.

Two metal plates are a distance of 30 cm apart in a vacuum.

A current exists between the two plates consisting of electrons moving at a constant speed of $1.5 \times 10^{6}\,m\,s^{-1}$.

At any instant, there is always just one electron travelling between the plates.

What is the current between the plates?

A 3.2×10^{-26} A

B 8.0×10^{-13} A

C 1.6×10^{-12} A

D 2.0×10^{-7} A

$I = nAvq$

nA = no. of e^- per unit length

$= \frac{1}{0.3}$

$I = \frac{1}{0.3} \times 1.5 \times 10^{6} \times 1.6 \times 10^{-19}$

$= 8 \times 10^{-13}$

9.

A crane is being used to lift containers off a ship. One container has a mass of 14 000 kg and is being lifted vertically with a speed of $3.2\,m\,s^{-1}$.

The electric motor being used to supply the power to lift the container is using a current of 240 A at a potential difference of 2200 V.

What is the efficiency of the system?

A 8.1% **B** 8.5% **C** 48% **D** 83%

Ans: D

- Power from the electric motor (input) = VI = 2200 x 240 = 528000
- Power from a crane (output) = E/t = Fd/t
- d/t = v, thus P = Fv
- F = mg, thus P = mgv = 14000 x 9.81 x 3.2 = 439488
- Efficiency = (439488/528000) x 100 = 83.236

10.

Which two units are used to define the volt?

A ampere and ohm

B coulomb and joule

C coulomb and ohm

D coulomb and second

Ans: B

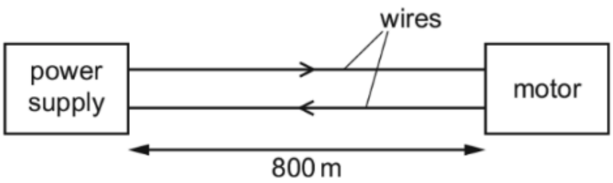
NOTE: definitions of different quantities

- To define p.d: V = E/Q = W/Q
- To define charge: Q = It
- To define resistance: V = IR

11.

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 $0.0050\,\Omega$ 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

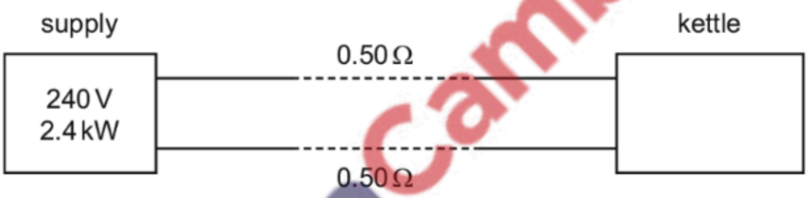
Ans: D

- Current of 0.6 A is same throughout
- R in each wire = 800 x 0.005 = 4Ω
- V lost in each wire = 0.6 x 4 = 2.4V
- Input V – V lost = output V

- Thus input V = 16 + 2.4 + 2.4 = 20.8V

12.

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 Ω, as shown.



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

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

Ans: A

- $I = (2.4 \times 10^3) / 240 = 10A$
- V lost = (0.5 x 10) + (0.5 x 10) = 10V
- Output V = 240 - 10 = 230V
- Output power = 230 x 10 = 2300W = 2.3kW

13.

The potential difference across a resistor is 12 V. The current in the resistor is 2.0 A.

A charge of 4.0 C passes through the resistor.

What is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

Ans: C

- E = VIt = VQ = 12 x 4 = 48J
- t = E/VI = 48/(12 x 2) = 2s

14.

The filament of a 240 V, 100 W electric lamp heats up from room temperature to its operating temperature. As it heats up, its resistance increases by a factor of 16.

What is the resistance of the filament at room temperature?

A 36 Ω **B** 580 Ω **C** 1.5 kΩ **D** 9.2 kΩ

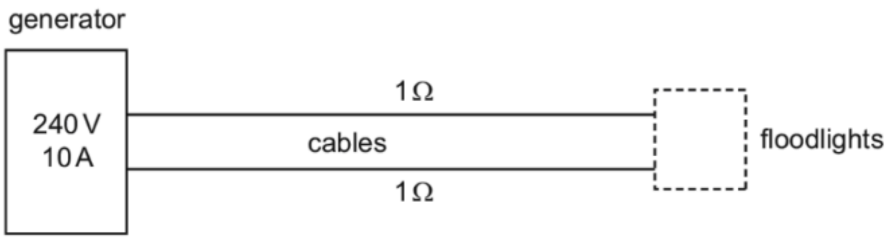
Ans: A

- R at operating temperature = $V^2/P = 240^2/100 = 576$
- R at room temperature = 576 / 16 = 36Ω

15.

The diagram shows a portable generator connected by cables to floodlights. The generator produces a current of 10 A at a constant potential difference (p.d.) of 240 V.

The total resistance of the cables is 2 Ω.



What is the p.d. *V* across, and the power *P* delivered to, the floodlights?

