Electrostatics and Electrical quantities

Following subtopics will be covered in this unit:

- ✓ Electric charge
- ✓ Electric current
- ✓ Electromotive force
- ✓ Potential difference
- ✓ Resistance
- ✓ Electrical working

Electric charge

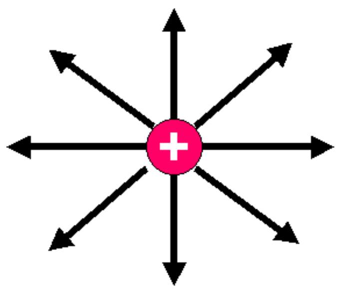
- There are 2 kinds of charges; namely the positive and the negative charge.
- Unlike charges attract and like charges repel.
- Charge is measured in coulombs.

==

Electric field:

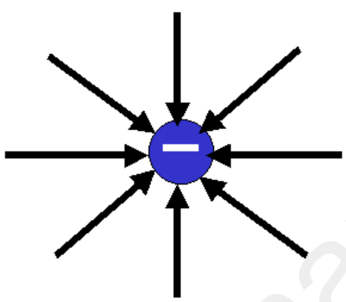
A region around a charged particle or object within which a force would be exerted on other charged particles or objects is called as an electric field

----

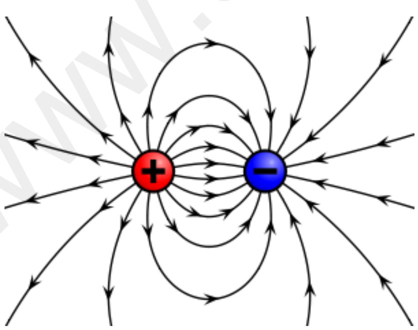


Electric field around a positive charge: The electric field is radially outward from a positive charge

----

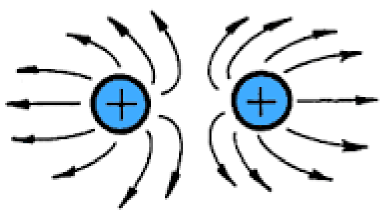


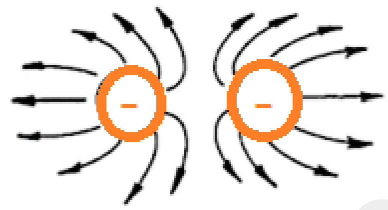
Electric field around a negative charge: The electric field is radially in towards a negative point charge.



Electric field between unlike charges: The electric field lines originate from the positive point charge and travel towards the negative point charge.

Electric field between like charges: The lines of force radiate away from the individual charges. There is no field between the two charges. This region of no field is indicated by the absence of the electric field lines.,



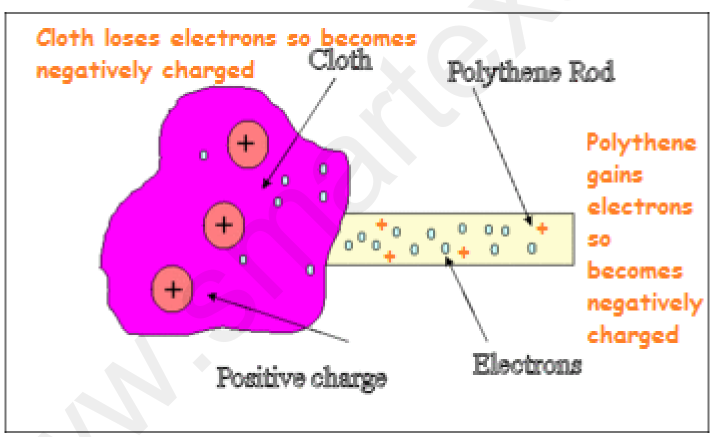


Electrostatic charges:

Production of electrostatic charges:

When two insulators are rubbed on each other, electrons are transferred from one insulator to the other. Hence charges are produced on the insulators. These charges stay on the insulators. Hence these charges are called as electrostatic charges.

