ELECTRICITY

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9 Electricity

9.1 Electric current

Candidates should be able to:

1 understand that an electric current is a flow of charge carriers

2 understand that the charge on charge carriers is quantised

3 recall and use $Q = It$

4 use, for a current-carrying conductor, the expression $I = Anvq$, where n is the number density of charge carriers

9.2 Potential difference and power

Candidates should be able to:

1 define the potential difference across a component as the energy transferred per unit charge

2 recall and use $V = W / Q$

3 recall and use $P = VI$, $P = I^2R$ and $P = V^2 / R$

9.3 Resistance and resistivity

Candidates should be able to:

1 define resistance

2 recall and use $V = IR$

3 sketch the I–V characteristics of a metallic conductor at constant temperature, a semiconductor diode and a filament lamp

4 explain that the resistance of a filament lamp increases as current increases because its temperature increases

5 state Ohm's law

6 recall and use $R = \rho L / A$

7 understand that the resistance of a light-dependent resistor (LDR) decreases as the light intensity increases

8 understand that the resistance of a thermistor decreases as the temperature increases (it will be assumed that thermistors have a negative temperature coefficient)

charge carriers — flow

Electric current:

Def. Flow of charge carriers is current.

Symbol: I

Formula: (i) $I = \frac{Q}{t}$

(ii) If n-charged carriers, each having a charge e flows through a cross-section in time t.

Total charge, $Q = ne$

Total time = t

Average current = $\frac{\text{Total charge}}{\text{Total time}}$

$$\langle I \rangle = \frac{ne}{t}$$

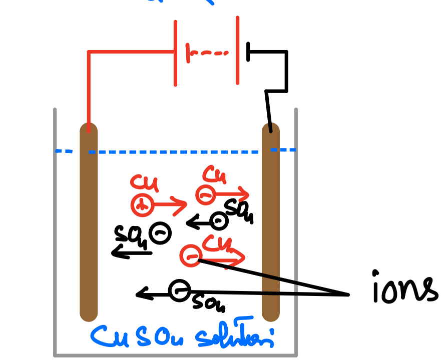
Units: Ampere (A)

Measuring device: Ammeter

P.S.: Scalar

Charge carriers: Any particle having charge and is used to define current due to its flow i.e electrons, protons or ions.

$$CuSO_4 \rightleftharpoons Cu^{+} + SO_4^{-}$$



Quantisation of charge:-

Charge on any particle / body is quantised i.e it is an integral multiple of a fixed value. No object can have charge lesser than this fundamental value of 1.60×10^{-19} C.

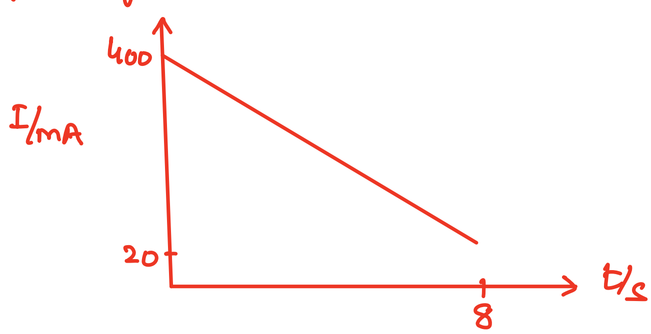
$$Q = ne$$

- Q → Total charge
- e → charge on an elementary particle
- n → integral multiple, $n = 1, 2, 3, \ldots$

Q) Which of the following value of charge on a particle is possible?

Charge / C	Quantisation check	Value	Possible
2.59×10^{-19}	$Q = ne$ $2.59\times10^{-19} = n(1.60\times10^{-19}) \Rightarrow n = 1.56$	1.56	Impossible
8.0×10^{-19}	$8.0\times10^{-19} = n(1.60\times10^{-19}) \Rightarrow n = 5$	5	Possible
3.2×10^{-19}	$3.2\times10^{-19} = n(1.60\times10^{-19}) \Rightarrow n = 2$	2	Possible
10.0×10^{-19}	$10.0\times10^{-19} = n(1.60\times10^{-19}) \Rightarrow n = 6.25$	6.25	Impossible
6.0×10^{-19}	$6.0\times10^{-19} = n(1.60\times10^{-19}) \Rightarrow n = 3.75$	3.75	Impossible

Q) A graph of current against time is given below.



(a) Calculate total charge which flows over this time.

Method 1:

$$\text{Average current} = \frac{\text{Total charge}}{\text{Total time}}$$

$$\left(\frac{400+20}{2}\right)10^{-3} = \frac{Q}{8}$$

Method 2:

Total charge = Area under I/A against t/s graph

$$Q = \frac{1}{2}\left[(400+20)10^{-3}\right][8]$$

$$Q = 1.68 \text{ C}$$

(b) Using quantisation concept, state is this value of charge possible or not.

$$Q = ne \Rightarrow 1.68 = n(1.60\times10^{-19})$$

$$n = 1.05\times10^{19} \Rightarrow n = 105\times10^{17}$$

Since 105×10^{17} an integer, so it is possible.

Number density:-

Def. Number of free / conduction electrons per unit volume.

Symbol: n

Formula: $n = \dfrac{\text{No. of conduction electrons}}{\text{Volume}}$

Units: m^{-3}

P.S. Scalar

Example: For Copper, $n = 10^{29}\ m^{-3}$

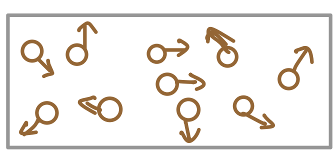
Drift velocity:-

Def. Displacement travelled by the free electrons in a metal per unit time when p.d. is applied across its ends.

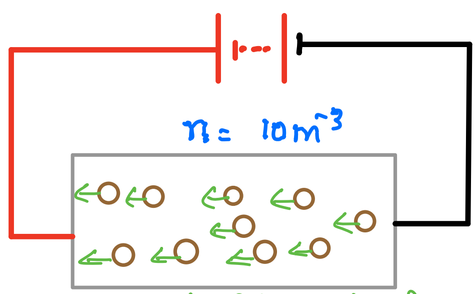
Symbol: ν or v

Concept.

$n = 10\ m^{-3}$



Random movement of free electrons in a metallic crystal



Defined flow of free electrons with drift velocity

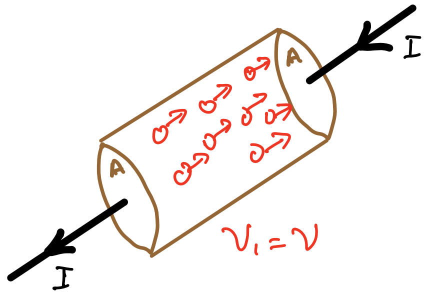
Formula $v = \dfrac{I}{n\,q\,A}$

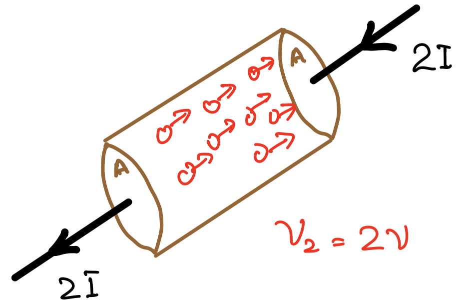
Here I - Current
n - Number density
q - charge on an elementary particle
A - cross-sectional Area

Dependance:

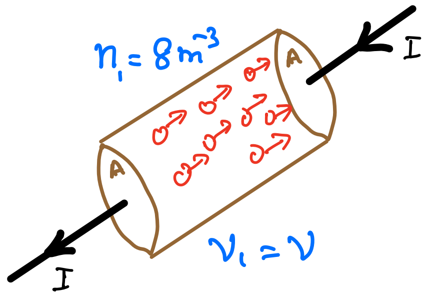
$v = \frac{I}{nqA}$

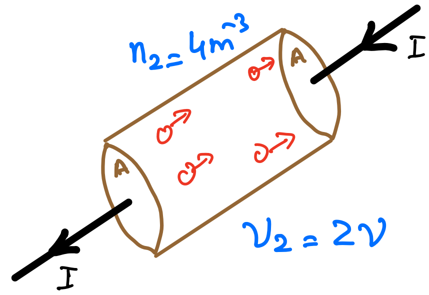
(1) <u>Current</u> : $v \propto I$





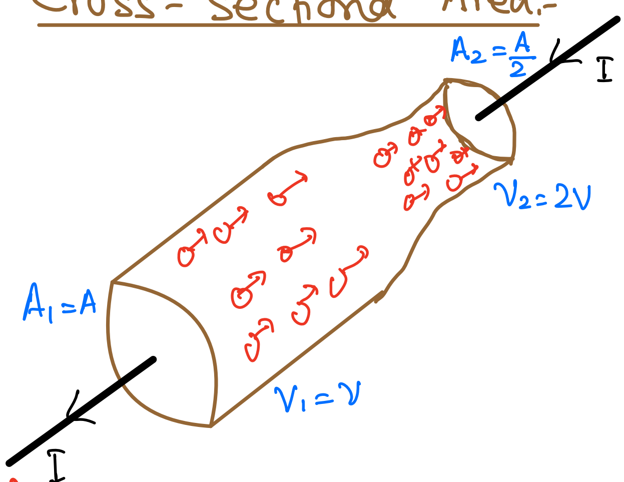
(2) <u>Number density</u> : $v \propto \frac{1}{n}$