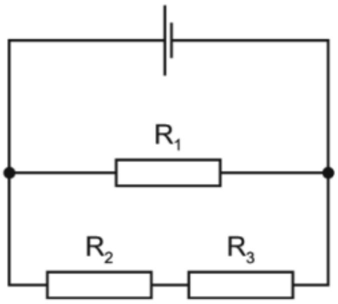
	V / V	*P* / W
A	220	2000
B	220	2200
C	230	2000
D	230	2300

Ans: B

- I = 10A throughout
- V lost = (1 x 10) + (1 x 10) = 20V
- Output V = 240 - 20 = 220V
- Output P = 220 x 10 = 2200W

16.

A cell of negligible internal resistance is connected to resistors R_1, R_2 and R_3, as shown. The cell provides power to the circuit and power is dissipated in the resistors.



Which word equation **must** be correct?

A power loss in R_1 = power loss in R_2 + power loss in R_3

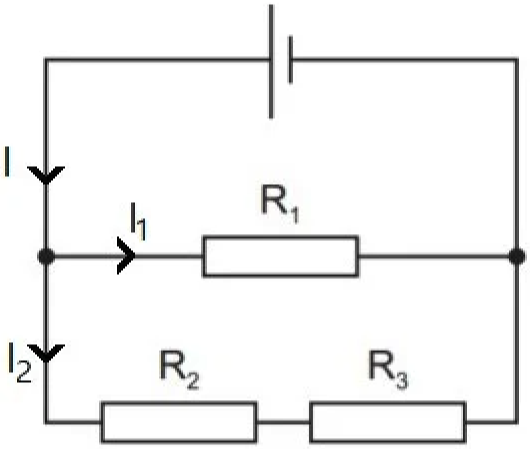
B power loss in R_2 = power loss in R_3

C power output of cell = power loss in R_1 + power loss in R_2 + power loss in R_3

D power output of cell = power loss in R_1

Ans: C

- Option A
    - $P = V^2/R$
    - For the statement to be true, $P = V^2/R_1 = V^2/(R_2 + R_3)$
    - V is same in both branches, but R_1 is not necessarily equal to $R_2 + R_3$
- Option B
    - $P = V^2/R$
    - For the statement to be true, $P = V^2/R_2 = V^2/R_3$
    - R_2 is not necessarily equal to R_3
- Option C
    - Conservation of energy!!
    - Power output of cell = VI
    - $I = I_1 + I_2$
    - P dissipated in $R_1 = VI_1$
    - P dissipated in R_2 and $R_3 = VI_2$
    - (P dissipated in R_2 and R_3 should be taken together, since ratio of their resistance and their p.d.s is not known - assume that R_2 and R_3 are combined to give a single resistance)
    - $VI = V(I_1 + I_2)$
- Option D: there should be power dissipation from R_2 and R_3



Using Kirchhoff's first law,

$I = I_1 + I_2$

Power output of the cell, $P = VI$

Power dissipated in $\mathrm{R}_1 = VI_1$

power dissipated in R_1 and $\mathrm{R}_1 = VI_2$

$I = I_1 + I_2$

$VI = VI_1 + VI_2$

Hence, option (C) is correct.

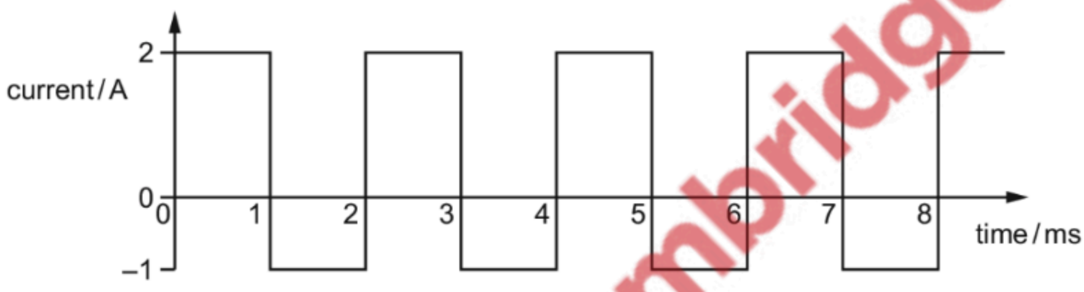
DOUBT!!

<u>Power dissipation in series circuit</u>
$P = I^2R$
- Current is the same everywhere
- Greater the resistance, greater the power dissipated

<u>Power dissipation in parallel circuit</u>
$P = V^2/R$
- Voltage / p.d is the same across each branch
- Greater the resistance, lesser the power dissipated

17.

A 100 Ω resistor conducts a current with changing direction and magnitude, as shown.



What is the mean power dissipated in the resistor?

A 100 W **B** 150 W **C** 250 W **D** 400 W

Ans: C

- Power dissipated = I^2R
- Power dissipated when current is 2A = 2^2 x 100 = 400W
- Power dissipated when current is –1A = 1^2 x 100 = 100W
- Mean power dissipated = (400 + 100) / 2 = 250W

18.

Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

Which statement most accurately describes what happens?

A Both lamps light at less than their normal brightness.

B Both lamps light at their normal brightness.

C Only the 240 V lamp lights.

D The 10 V lamp blows.

Ans: B

- Current in first lamp = 60/240 = 0.25A
- Current in second lamp = 2.5/10 = 0.25A
- Current is same, and both lamps are connected in series, thus both light at normal brightness

19.

What describes the electric potential difference between two points in a wire that carries a current?

A the force required to move a unit positive charge between the points

B the ratio of the energy dissipated between the points to the current

C the ratio of the power dissipated between the points to the current

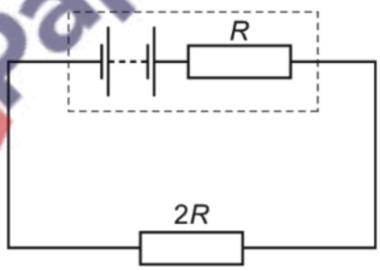
D the ratio of the power dissipated between the points to the charge moved

Ans: C

- P.d = E/Q
- P = (E/t) and I = (Q/t)
- E/Q = (E/t) / (Q/t)
- Thus p.d. = P/I

20.

The diagram shows an electric circuit in which the resistance of the external resistor is $2R$ and the internal resistance of the source is R.



What is the ratio $\dfrac{\text{power in internal resistance}}{\text{power in external resistor}}$?

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

Ans: B

- $P = I^2R$
- Current is the same throughout, so P is directly proportional to R.

21.

A cylindrical metal wire X has resistance R. The same volume of the same metal is made into a cylindrical wire Y of double the length.

What is the resistance of wire Y?

A R **B** $2R$ **C** $4R$ **D** $8R$

Ans: C

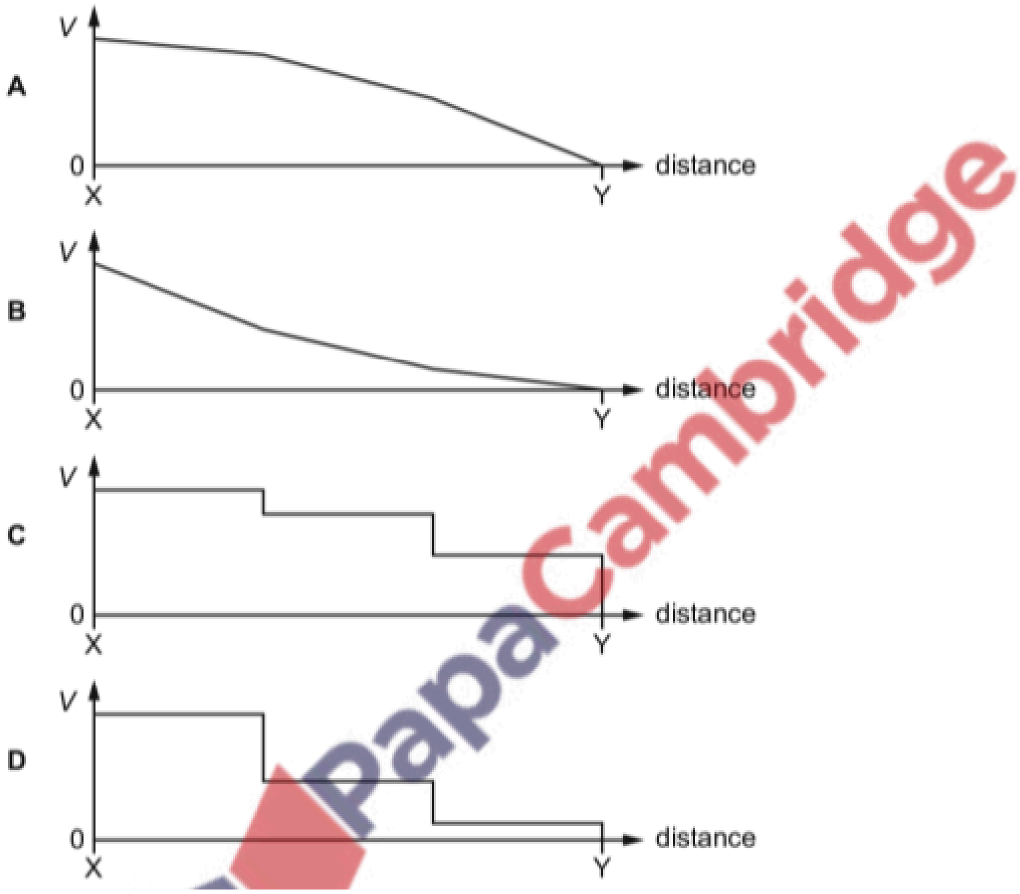
- Length is doubled
- Same volume, so area is halved
- Thus R is quadrupled

22.