Example:



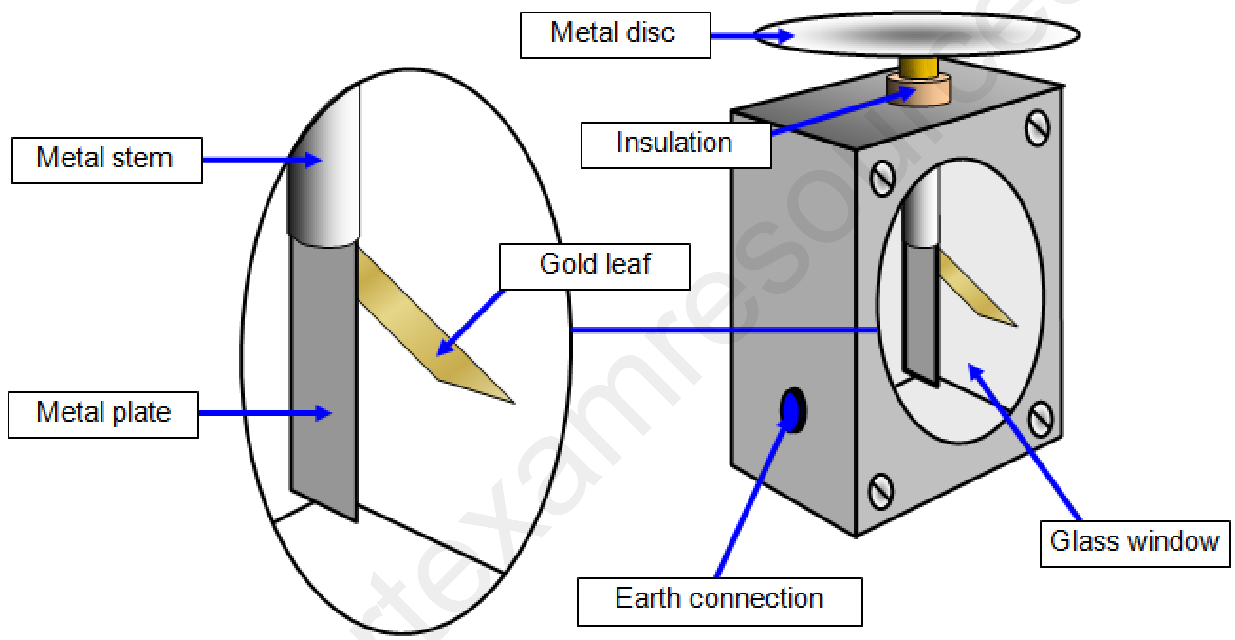
When the polythene rod is rubbed on a cloth, some electrons leave the cloth and move to the polythene rod.So the polythene rod has more electrons than protons so it develops a negative charge. Similarly, the cloth loses electrons so it becomes positively charged.

Detection of electrostatic charges:

Electrostatic charges can be detected by a gold leaf electroscope.

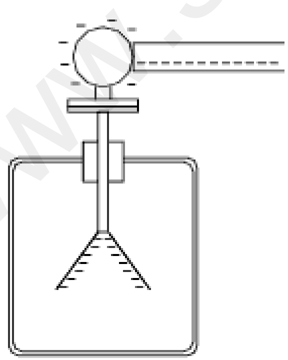
An electroscope is a device that detects static electricity by using thin metal or plastic leaves, which separate when charged.

A metal disc is connected to a narrow metal plate and a thin piece of gold leaf is fixed to the plate. The whole of this part of the electroscope is insulated from the body of the instrument. A glass front prevents air draughts but allows you to watch the behaviour of the leaf.



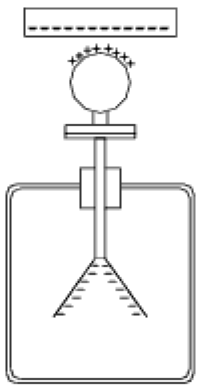
The electroscope can be charged in two ways:

(a) By contact - a charged rod say a negatively charged rod is touched on the surface of the disc then some of the negative charge is transferred to the electroscope. This charge flows through the electroscope leaves and they develop a negative charge and hence repel



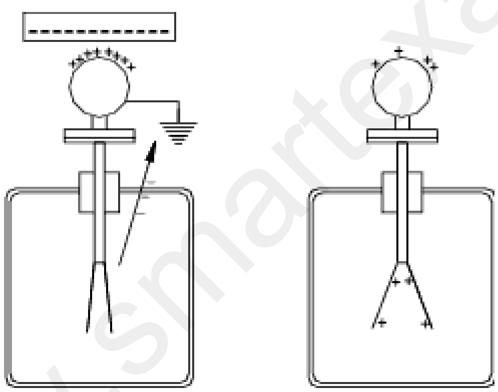
(b)By induction - a charged rod is brought up to the disc and then the electroscope is earthed, the rod is then removed.