(3) <u>Cross-sectional Area</u>:-

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



ie half the cross-sectional Area, double the mean drift velocity

of

Proof of eq. of current ie Proof of $I = nqvA$ [Not in syllabus from June 22]

$$\text{Number density} = \frac{\text{No. of free electron}}{\text{Volume}}$$

$$n = \frac{\text{No. of free electron}}{V}$$

$$\text{No. of free electron} = nV$$

$$N = nAL$$

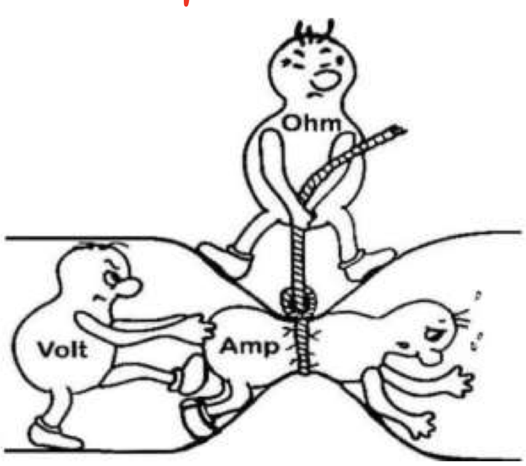
$$\text{current, } I = \frac{Q}{t} = \frac{(\text{no. of free electrons})(\text{charge on an electron})}{t}$$

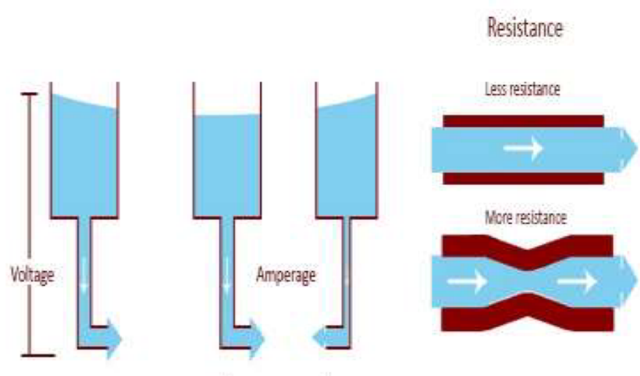
$$I = \frac{Nq}{t}$$

$$I = nA\left(\frac{L}{t}\right)q \Rightarrow \boxed{I = nAvq}$$

Electrical resistance:-

Concept:-

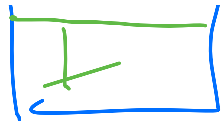




$$V = IR \Rightarrow R = \frac{V}{I}$$

V → P.d

I → current



Def.

p.d. per unit current is electrical resistance

Symbol: r - Internal resistance of source ie cell, battery, generator etc.

R - External resistance of an appliance/load i.e. heater, Iron, motor, filament lamp, A.C.

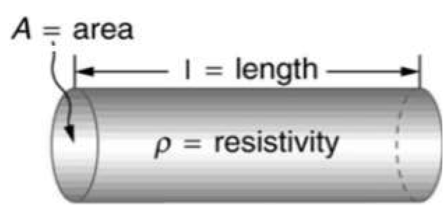
Formula: $R = \frac{V}{I}$

Units: Ohm (Ω) $\quad 1\,\Omega = \frac{1\ \text{Volt}}{1\ \text{Ampere}}$

J-21/P22/Q1
P.S: Scalar

Formula: $R \propto \frac{L}{A} \Rightarrow R = \frac{\rho L}{A}$

ρ – Resistivity of the material and depends upon nature of material



$\rho_{conductor} \approx 10^{-6}\ \Omega\,cm$

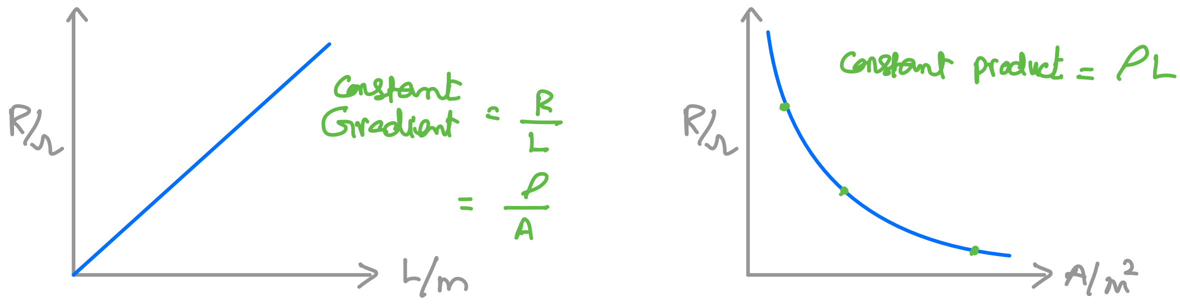
$\rho_{insulator} \approx 10^{12}\ \Omega\,cm$

$\rho_{semiconductor} \approx 10^{6}\ \Omega\,cm$

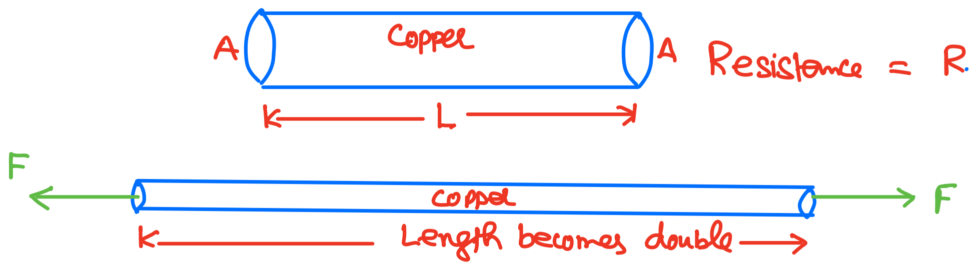
L – Length of material

A – cross-sectional Area

Graph:



Q1)



What is its resistance in terms of R if its length is doubled but volume is kept constant?

$R_1 = R$
$L_1 = L$
$A_1 = A$

$R_2 = ?$
$L_2 = 2L$
$A_2 = \frac{A}{2}$

$V = (A)(L)$
$V = \left(\frac{A}{2}\right)(2L)$

$$\frac{R_2}{R_1} = \frac{\rho \frac{L_2}{A_2}}{\rho \frac{L_1}{A_1}} \Rightarrow \frac{R_2}{R_1} = \left(\frac{L_2}{A_2}\right)\left(\frac{A_1}{L_1}\right)$$

$$\frac{R_2}{R} = \left[\frac{2L}{\frac{A}{2}}\right]\left[\frac{A}{L}\right] \Rightarrow \frac{R_2}{R} = 4 \Rightarrow \boxed{R_2 = 4R}$$

Q. A wire of length 0.50 m and cross-sectional area 1.0×10^{-6} m² has a resistance of 0.75 Ω. Another wire of the same material has a length of 2.0 m and a cross-sectional area of 0.50×10^{-6} m². What is the resistance of the longer wire?

A 0.094 Ω **B** 0.38 Ω **C** 1.5 Ω **D** 6.0 Ω

$L_1 = 0.50m$ | $L_2 = 2.0m$

$A_1 = 1.0 \times 10^{-6} m^2$ | $A_2 = 0.50 \times 10^{-6} m^2$

$R_1 = 0.75 \Omega$ | $R_2 = ?$

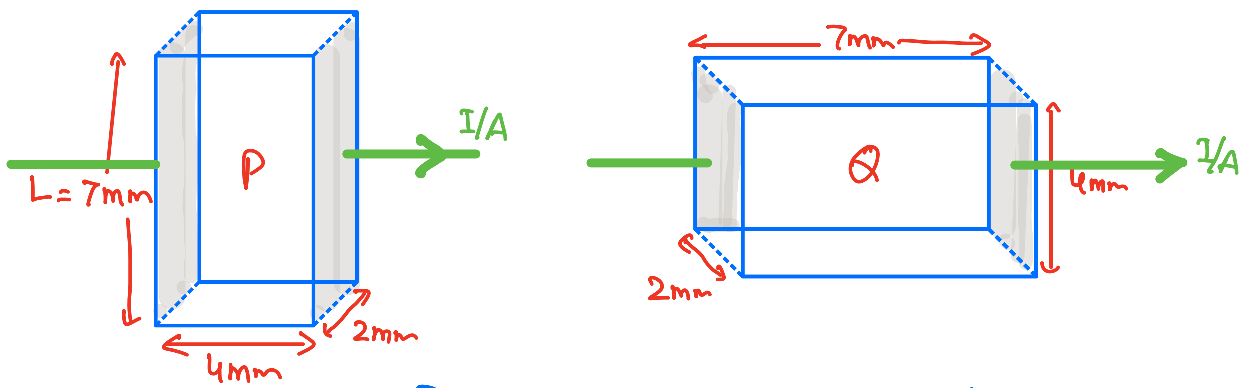
Same material means same value of resistivity (ρ)

$$\frac{R_2}{R_1} = \frac{\rho \frac{L_2}{A_2}}{\rho \frac{L_1}{A_1}} \Rightarrow \frac{R_2}{R_1} = \left[\frac{L_2}{A_2}\right]\left[\frac{A_1}{L_1}\right]$$

$$\frac{R_2}{0.75} = \left[\frac{2.0}{0.50 \times 10^{-6}}\right]\left[\frac{1.0 \times 10^{-6}}{0.50}\right] = 8$$

$$R_2 = (0.75)(8) = 6.0 \Omega$$

Q) P and Q are made of same material as shown.