A conductor consists of three wires connected in series. The wires are all made of the same metal but have different cross-sectional areas. There is a current I in the conductor.

Point Y on the conductor is at zero potential.

Which graph best shows the variation of potential V with distance along the conductor?



Ans: A

- There is a potential drop
- In a conductor, the potential drop is continuous: even along each wire, there is a drop; this eliminates options C & D.
- In A, initial drop is least steep and final drop is most steep;
  In B, initial drop is most steep and final drop is least steep.
- Potential drop depends on resistance.
- Widest wire has least resistance, and narrowest wire has most resistance.
- Least resistance = potential drop is smallest;
  Most resistance = potential drop is largest.
- Thus initial drop has to be less and final drop has to be highest = option A.

23.

The wire of a heating element has resistance R. The wire breaks and is replaced by a different wire.

Data for the original wire and for the replacement wire are shown in the table.

	length	diameter	resistivity of metal
original wire	l	d	ρ
replacement wire	l	$2d$	2ρ

What is the resistance of the replacement wire?

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

Ans: B

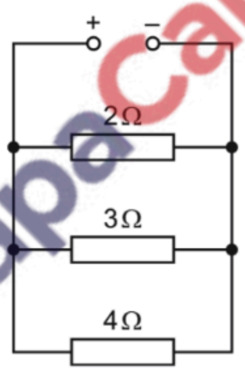
$$R_1 = \frac{\rho l}{\pi \left(\frac{d}{2}\right)^2} = \frac{4\rho l}{\pi d^2}$$

$$R_2 = \frac{2\rho l}{\pi \left(\frac{2d}{2}\right)^2} = \frac{2\rho l}{\pi d^2}$$

$$R_2 : R_1 = 1/2$$

24.

Three resistors are connected in parallel across a power supply, as shown.



The power dissipated in each of the resistors of resistance 2Ω, 3Ω and 4Ω is P_2, P_3 and P_4 respectively.

What is the ratio $P_2 : P_3 : P_4$?

A 2 : 3 : 4 **B** 4 : 3 : 2 **C** 6 : 4 : 3 **D** 36 : 16 : 9

Ans: C

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

V is same across all

$P_2 = \frac{V^2}{2}$

$P_3 = \frac{V^2}{3}$

$P_4 = \frac{V^2}{4}$

$\therefore P_2 : P_3 : P_4 =$

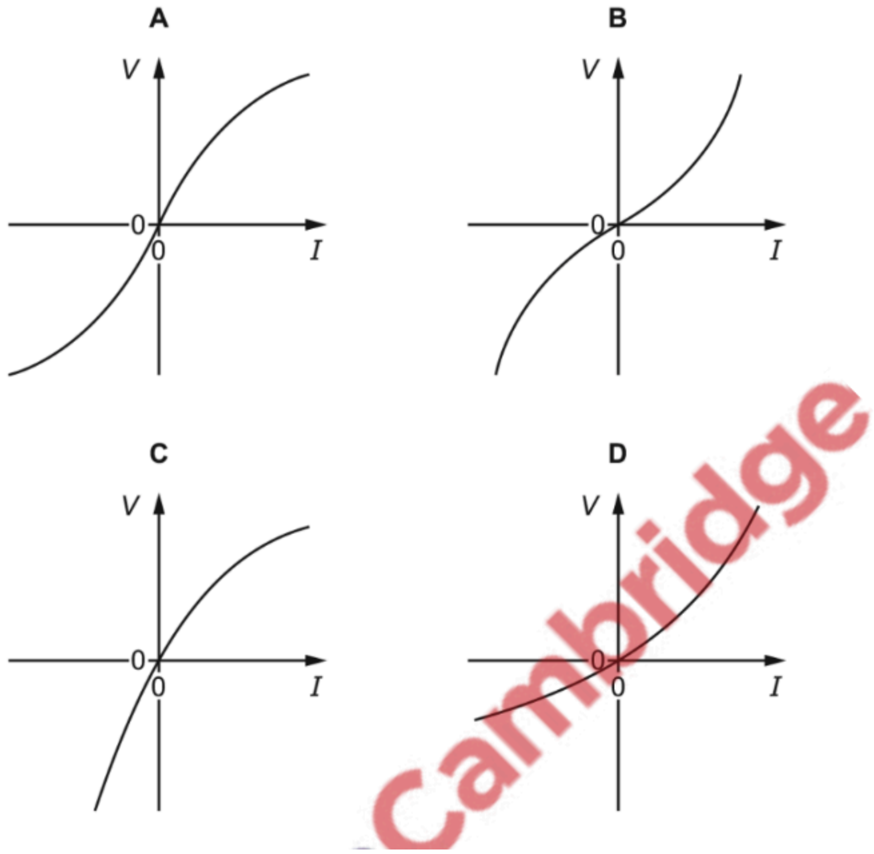
$\frac{1}{2} : \frac{1}{3} : \frac{1}{4}$

$= \frac{1}{2} \times 6 : \frac{1}{3} \times 4 : \frac{1}{4} \times 3$

$= 6 : 4 : 3$

25.