- Imagine a charged rod; say a negavitely charged rod is brought close to the conducting surface of the electroscope.

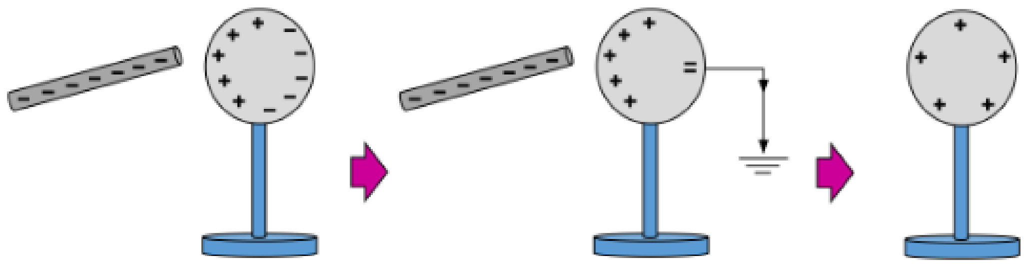


- Separation of charges takes place and the part of the conducting sphere close to the rod develops a positive charge.Negative charges are repelled they flow to the leaves of the electroscope. Since the leaves have the same charge, they repel.

- But if the electroscope is earthed, the electrons flow through the earth and the sphere becomes positively charged.

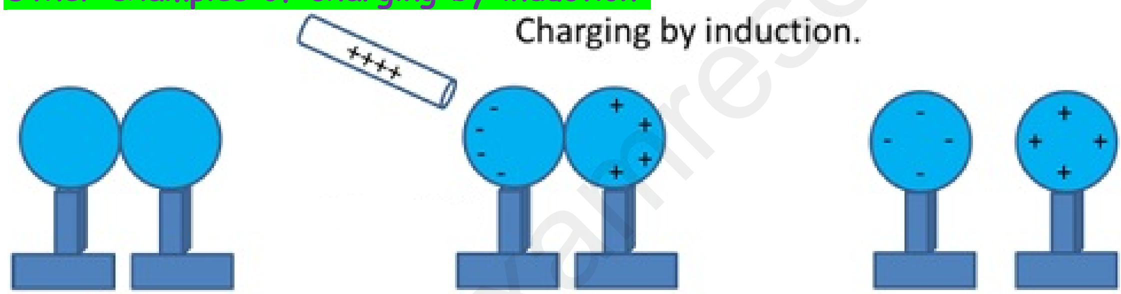


Charging by induction:



- When a negatively charged rod is brought near a sphere, the electrons close to the rod are repelled and hence a charge separation occurs.
- When such a sphere is now earthed, the excess electrons from the right side of the sphere leave the sphere and the sphere is left with a complete positive charge only.

Other examples of charging by induction:

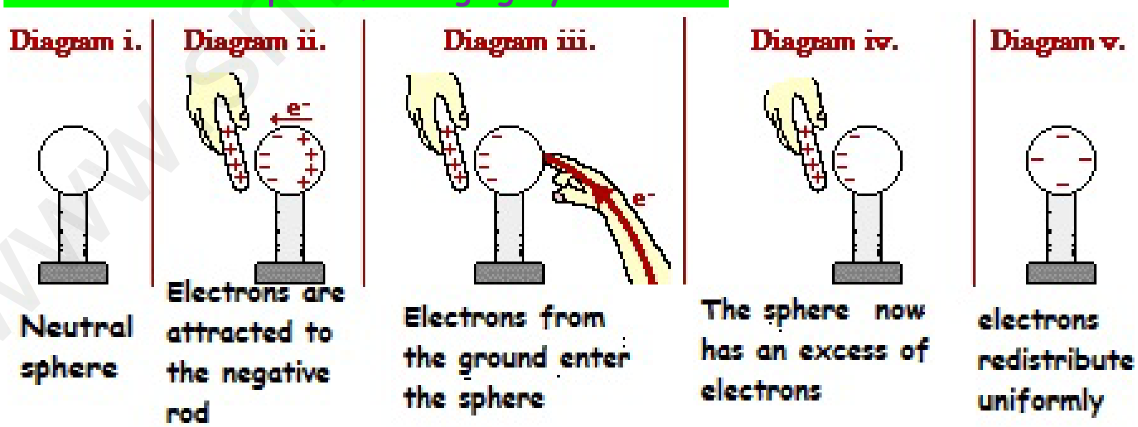


Uncharged Metal spheres

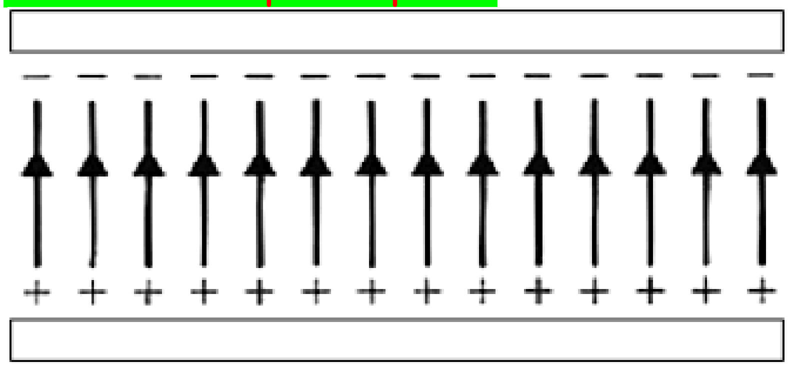
A +vely charged rod charges one sphere with -ve charge. The other sphere automatically gets +vely charge.

When the spheres are separated, the charges get equally distributed.

Some more examples of charging by induction:



Field between 2 parallel plates:



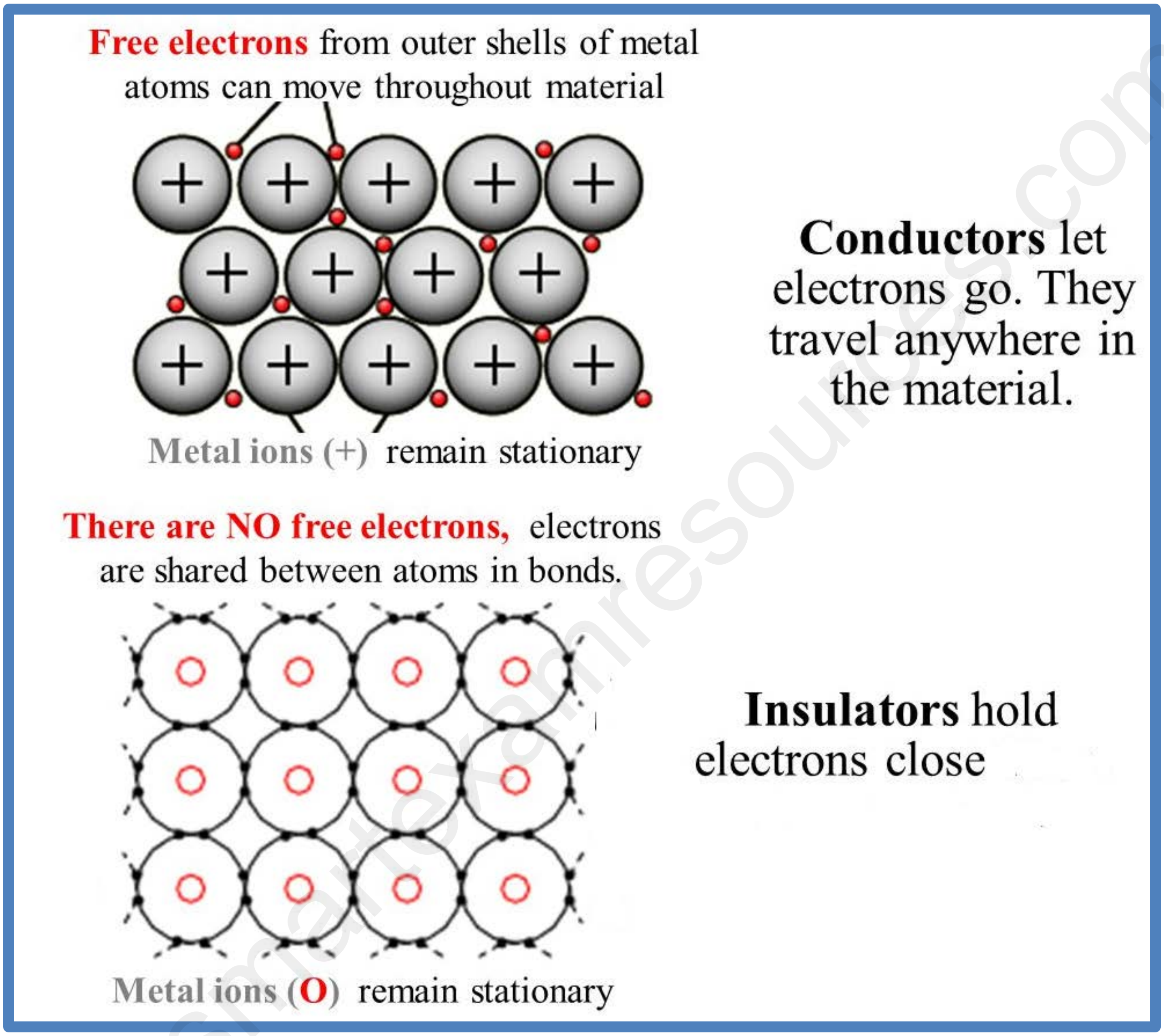
The direction of field lines are from the positively charged plate to the negatively charged plate.