Calculate $\frac{R_P}{R_Q}$ between their shaded regions.

$$\frac{R_P}{R_Q} = \frac{\rho \frac{L_P}{A_P}}{\rho \frac{L_Q}{A_Q}} \Rightarrow \frac{R_P}{R_Q} = \left(\frac{L_P}{A_P}\right)\left(\frac{A_Q}{L_Q}\right)$$

$$\frac{R_P}{R_Q} = \left[\frac{4}{(7)(2)}\right]\left[\frac{(2)(4)}{7}\right] = \frac{16}{49} = 0.327$$

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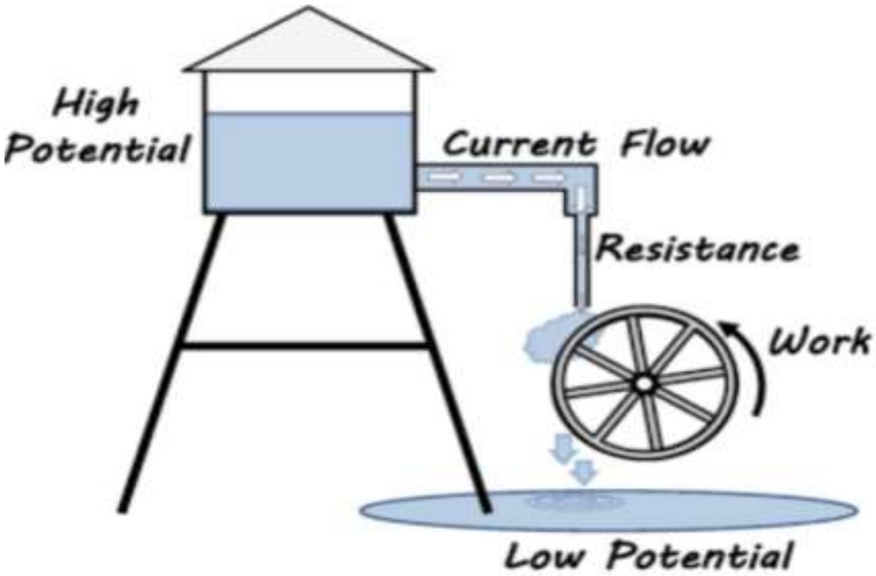
Ohms Law:

Concept:



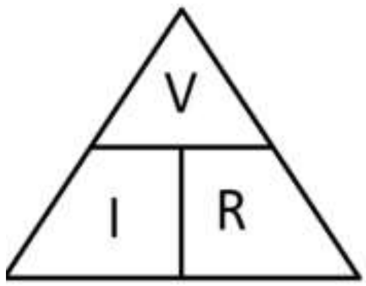
Statement: The p.d. across the ends of a conductor is directly proportional to current provided there is no change in the physical conditions of the conductor.

Mathematical Form:

$$V \propto I$$

$$V = RI \Rightarrow V = IR$$

$$V = I\left(\frac{\rho L}{A}\right)$$



I = V/R

V = IR

R = V/I

Limitations of Ohms Law:

(1) Ohm's Law is only applicable to conductors, not to semi-conductors or insulators.

(2) The physical conditions of the conductor such as its length, cross-sectional Area, temperature etc must be constant. Also the conductor must not be under tension or compression.

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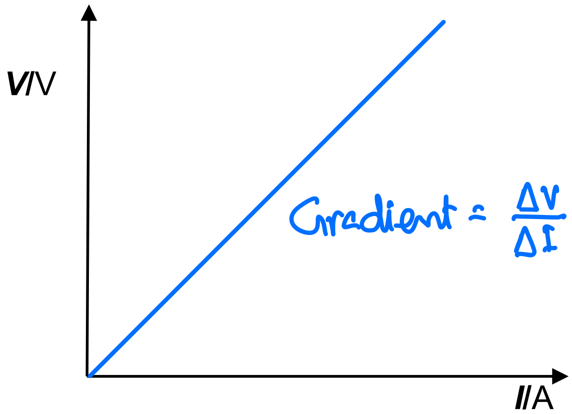
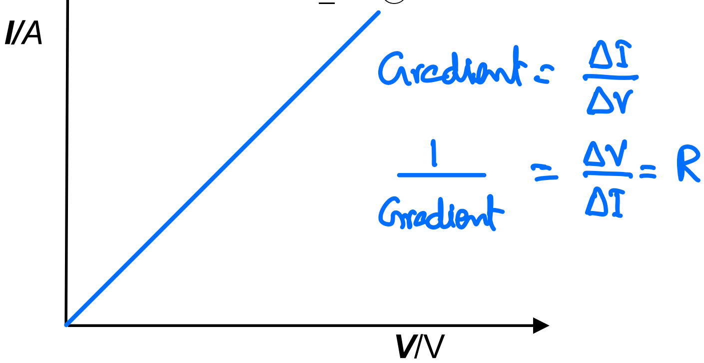
Graph:

$V \propto I \Rightarrow V = RI$





Ohmic & Non-Ohmic Conductors:

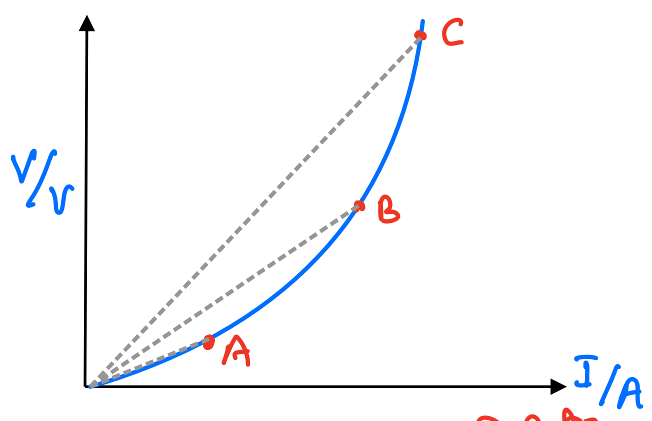
Ohmic Conductors: Materials which obey Ohm's law and provide a straight line graph b/w V/V and I/A due to constant resistance i.e Metals at low temperature.

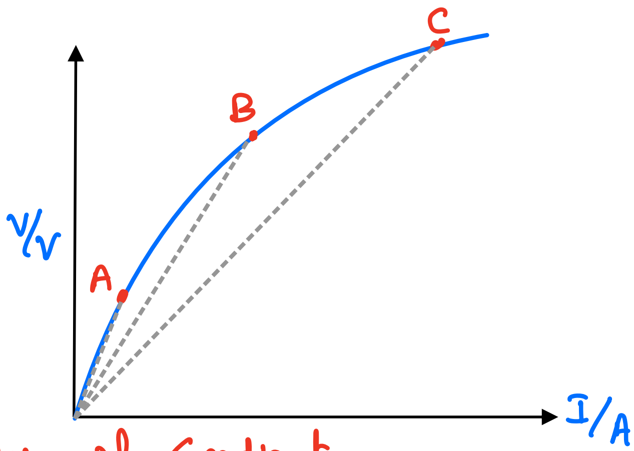
Non-Ohmic Conductors:

Materials which do not obey Ohm's law and provide a curved graph b/w V/V and I/A due to change of resistance.

Note:

For curved graph of V/V and I/A, always draw a straight line from an instantaneous point on graph to origin and get its gradient to define resistance.