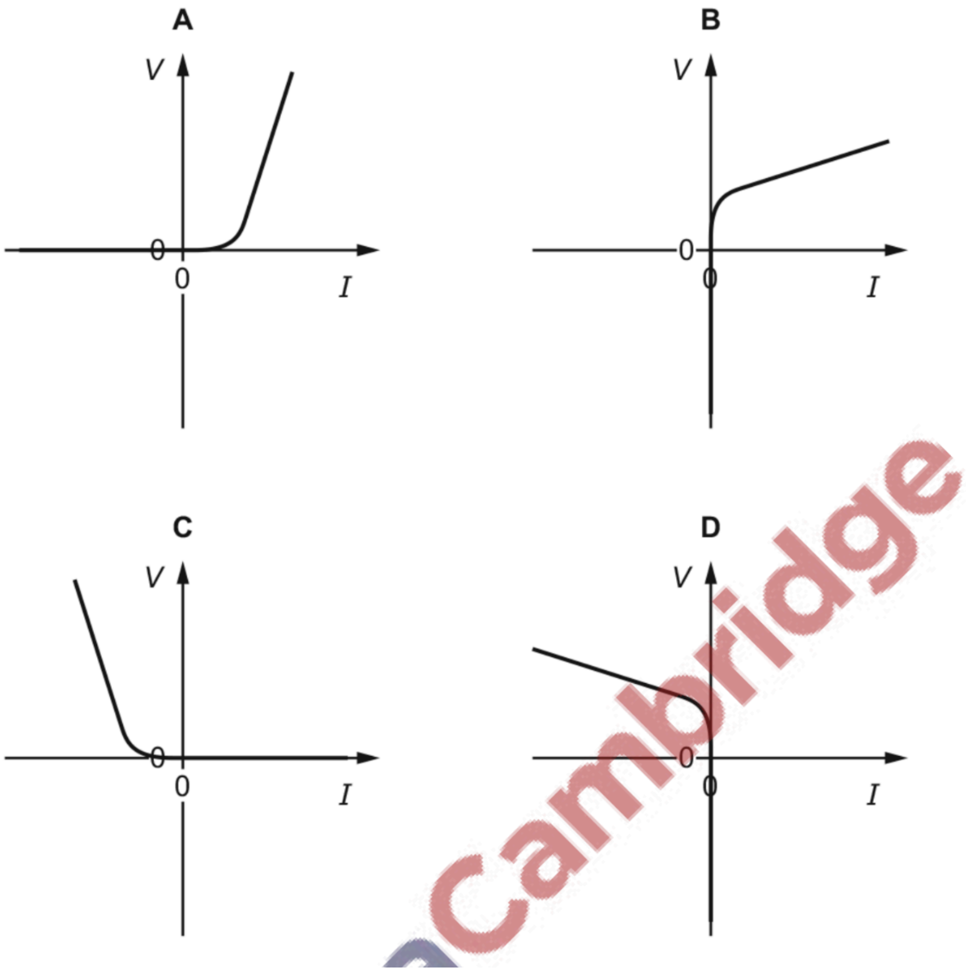
Which graph best represents the variation with current I of potential difference V for a filament lamp?



Ans: B

26.

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

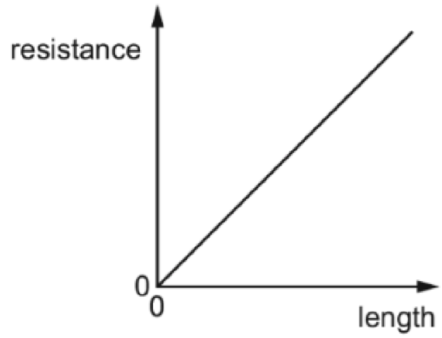


Ans: B

NOTE: Graph of V–I is a reflection of graph of I–V in line y=x; V–I is inverse of I–V

27.

The graph shows the variation with length of the resistance of a uniform metal wire.



The gradient of the graph is G.
The wire has cross-sectional area A.

Which expression could be used to calculate the resistivity of the metal of the wire?

A $G \times A$ **B** $\dfrac{G}{A}$ **C** $\dfrac{A}{G}$ **D** $G \times A^2$

Ans: A

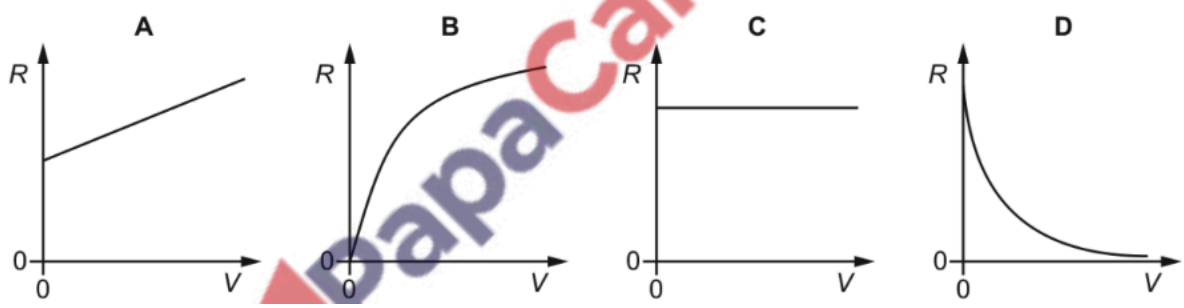
$G = \dfrac{\Omega}{m}$ $\quad\quad \dfrac{\Omega}{m} \times m^2$

$A = m^2$ $\quad\quad = \Omega m$

Careful not to select option D!