Difference between electrical conductors and insulators

Electrical conductors	Electrical insulators
Substances that allow electricity to pass through them are called as conductors	Substances that do not allow electricity to pass through them are called as insulators
Electrical resistances of conductors are very low	Electrical resistances of insulators are very high
They contain large number of free electrons	They do not contain free electrons
Generally metals are conductors. Example, copper, silver, gold etc	Generally non- metals are insulators. Example: plastics, rubbers, polystyrene etc

---

Simple electron model to distinguish between conductors and insulators



Current:

- Current is related to the flow of electrons.
- Ammeter is used to measure electric current.
- Ammeter can be analogue or digital.
- Ammeter is always connected in series with the component whose current needs to be measured.
- Metals conduct electricity because they have free(mobile) electrons.
- Electrons flow from the negative terminal of the power supply to the positive.
- Conventional current flows from positive terminal of the power supply to the negative.
- Current is the rate of flow of charge=$I = \frac{q}{t}$

Electromotive force:

- Electromotive force is measured across the power supply using a voltmeter
- It is measured in volts
- Emf is defined as the energy supplied by a source in driving the charge round a complete circuit.

Potential difference :

- Potential difference is measured across the electrical components using a voltmeter
- Unit of potential difference is volts(V).
- Voltage is measured using an analogue or digital voltmeter.

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

----------------------------=------------------------------

Resistance:

- A resistor is a component designed to offer a particular resiustance .
- Resistors are usually made from metal wires or carbon.
- Resistance= $\frac{Potential\ difference}{Current} \Longrightarrow R = \frac{V(volts)}{I(\ amperes)}$
- Unit of resistance is ohms (Ω)
- Resistance is measured using an ohmmeter

Uniform wire: A wire that has the same diameter all along its length is said to be a uniform wire.

The resistance of a uniform wire depends upon the following factors

- material- e.g. copper has lower resistance than steel
- length - longer wires have greater resistance
- thickness - smaller diameter wires have greater resistance
- temperature - heating a wire increases its resistance

Current -voltage characteristic of:

- an ohmic resistor
- filament lamp

===

Ohm's law:

Statement: The current in a resistor at constant temperature is proportional to the potential difference across the resistor

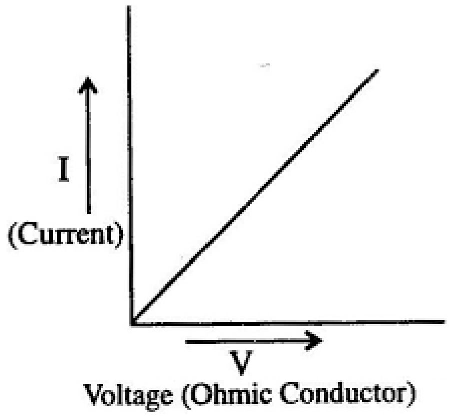
===

Conductors that follow ohms law are called as ohmic conductors. Those that do not follow are called as non-ohmic conductors.