	Relative order of Gradient	
$A < B < C$		$A > B > C$

	Relative order of Resistance	
$R_A < R_B < R_C$		$R_A > R_B > R_C$

Graphs of Non-Ohmic materials:

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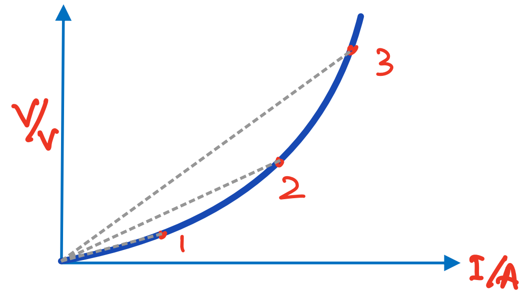
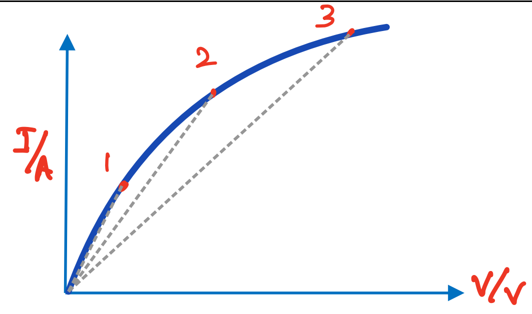
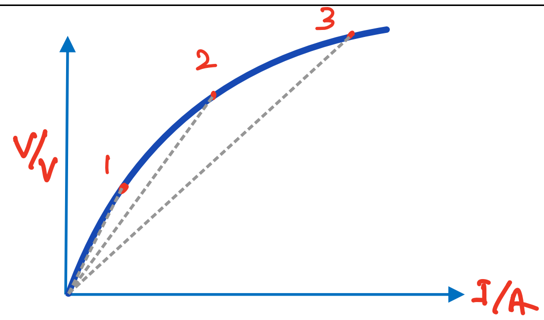
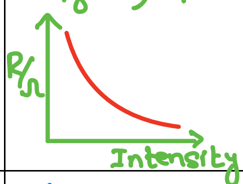
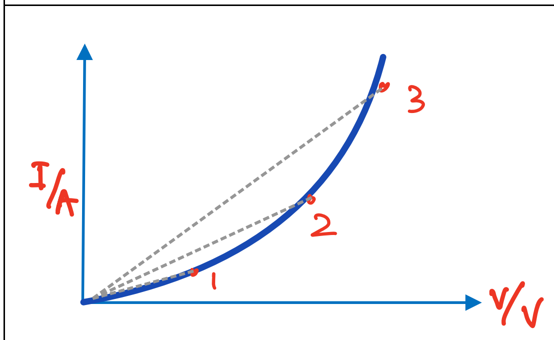
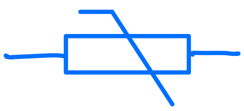
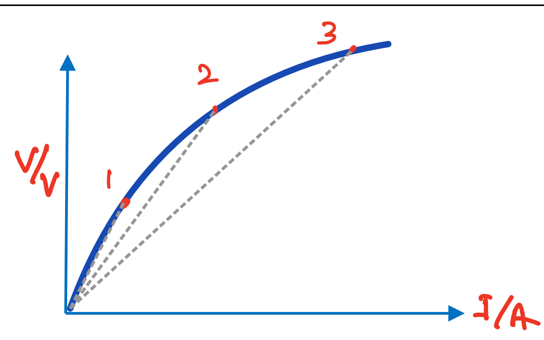
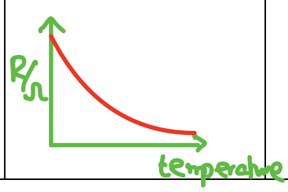
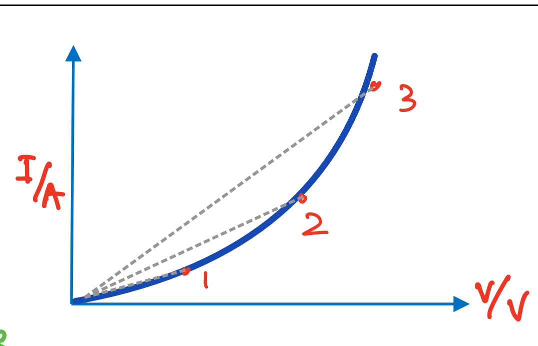
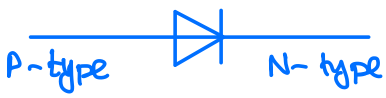
S.No.	Material	Graph	Relative order of Gradient	Relative order of Resistance
1.	Metals at high temperature ie Filament lamp		$1 < 2 < 3$	$R_1 < R_2 < R_3$
	R_{metal} ↑ if (temperature) ↑		$R = \frac{1}{Gradient}$ $1 > 2 > 3$	$R_1 < R_2 < R_3$
2.	Light Dependent Resistor (LDR) 		$1 > 2 > 3$	$R_1 > R_2 > R_3$
	R_{LDR} ↓ if (Intensity of light) ↑ 		$R = \frac{1}{Gradient}$ $1 < 2 < 3$	$R_1 > R_2 > R_3$
3.	Thermistor 		$1 > 2 > 3$	$R_1 > R_2 > R_3$
	R_T ↓ if (temperature) ↑ or vice versa 		$R = \frac{1}{Gradient}$ $1 < 2 < 3$	$R_1 > R_2 > R_3$

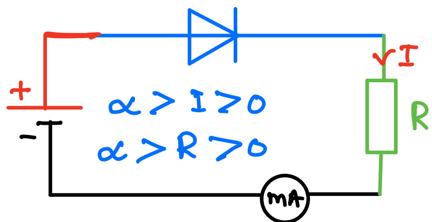
4. Semiconductor – Diode

Symbol :



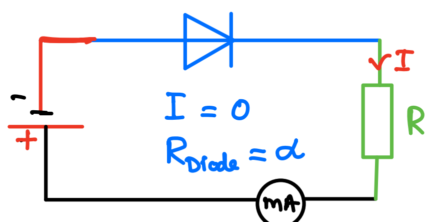
Connectivity / Biasing :-

(i) Forward biasing: If P-type is connected to +ve and N-type to -ve terminal of battery, then Diode is forward biased and conduct. Diode acts as a closed switch in forward biasing.

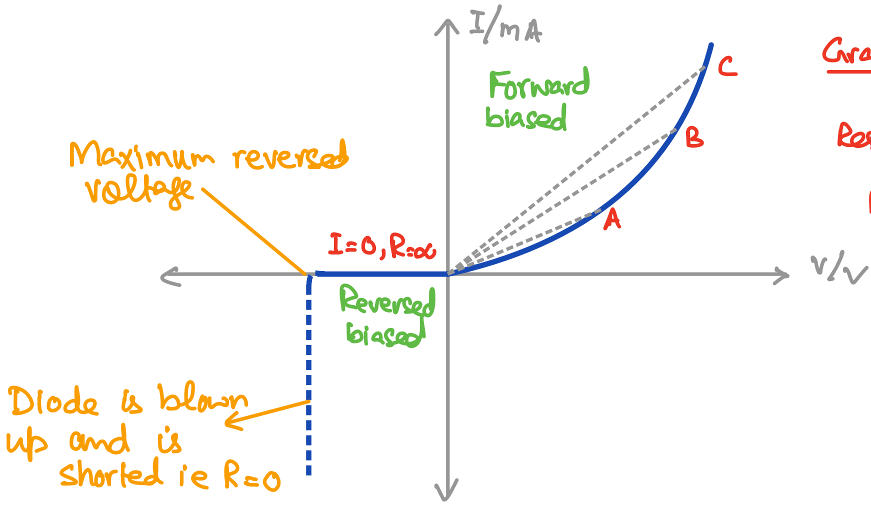


Note: Resistance of Diode in forward biasing decreases.

(ii) Reversed biasing: If P-type is connected to -ve and N-type to +ve terminal of battery, then Diode is reversed biased and does not conduct. Diode acts as an open switch in reversed biasing.



Note: Resistance of Diode in reversed biasing is infinite.



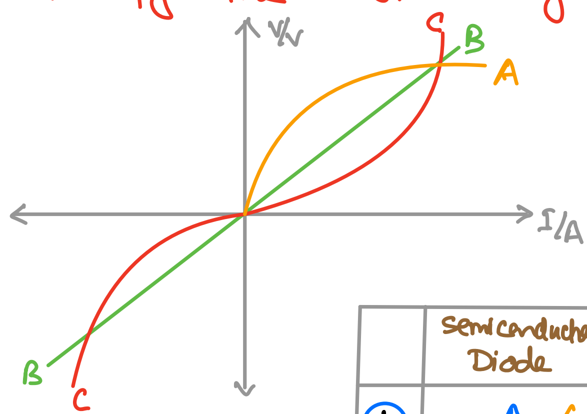
Gradient order:

A < B < C

Resistance = $\frac{1}{\text{Gradient}}$

$R_A > R_B > R_C$

Q) Identify the correct graph.