28.

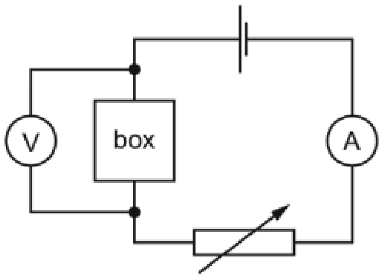
Which graph could show how the resistance R of a filament lamp varies with the applied potential difference (p.d.) V, as V is increased to the normal operating p.d.?



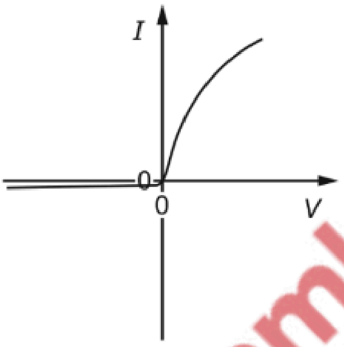
Ans: A

29.

A box containing two electrical components is connected into a circuit.



The variable resistor is adjusted and measurements are taken to determine the I–V characteristic for the box, as shown.



Which arrangement of two electrical components in the box would create the best fit to the measured I–V characteristic?

A a filament lamp and a fixed resistor in parallel

B a filament lamp and a fixed resistor in series

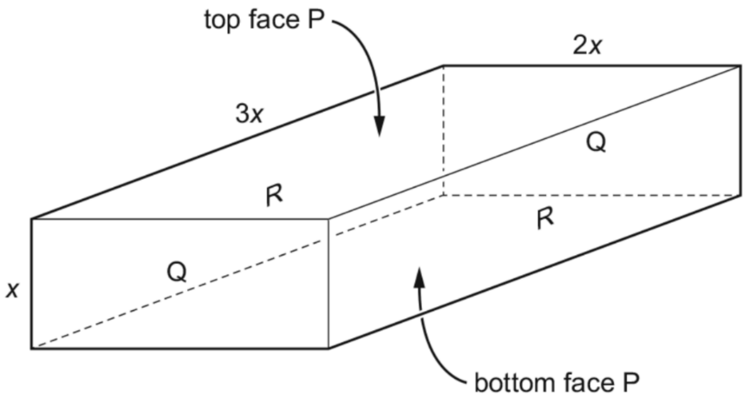
C a semiconductor diode and a filament lamp in parallel

D a semiconductor diode and a filament lamp in series

Ans: D

30.

The diagram shows a rectangular block with dimensions x, $2x$ and $3x$.



Electrical contact can be made to the block between opposite pairs of faces (for example, between the faces labelled R).

Which statement describing the electrical resistance of the block is correct?

A It is maximum between the faces labelled P.

B It is maximum between the faces labelled Q.

C It is maximum between the faces labelled R.

D It is the same, whichever pair of faces is used.

Ans: B

31.

A wire of length L has resistance R. The cross-section of the wire is circular with radius r.

A second wire, also of circular cross-section, and of the same material, has resistance $\frac{1}{2}R$.

What could be the radius and the length of the second wire?

	radius	length
A	$\frac{r}{2}$	$\frac{L}{2}$
B	$\frac{r}{\sqrt{2}}$	$\frac{L}{2}$
C	$r\sqrt{2}$	$2L$
D	$2r$	$2L$

Ans: D

32.

A coil contains N turns of insulated copper wire wound on to a cylindrical iron core of diameter D. The copper wire has a diameter d. The resistivity of copper is ρ. Diameter D is much greater than diameter d.

What is the total resistance between the two ends of the coil?

A $\dfrac{4N\rho D}{d^2}$ **B** $\dfrac{4N\rho d}{D^2}$ **C** $\dfrac{8N\rho D}{d^2}$ **D** $\dfrac{8N\rho d}{D^2}$

Ans: A

- Length of wire = ND
- Cross sectional area = $(d/2)^2 = d^2/4$
- R = pND / $(d^2/4)$ = 4pND/ d^2

33.

Two wires have the same length and the same resistance. Wire X is made of a metal of resistivity $1.7 \times 10^{-8}\,\Omega\,m$ and wire Y is made of a metal of resistivity $5.6 \times 10^{-8}\,\Omega\,m$.