===

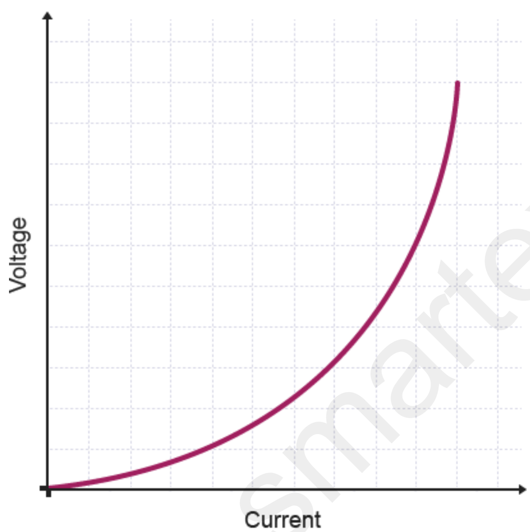
==

Ohmic conductor:



- A linear resistor is ohmic conductor.
- Ohmic examples include all metals like Cu and Al.
- Graph for a ohmic conductor

Non-ohmic conductor:



- A light-bulb is a non-ohmic conductor.
- It's voltage-current graph does not follow a straight line.
- A lightning arrestor, a diode are non ohmic conductors
- Graph for a non ohmic conductor

==

Electrical energy supplied and potential difference:

Energy= power x time

Electrical power= current x potential difference x time

= IVt

where; I = current in amperes

V=potential difference

t= time taken in seconds

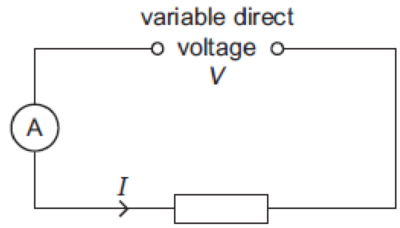
Note:

- For a resistor of resistance R, the pd across it, V=IR when the current in it is I.
- In time t, the electrical energy developed in the resistor $=I^2RT$

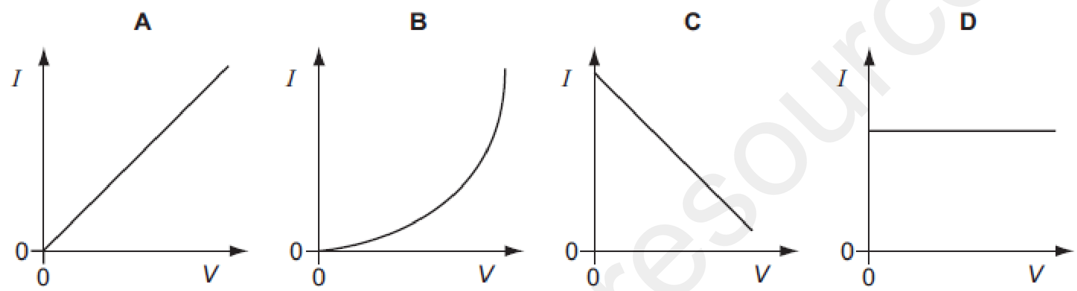
APPLICATION BASED QUESTIONS

28 Using the circuit shown, the current I is found for various voltages V. The temperature of the resistor does not change.

0625/11/M/J/09

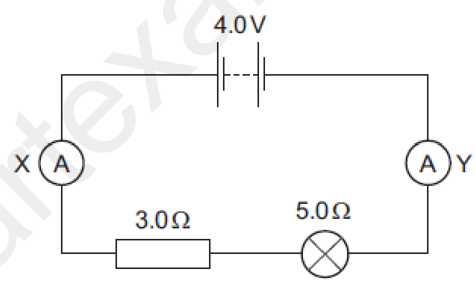


Which graph shows the results obtained?



29 In the circuit shown, ammeter X reads 0.5 A.

0625/11/M/J/09



What does ammeter Y read?

A 0 **B** 0.5 A **C** 3.5 A **D** 4.0 A

28 The table shows the lengths and diameters of four copper wires.

Which wire has the **least** resistance?

0625/11/M/J/10

	length / m	diameter / mm
A	0.50	1.0
B	0.50	2.5
C	0.75	1.0
D	0.75	2.5

28 A polythene rod repels an inflated balloon hanging from a nylon thread.

What charges must the rod and the balloon carry?