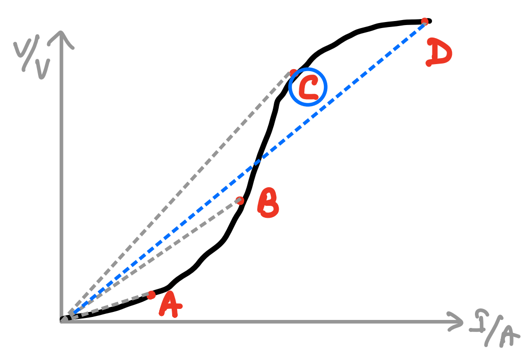
R = Gradient of graph

	Semiconductor Diode	Metal at low temperature	Metals at high temp
(1)	A ✓	B ✓	C ✓
2	B	C	A
3	C	B ✓	A
4	A ✓	C	B

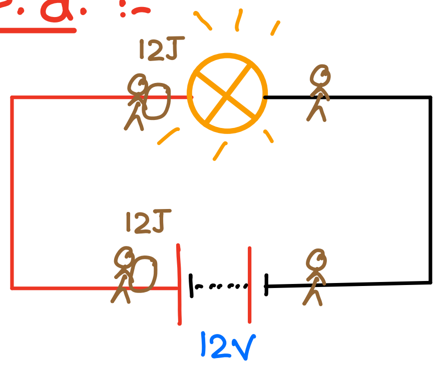
Q) At which position, resistance of a material has maximum value.

R = Gradient

i.e $R_C > R_D > R_B > R_A$



Voltage / P.d. :-



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

$$12V = \frac{12J}{1C}$$

Def Electrical energy converted into any other form per unit charge is p.d./voltage.

OR

Work done per unit charge is p.d.

Symbol : V

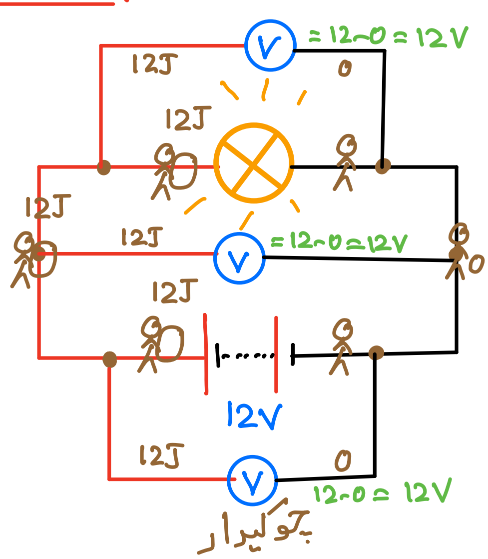
Formula $V = \frac{W}{Q}$

Units : Volt ($1\,\text{volt} = \frac{1\,\text{Joule}}{1\,\text{Coulomb}}$)

P.S : Scalar

Measuring device : Voltmeter

Note :



Internal resistance of voltmeter is infinite. i.e no current can flow through it.

p.d. is always across a component or appliance. ie motor, heater, filament lamp, vacuum cleaner etc

p.d. can only be measured if current flows through a circuit.

Electrical Power:-

Def. Electrical energy transferred per unit time is Power.

Symbol: P

Formula:

$$P = \frac{W}{t}$$

But $V = \frac{W}{Q} \Rightarrow W = VQ$

$$P = \frac{VQ}{t} \Rightarrow P = V\left(\frac{Q}{t}\right)$$

$$\boxed{P = VI}$$

But $V = IR$

$$P = (IR)I$$

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

$$P = (V)\left(\frac{V}{R}\right)$$

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

P.S. Scalar

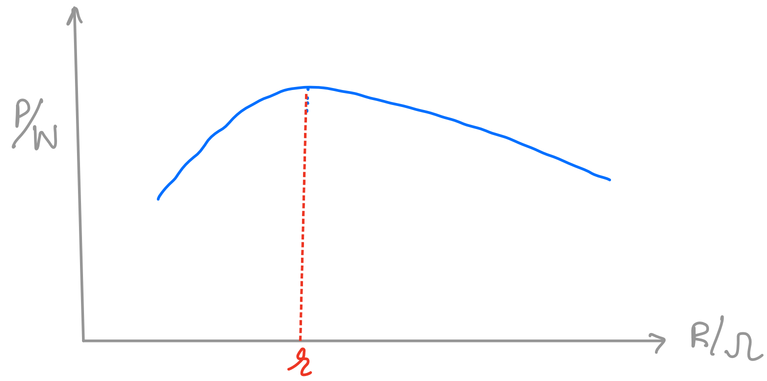
Units. Watt (W)

$$1\ \text{Watt} = \frac{1\ \text{Joule}}{1\ \text{second}}$$

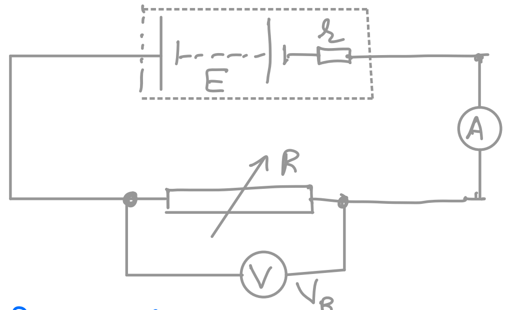
Note:- Power dissipated in a circuit is maximum if

internal resistance of source = External resistance of load

Graph :



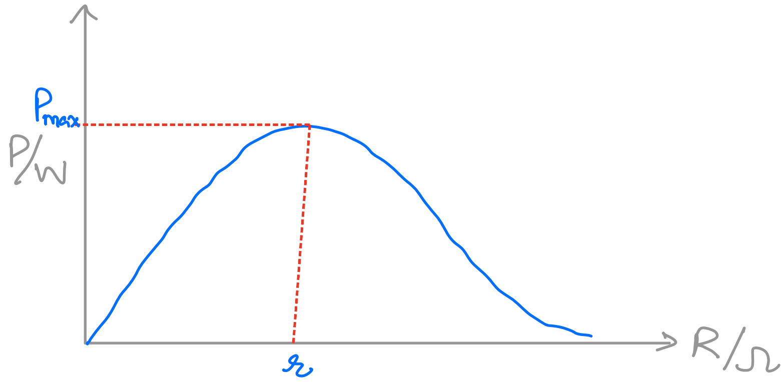
Effect of internal resistance on Power supplied by a battery



The Power delivered by a battery to a variable external load resistance (Rheostat) can be investigated using variable resistor R as shown.
The Power dissipated in the load is given as

$$P_R = (V_R)(I)$$

Graph :-



Note: Battery delivers maximum Power to a circuit when the load resistance of the circuit is equal to the internal resistance of battery.

Electrical Energy:-

$$P = \frac{E}{t}$$

$$E = Pt$$

$$\boxed{E = VIt = I^2Rt = \left(\frac{V^2}{R}\right)t}$$

Units: Joule (J)

Note: Commercial unit of Electrical energy is kilo watt hour (kWh)

$$1\ kWh = (1000)(W)(60 \times 60\ s)$$

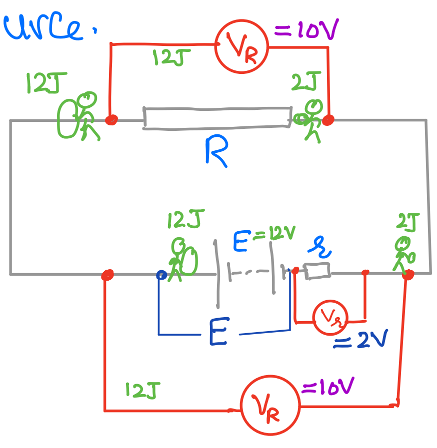
$$= 3.6 \times 10^6\ Ws$$

$$\boxed{1\ kWh = 3.6\ MJ}$$

Terminal p.d:- It is the p.d between terminals of a cell / battery when a current is being delivered.

Lost Voltage:- It is the p.d across internal resistance of source.

Concept:



V_R = Terminal p.d

V_r = Lost voltage

By Principle of conservation of energy

$$E = V_R + V_r$$

Note:

(1) The terminal p.d. is always less than the emf of source when power supply delivers a current. This is because of the potential drop across the internal resistance.