The diameter of wire X is 0.315 mm.

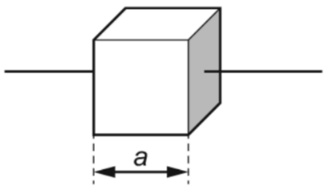
What is the diameter of wire Y?

A 0.17 mm **B** 0.33 mm **C** 0.57 mm **D** 1.0 mm

Ans: C

34.

A metal cube with sides of length a has electrical resistance R between opposite faces.



What is the resistance between the opposite faces of a cube of the same metal with sides of length $3a$?

A $9R$ **B** $3R$ **C** $\dfrac{R}{3}$ **D** $\dfrac{R}{9}$

Ans: C

35.

Which **measurements** are taken in order to calculate the resistivity of the metal of a piece of wire?

A p.d., current, area, length

B p.d., current, diameter, length

C resistance, area, length

D resistance, length, radius

Ans: B

- To calculate resistance, measurement of p.d and current is taken
- Length is directly measured
- To calculate area, measurement of diameter is taken

36.

Two copper wires of equal length are connected in parallel. A potential difference is applied across the ends of this parallel arrangement. Wire S has a diameter of 3.0 mm. Wire T has a diameter of 1.5 mm.

What is the value of the ratio $\frac{\text{current in S}}{\text{current in T}}$?

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

Ans: D

37.

The charge that a fully charged 12 V car battery can supply is 100 kC. The starter motor of the car requires a current of 200 A for an average period of 2.0 s. The battery does not recharge because of a fault.

What is the maximum number of times the starter motor of the car can be used?

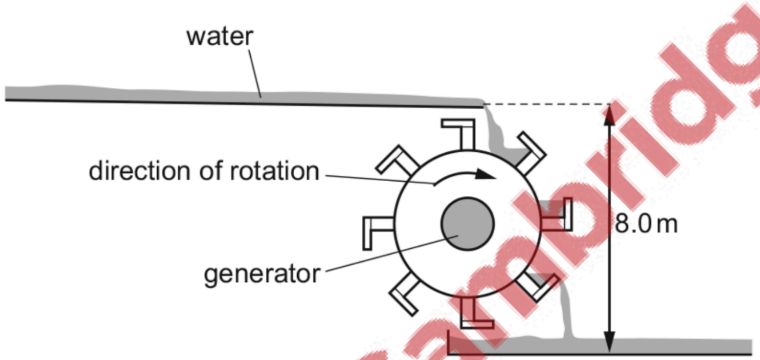
A 21 **B** 25 **C** 42 **D** 250

Ans: D

- $(100 \times 10^3) / (200 \times 2) = 250$

38.

The diagram shows the design of a water wheel which drives a generator to produce electrical power. The flow rate of the water is 200 kg s^{-1}. The generator supplies a current of 32 A at a voltage of 230 V.



Ignoring any changes in kinetic energy of the water, what is the efficiency of the system?

A 14% **B** 16% **C** 22% **D** 47%

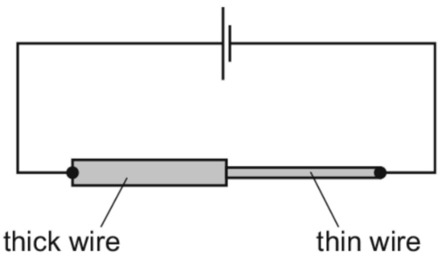
Ans: D

- Efficiency = (output power / input power) x 100
- Input power = mgh/t = 200 x 9.81 x 8 = 15696 (m/t is given)
- Ouput power = 32 x 230 = 7360
- Efficiency = (7360/15696) x 100 = 46.891

NOTE: typical value for the order of magnitude of the resistivity of copper = $10^{-8}\Omega m$

39.

A thick copper wire is connected to a thin copper wire in series with a cell, as shown.



What is significantly **less** in the thick wire than in the thin wire?

A the charge passing a point per unit time

B the drift speed of the electrons

C the number density of the free electrons

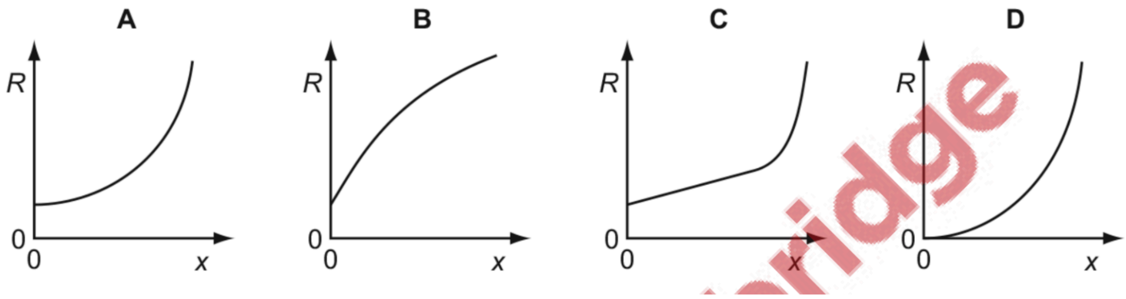
D the number of free electrons passing a point per unit time

Ans: B

40.