0625/11/M/J/11

A The rod and the balloon carry opposite charges.

B The rod and the balloon carry like charges.

C The rod is charged but the balloon is not.

D The balloon is charged but the rod is not.

29 In which unit is potential difference measured?

0625/13/M/J/12

A ampere

B ohm

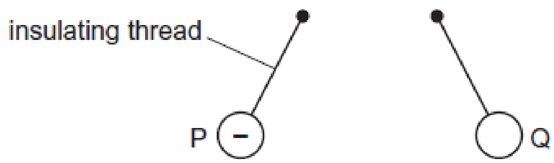
C volt

D watt

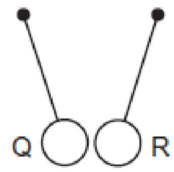
28 Three charged balls, P, Q and R are suspended by insulating threads. Ball P is negatively charged.

0625/11/M/J/13

Ball Q is brought close to ball P.



Ball Q is now brought close to ball R.



What are the charges on ball Q and on ball R?

	ball Q	ball R
A	positive	positive
B	positive	negative
C	negative	positive
D	negative	n

---

27 The diagram shows a piece of metal resistance wire.

0625/11/M/J/15

Which wire, made of the same metal, has a smaller resistance?

A a wire of the same length with a larger diameter

B a wire of the same length with a smaller diameter

C a wire of greater length with the same diameter

D a wire of greater length with a smaller diameter

---

28 What is the unit of electromotive force (e.m.f.)? **0625/11/M/J/15**

A ampere

B joule

C volt

D watt

APPLICATION BASED QUESTION-EXTENDED THEORY

10 Fig. 10.1 shows two parallel conducting plates connected to a very high voltage supply.

M/J/15-P31

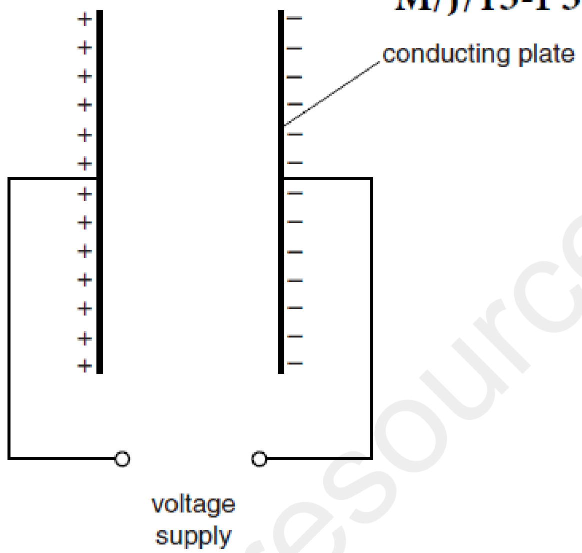


Fig. 10.1

The left-hand plate is positively charged and the right-hand plate is negatively charged.

(a) On Fig. 10.1, draw the electric field pattern produced between the charged plates. Use arrows to show the direction of the field. [2]

(b) A light, conducting ball is suspended by an insulating string. Fig. 10.2 shows the ball in the middle of the gap between the plates.

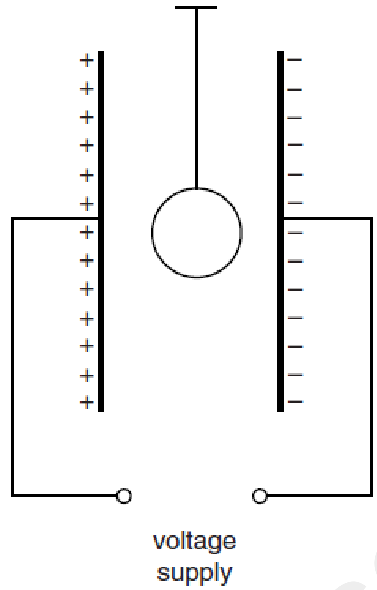


Fig. 10.2

On Fig. 10.2, show the distribution of charge on the ball. [2]

(c) The ball is displaced to the left and then oscillates backwards and forwards between the two plates.

The ball touches a plate once every 0.05 s. Every time it touches a plate, a charge of 2.8×10^{-8} C (0.000 000 028 C) is transferred.

Calculate the average current produced by the repeated transfer of charge.

current = ... [2]

[Total: 6]