(2) Lost voltage = current × Internal resistance

ie $$V_r = Ir$$

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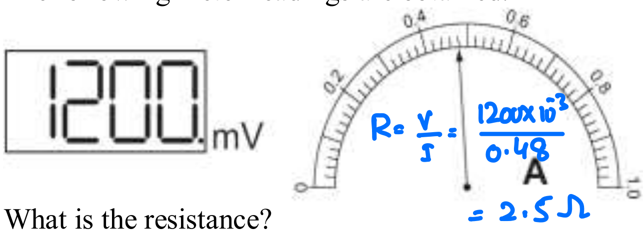
CURRENT OF ELECTRICITY

1. The resistance of an electrical component is measured. The following meter readings are obtained.

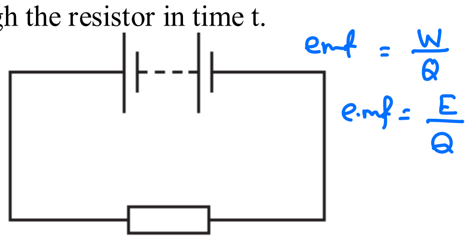


What is the resistance?
A 2.5Ω **B** 2.7Ω **C** 2500Ω **D** 2700Ω
{Q.5/P1/June 2007}

2. What is a correct statement of Ohm's law?
A The potential difference across a component equals the current providing the resistance and other physical conditions stay constant.
B The potential difference across a component equals the current multiplied by the resistance.
C The potential difference across a component is proportional to its resistance.
D The potential difference across a component is proportional to the current in it providing physical conditions stay constant.
{Q. 31/P1/June 2007}

3. The current in a resistor is 8.0 mA.
What charge flows through the resistor in 0.020 s?
A 0.16mC **B** 1.6mC **C** 4.0mC **D** 0.40C
{Q. 32/P1/June 2007}

4. In the circuit below, the battery converts an amount E of chemical energy to electrical energy when charge Q passes through the resistor in time t.

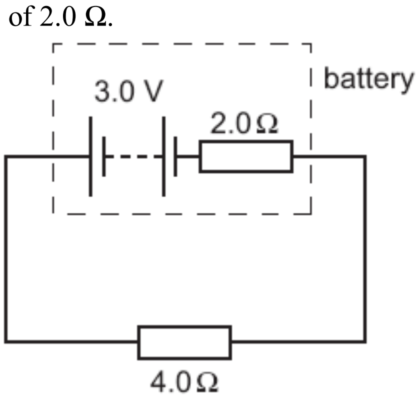


Which expressions give the e.m.f. of the battery and the current in the resistor?

	e.m.f..	current
A	EQ	Q / t
B	EQ	$Q\,t$
C	E / Q	Q / t
D	E / Q	$Q\,t$

{Q. 35/P1/June 2007}

5. A battery has an e.m.f. of 3.0 V and an internal resistance of 2.0 Ω.

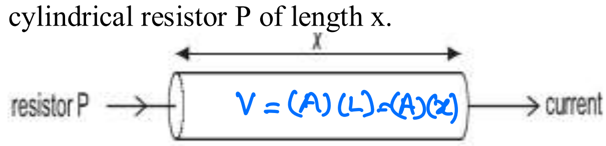


The battery is connected to a load of 4.0 Ω.
What are the terminal potential difference V and output power P?

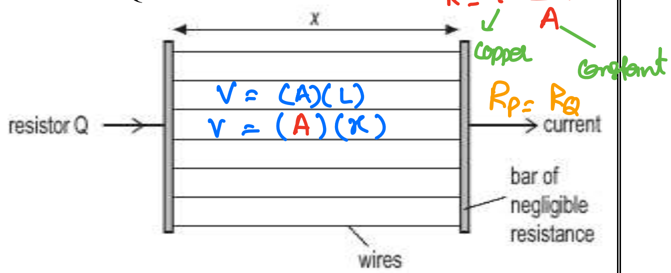
	V / V	P / W
A	1.0	0.50
B	1.0	1.5
C	2.0	1.0
D	2.0	1.5

{Q. 36/P1/June 2007}

6. A researcher has two pieces of copper of the same volume. All of the first piece is made into a cylindrical resistor P of length x.

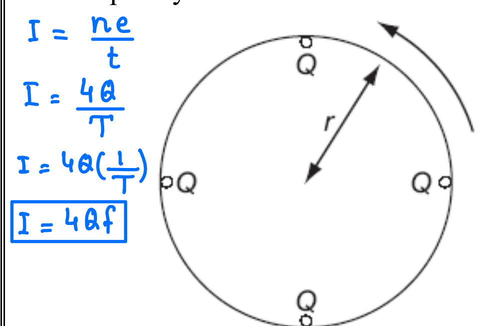


All of the second piece is made into uniform wires each of the same length x which he connects between two bars of negligible resistance to form a resistor Q.



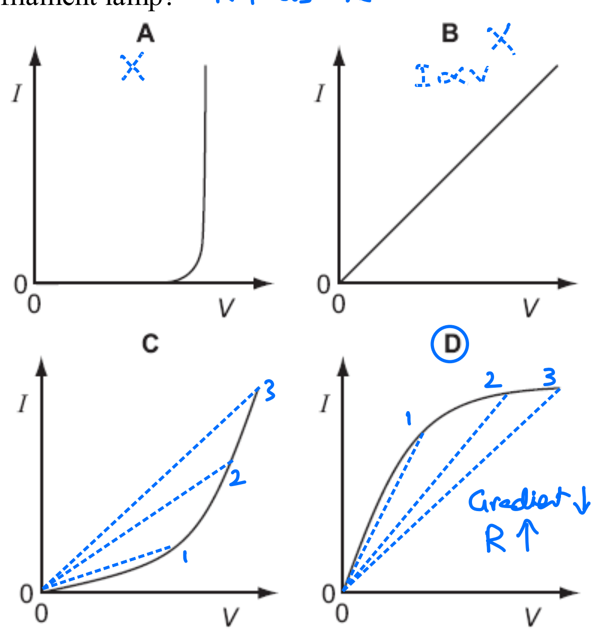
How do the electrical resistances of P and Q compare?
A P has a larger resistance than Q.
B Q has a larger resistance than P.
C P and Q have equal resistance.
D Q may have a larger or smaller resistance than P, depending on the number of wires made.
{Q. 37/P1/June 2007}

7. Four point charges, each of charge Q, are placed on the edge of an insulating disc of radius r.
The frequency of rotation of the disc is f.



What is the equivalent electric current at the edge of the disc?
A $4Qf$ **B** $4Q / f$ **C** $8\pi rQf$ **D** $2Qf / \pi r$
{Q. 31/P1/June 2006, Q.14/P1/9243-June 2001}

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



{Q. 32/P1/June 2006}

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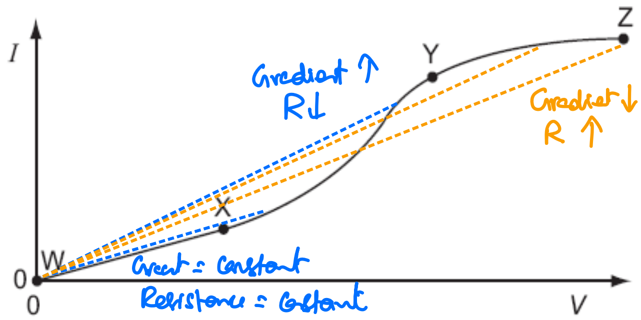
CURRENT OF ELECTRICITY

9. An electrical component has a potential difference V across it and a current I through it. A graph of I against V is drawn and is marked in three sections WX, XY and YZ.



In which ways does the resistance of the component vary within each of the three sections?

	WX	XY	YZ
A	constant	decrease	increase
B	constant	increase	increase
C	increase	decrease	constant
D	increase	increase	decrease

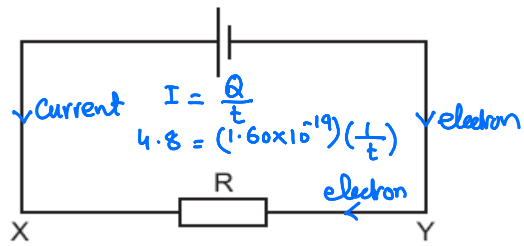
{Q. 33/P1/June 2006}

10. The resistance of a device is designed to change with temperature. What is the device?

A a light-dependent resistor **B** a potential divider
C a semiconductor diode **D** a thermistor

{Q. 35/P1/June 2006}

11. The current in the circuit is 4.8 A.



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

A 3.0×10^{19} s^{-1} in direction X to Y
B 6.0×10^{18} s^{-1} in direction X to Y
C 3.0×10^{19} s^{-1} in direction Y to X
D 6.0×10^{18} s^{-1} in direction Y to X

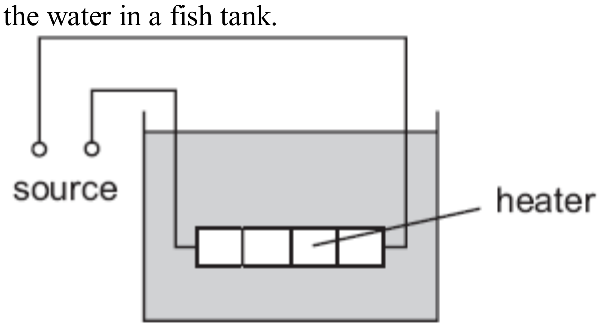
{Q.31/P1/June 2006}

12. Which equation is used to define resistance?

A energy = (current)^2 x resistance x time
B potential difference = current x resistance
C power = (current)^2 x resistance
D resistivity = resistance x area x length

{Q.32/P1/June 2006}

13. The diagram shows a low-voltage circuit for heating the water in a fish tank.

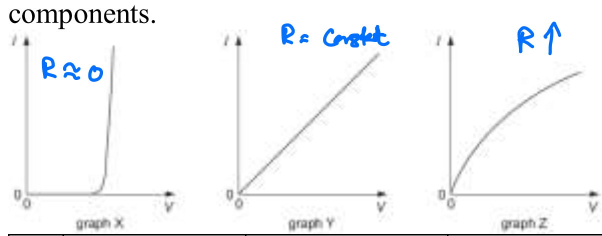


The heater has a resistance of 3.0 Ω. The voltage source has an e.m.f. of 12 V and an internal resistance of 1.0 Ω. At what rate does the voltage source supply energy to the heater?