When a thin metal wire is stretched, it becomes longer and thinner. This causes a change in the resistance of the wire. The volume of the wire remains constant.

Which graph could represent the variation with extension x of the resistance R of the wire?

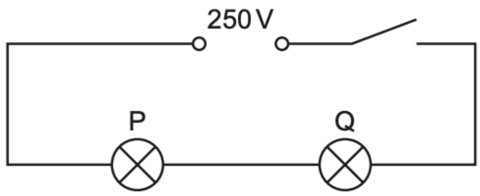


Ans: A

- Length increases, area decreases; because volume remains constant.
- V = A x L
- R = (pL) / A = (pL) / (V/L) = (pL^2) / V
- V and p are constant; only L is changing from the equation above.
- R is increasing by quadratic factor, because R $\propto$ L^2, thus parabola.
- At 0 extension there will be some resistance, so the graph doesn't start from origin.

41.

In the circuit shown, lamp P is rated 250 V, 50 W and lamp Q is rated 250 V, 200 W. The two lamps are connected in series to a 250 V power supply.



Assume that the resistance of each lamp remains constant.

Which statement most accurately describes what happens when the switch is closed?

A Lamp P emits four times as much power as lamp Q.

B Lamp P emits twice as much power as lamp Q.

C Lamp Q emits four times as much power as lamp P.

D Lamp Q emits twice as much power as lamp P.

Ans: A

→ I through both lamps should be the same

P	Q
$R = \frac{250^2}{50}$	$R = \frac{250^2}{200}$
$= 1250$	$= 312.5$
$I = \sqrt{\frac{P_P}{1250}}$	$I = \sqrt{\frac{P_Q}{312.5}}$

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

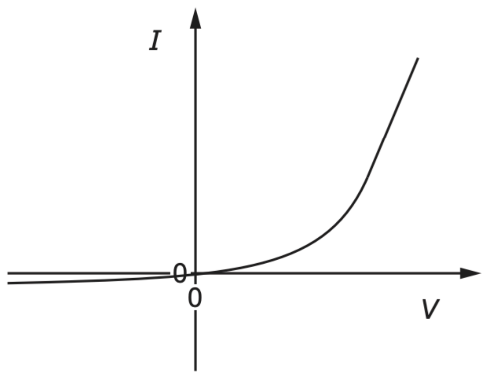
$P = I^2R$

$$\Rightarrow \sqrt{\frac{P_P}{1250}} = \sqrt{\frac{P_Q}{312.5}}$$

$$\Rightarrow \frac{P_P}{1250} = \frac{P_Q}{312.5} \qquad \therefore \frac{P_P}{P_Q} = \frac{1250}{312.5} = 4$$

42.

The graph shows the *I*–*V* characteristic for a semiconductor diode.



Which statement can be deduced from the graph?

A Above a certain positive potential difference the diode obeys Ohm's law.

B Current is directly proportional to potential difference when the current in the diode is in one direction.

C The diode has zero resistance when the current in the diode is in one direction.

D The resistance of the diode depends upon the potential difference across it.

Ans: D

- For Ohm's law, I should be directly proportional to V. In this case, it is not directly proportional since the line does not pass through the origin!!

43.

A radioactive source produces a beam of α-particles in a vacuum. The average current caused by the α-particles in the beam is 1.5×10^{-9} A.

The beam is incident on a metal target.

What is the average number of α-particles hitting the metal target in a time of 3.0 s?

A 4.7×10^{9} **B** 9.4×10^{9} **C** 1.4×10^{10} **D** 2.8×10^{10}

Ans: C

- Q = It | Q = ne | ne = It
- $n = ((1.5 \times 10^{-9})(3)) / (2 \times 1.6 \times 10^{-19}) = 1.4 \times 10^{10}$

REMEMBER: α–particle has charge of 2e

44.

The charge carriers in a metal wire are free electrons.

Which statement about the charge of each free electron is correct?

A The magnitude of the charge increases with the potential difference across the wire.

B The magnitude of the charge is zero unless there is a potential difference across the wire.

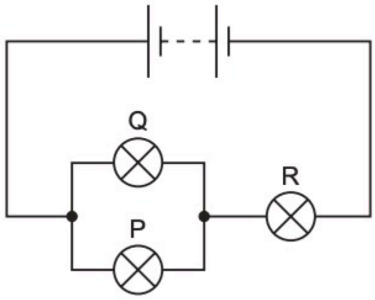
C The sign and magnitude of the charge do **not** depend on the potential difference across the wire.

D The sign of the charge depends on the potential difference across the wire.

Ans: C

45.

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

Ans: B

- When Q is removed, current through P increases, so its gets brighter
- Total current in circuit decreases when Q is removed, so R gets dimmer