A 27 W **B** 36 W **C** 48 W **D** 64 W

{Q.34/P1/June 2006}

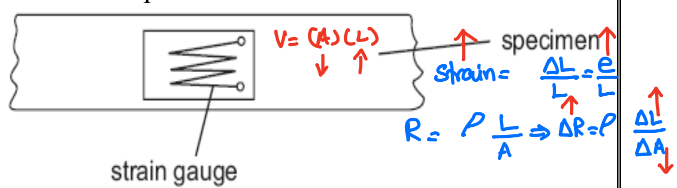
14. The graphs show the variation with potential difference V of the current I for three circuit components.



	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

{Q.32/P1/Nov. 2005}

15. Tensile strain may be measured by the change in electrical resistance of a strain gauge. A strain gauge consists of folded fine metal wire mounted on a flexible insulating backing sheet. The strain gauge is firmly attached to the specimen, so that the strain in the metal wire is always identical to that in the specimen.

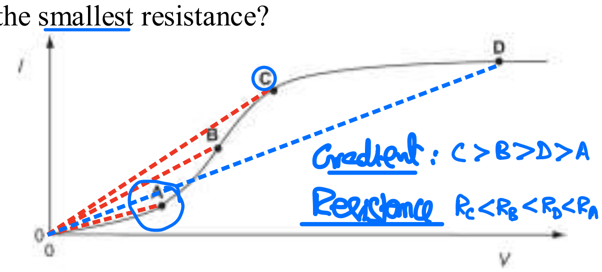


When the strain in the specimen is increased, what happens to the resistance of the wire?

A It decreases, because the length decreases and the cross-sectional area increases.
B It decreases, because the length increases and the cross-sectional area decreases.
C It increases, because the length decreases and the cross-sectional area increases.
D It increases, because the length increases and the cross-sectional area decreases.

{Q.33/P1/Nov. 2005}

16. The graph shows how the electric current *I* through a conducting liquid varies with the potential difference *V* across it.
At which point on the graph does the liquid have the smallest resistance?



{Q.34/P1/Nov. 2005}

17. A copper wire of cross-sectional area 2.0 mm2 carries a current of 10 A.
How many electrons pass through a given cross-section of the wire in one second?

A 1.0×10^{1} **B** 5.0×10^{6}
C 6.3×10^{19} **D** 3.1×10^{25}

{Q.32/P1/June 2005}

18. 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 *R* / 2 **B** R **C** 2 R **D** 4 R

{Q.33/P1/June 2005}

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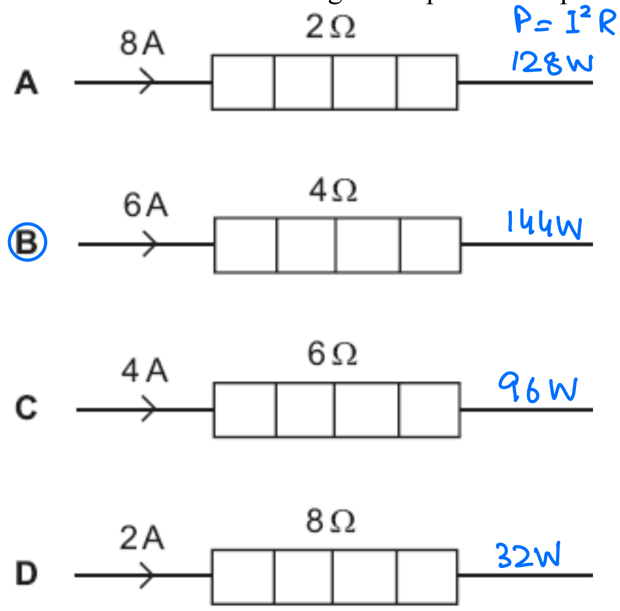
CURRENT OF ELECTRICITY

19. Which of the following 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
{*Q.31/P1/Nov. 2004*}

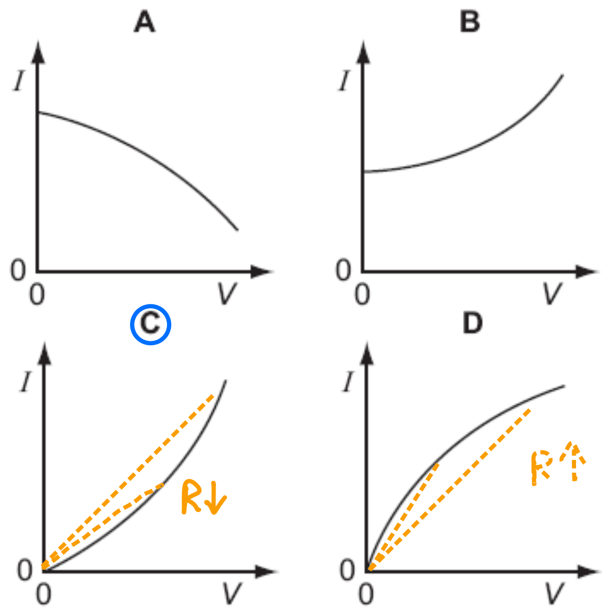
20. The diagram shows four heaters and the current in each. Which heater has the greatest power dissipation?



{*Q.32/P1/ Nov. 2004*}

21. When a potential difference *V* is applied between the ends of a wire of diameter *d* and length *l*, the current in the wire is *I*.
What is the current when a potential difference of 2*V* is applied between the ends of a wire of the same material of diameter 2*d* and the length 2*l* ? Assume that the temperature of the wire remains constant.
A *I* **B** 2*I* **C** 4*I* **D** 8*I*
{*Q.33/P1/ Nov. 2004*}

22. The resistance of a thermistor decreases significantly as its temperature increases. The thermistor is kept in air. The air is at room temperature.
Which graph best represents the way in which the current I in the thermistor depends upon the potential difference V across it?



{*Q.34/P1/Nov. 2004*}

23. Two wires made of the same material and of the same length are connected in parallel to the same voltage supply. Wire P has a diameter of 2 mm. Wire Q has a diameter of 1 mm.
What is the ratio Q in current / P in current ?
A 1 / 4 **B** 1 / 2 **C** 2 **D** 4
{*Q.31/P1/June 2004*}

24. What is an equivalent unit to 1 volt?
A 1 JA^{-1} **B** 1 JC^{-1} **C** 1 WC^{-1} **D** 1 Ws^{-1}
{*Q.32/P1/June 2004*}

25. The terminal voltage of a battery is observed to fall when the battery supplies a current to an external resistor. What quantities are needed to calculate the fall in voltage?
A the battery's e.m.f. and its internal resistance
B the battery's e.m.f. and the current
C the current and the battery's internal resistance
D the current and the external resistance
{*Q.33/P1/June 2004*}

26. The potential difference between point X and point Y is 20 V. The time taken for charge carriers to move from X to Y is 15 s, and, in this time, the energy of the charge carriers changes by 12 J.
What is the current between X and Y?
A 0.040 A **B** 0.11 A
C 9.0 A **D** 25 A
{*Q.34/P1/June 2004*}

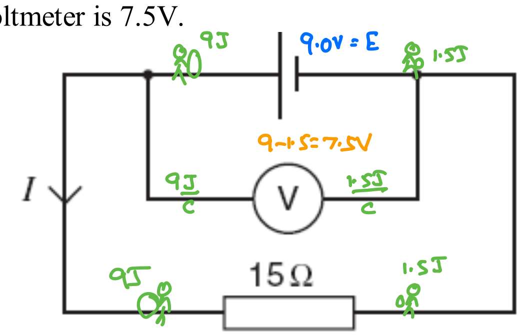
27. Which electrical quantity would be the result of a calculation in which energy is divided by charge?
A current **B** potential difference
C power **D** resistance
{*Q.29/P1/Nov. 2003*}

28. A wire carries a current of 2.0 amperes for 1.0 hour. How many electrons pass a point in the wire in this time?
A 1.2×10^{-15} **B** 7.2×10^{3}
C 1.3×10^{19} **D** 4.5×10^{22}
{*Q.30/P1/Nov. 2003*}

29. What physical quantity would result from a calculation in which a potential difference is multiplied by an electric charge?
A electric current **B** electric energy
C electric field strength **D** electric power
{*Q.29/P1/June 2003*}

30. The current in a component is reduced uniformly from 100 mA to 20 mA over a period of 8.0 s.
What is the charge that flows during this time?
A 160mC **B** 320mC
C 480mC **D** 640mC
{*Q.30/P1/June 2003*}

31. The e.m.f. of the cell in the following circuit is 9.0V. The reading on the high-resistance voltmeter is 7.5V.

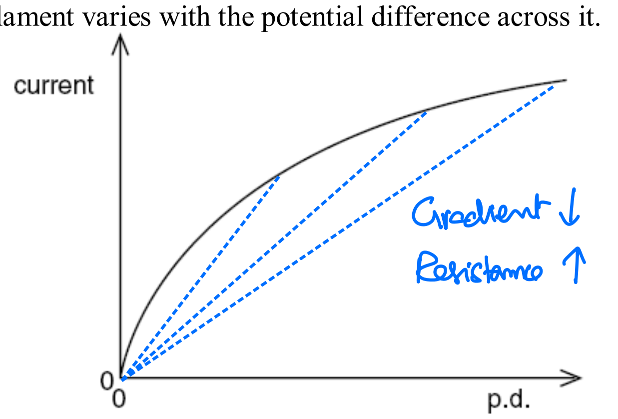


What is the current *I* ?
A 0.1A **B** 0.5A **C** 0.6A **D** 2.0A
{*Q.32/P1/June 2003*}

32. Which equation is used to define resistance?
A power = $(\text{current})^2$ x resistance
B resistivity = resistance x area ÷ length
C potential difference = current x resistance
D energy = $(\text{current})^2$ x resistance x time

{*Q.30/P1/Nov. 2002*}

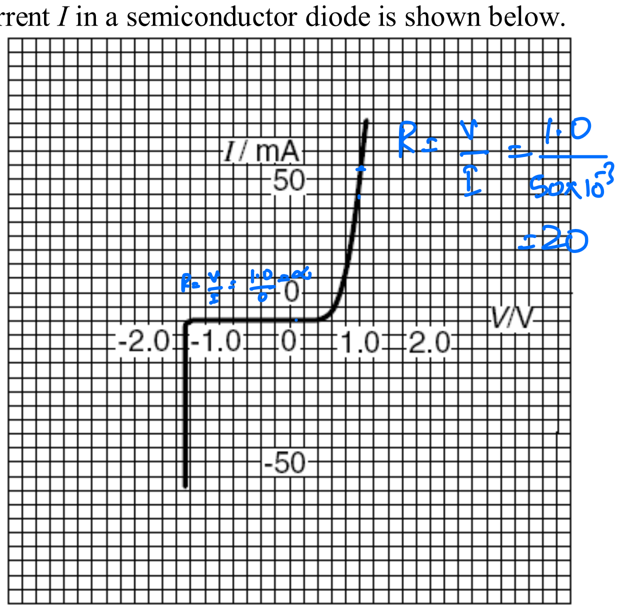
33. The graph shows how the current through a lamp filament varies with the potential difference across it.



Which statement explains the shape of this graph?
A As the filament temperature rises, electrons can pass more easily through the filament.
B It takes time for the filament to reach its working temperature.
C The power output of the filament is proportional to the square of the current through it.
D The resistance of the filament increases with a rise in temperature.

{*Q.31/P1/Nov. 2002*}

34. The variation with potential difference *V* of the current *I* in a semiconductor diode is shown below.

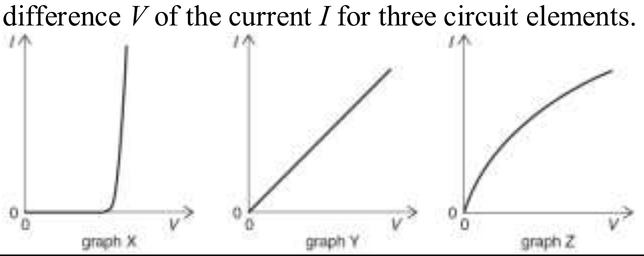


What is the resistance of the diode for applied potential differences of +1.0 V and –1.0 V?

	resistance	
	+1.0 V	–1.0 V
A	20 Ω	infinite
B	20 Ω	Zero
C	0.05 Ω	Infinite
D	0.05 Ω	zero

{*Q.32/P1/Nov. 2002*}

35. The graphs show the variation with potential difference *V* of the current *I* for three circuit elements.

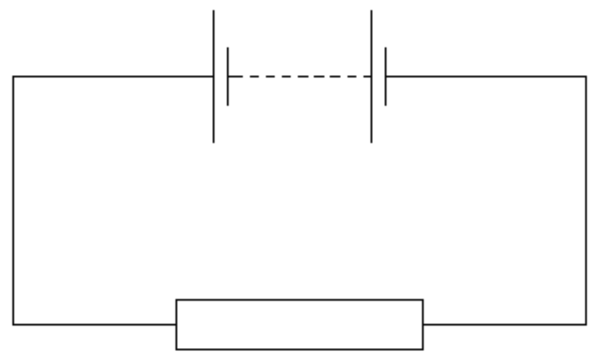


The three circuit elements are a metal wire at constant temperature, a semiconductor diode and a filament lamp. Which row of the table correctly identifies these graphs?

	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

{*Q.30/P1/June 2002*}

36. In the circuit below, the battery converts an amount *E* of chemical energy to electrical energy when charge *Q* passes through the resistor in time *t*.



Which expressions give the e.m.f. of the battery and the current in the resistor?

	e.m.f.	Current
A	*EQ*	*Q/t*
B	*EQ*	*Qt*
C	*E/Q*	*Q/t*
D	*E/Q*	*Qt*

{*Q.31/P1/June 2002*}

37. The filament of a 240 V, 100W 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 this lamp at room temperature?

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

{*Q.34/P1/June 2002*}

ANSWERS

Q.No.	Answer	Q.No.	Answer
1.		20.	
2.		21.	
3.		22.	
4.		23.	
5.		24.	
6.		25.	
7.		26.	
8.		27.	
9.		28.	
10.		29.	
11.		30.	
12.		31.	
13.		32.	
14.		33.	
15.		34.	
16.		35.	
17.		36.	
18.		37.	
19.			

21. When a potential difference V is applied between the ends of a wire of diameter d and length l, the current in the wire is I.
What is the current when a potential difference of $2V$ is applied between the ends of a wire of the same material of diameter $2d$ and the length $2l$? Assume that the temperature of the wire remains constant.

A I **B** $2I$ **(C)** $4I$ **D** $8I$

{Q.33/P1/ Nov. 2004}

$V_1 = V$, $I_1 = I$, $d_1 = d$, $L_1 = L$

$V_2 = 2V$, $d_2 = 2d$, $L_2 = 2L$, $I_2 = ?$

$$V = IR$$
$$V = I\frac{\rho L}{A}$$
$$I = \frac{VA}{\rho L}$$
$$I = \frac{V\left(\frac{\pi d^2}{4}\right)}{\rho L}$$
$$I = \frac{\pi V d^2}{4\rho L}$$

$$A = \pi r^2 = \pi\left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$$

$$\frac{I_2}{I_1} = \frac{\frac{\pi V_2 d_2^2}{4\rho L_2}}{\frac{\pi V_1 d_1^2}{4\rho L_1}} = \frac{\frac{V_2 d_2^2}{L_2}}{\frac{V_1 d_1^2}{L_1}}$$

$$\frac{I_2}{I_1} = \left(\frac{V_2 d_2^2}{L_2}\right)\left(\frac{L_1}{V_1 d_1^2}\right)$$

$$\frac{I_2}{I} = \left[\frac{(2V)(4d^2)}{2L}\right]\left[\frac{L}{(V)(d^2)}\right]$$

$$I_2 = 4I$$

(23) Two wires made of the same material and of the same length are connected in parallel to the same voltage supply. Wire P has a diameter of 2 mm. Wire Q has a diameter of 1 mm.
What is the ratio Q in current / P in current ?

(A) 1 / 4 **B** 1 / 2 **C** 2 **D** 4

{Q.31/P1/June 2004}

Wire P	Wire Q
$\rho_P = \rho$	$\rho_Q = \rho$
$L_P = L$	$L_Q = L$
$V_P = V$	$V_Q = V$
$d_P = 2mm$	$d_Q = 1mm$

$$V_P = V_Q$$
$$I_P R_P = I_Q R_Q$$
$$I_P \frac{\rho_P L_P}{\frac{\pi d_P^2}{4}} = I_Q\left(\frac{\rho_Q L_Q}{\frac{\pi d_Q^2}{4}}\right)$$
$$\frac{(I_P)(\rho)(L)}{(2)^2} = \frac{I_Q(\rho)(L)}{(1)^2}$$
$$\frac{I_Q}{I_P} = 1:4$$