Edexcel Physics IGCSE

Topic 2: Electricity

Summary Notes

(Content in bold is for physics only)

Mains electricity

Dangers of electricity

Hazards:

- Damaged insulation – contact with the wire due to gaps in the insulation can cause an electric shock or pose a fire hazard by creating a short circuit.
- Overheating of cables – high currents passing through thin wire conductors cause the wires to heat up to very high temperatures which could melt the insulation and cause a fire.
- Damp conditions – water can conduct a current so wet electrical equipment can cause an electric shock.

Fuses and circuit breakers:

- A fuse is a thin piece of wire which overheats and melts if the current is too high, protecting the circuit. They have a current rating which should be slightly higher than the current used by the device in the circuit. The most common are 3A, 5A and 13A.
- Circuit breakers consist of an automatic electromagnet switch which which breaks the circuit if the current rises over a certain value. This is better than a fuse as it can be reset and used again, and they operate faster.

Earthing metal cases:

- Earth wires creates a safe route for current to flow through in the case of a short circuit, preventing electric shocks.
- Earth wires have a very low resistance so a strong current surges through them which breaks the fuse and disconnects the appliance.

Double insulation:

- Appliances with double insulation have either plastic casings or have been designed so that the earth wire cannot touch the metal casing, preventing them from giving an electric shock.

Electrical transfer of energy

Energy, measured in joules (J), is transferred from chemical energy in the battery to electrical energy used by circuit components and then to the surroundings.

- The power of a component is measured in watts (W) and is given by P=IV (by using V=IR, this can be shown to be equivalent to $P=I^2R$ and $P=V^2/R$). Using this equation, the energy transferred is given by E=IVt.

Alternating current and direct current

In a direct current, the current only flows in one direction whereas in an alternating current, the current continuously changes direction.

Mains electricity is an alternating current (a.c.) whereas the current supplied by a cell or battery is direct current (d.c.).

Energy and voltage in circuits

Current

Current I is measured in amperes (A) and is the rate of flow of charge at a point in the circuit.

- The current is given by I=Q/t, where Q is measured in coulombs (C) and t in seconds (s).
- In metals, current is due to a flow of electrons. Because electrons are negatively charged, conventional current (which is the rate of flow of positive charge) is in the opposite direction to the flow of electrons.
- Current is conserved at a junction in a circuit because charge is always conserved.

Potential difference

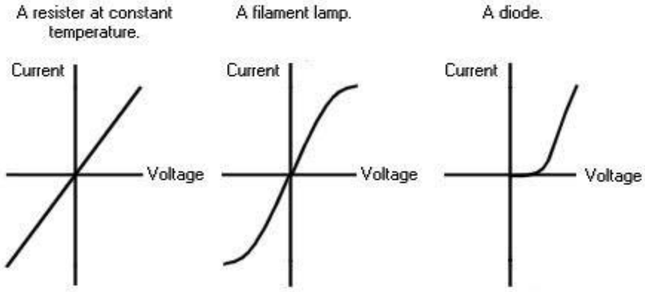
Potential difference V is measured in volts (V where 1 V = 1 JC^{-1}) and is the work done per unit charge in moving between two points in a circuit.

- The potential difference is given by V=E/Q.
- It is measured with a voltmeter placed in parallel across the component.
- The higher the potential difference, the greater the current.

Resistance

The resistance of a component is measured in ohms (Ω) and is given by the potential difference across it divided by the current through it, i.e. R=V/I. The greater the resistance, the harder it is for current to flow through the component.

In an ohmic conductor (such as a resistor at a constant temperature), the current is directly proportional to the voltage (i.e. it has constant resistance). In a non-ohmic conductor (such as a filament lamp), the resistance changes as the voltage and current changes.



In a filament lamp, this is because as the current increases through the filament, so does the temperature, which means electrons and ions vibrate more and collide more, increasing resistance.

A thermistor is a resistor whose resistance decreases as the temperature increases.
A light dependent resistor is a resistor whose resistance decreases as light intensity increases.

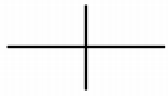
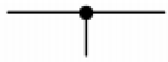
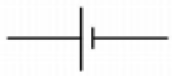
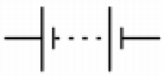
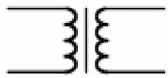
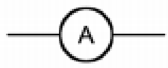
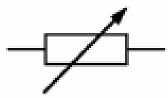
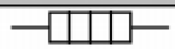
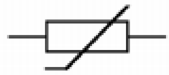
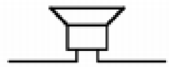
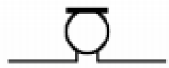
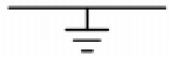
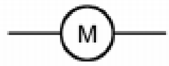
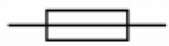
Electric circuits

Series:

- Components are connected end to end in one loop
- The same current flows through every component
- The potential difference is shared across each component (i.e. the sum of the p.d.s across the components is equal to the total p.d. across the supply).
- The total resistance is the sum of the resistances of each component $R_T = R_1 + R_2 + \dots$

Parallel:

- Components are connected to the power supply in separate branches
- The current is shared between each branch (i.e. the sum of the currents in the separate branches is equal to the current through the source)
- The potential difference is the same across every branch
- Connecting lamps in parallel is advantageous because if one breaks, current can still pass through the rest.

Description	Symbol
Conductors crossing with no connection	
Junction of conductors	
Open switch	
Cell	
Battery of cells	
Power supply (DC)	
Power supply (AC)	
Transformer	
Ammeter	
Voltmeter	
Fixed resistor	
Variable resistor	
Heater	
Thermistor	
Light-dependent resistor (LDR)	
Diode	
Light-emitting diode (LED)	
Lamp	
Loudspeaker	
Microphone	
Electric bell	
Earth or ground	
Motor	
Generator	
Fuse/circuit breaker	

Electric charge

Charge is measured in coulombs. There are positive and negative charges; unlike charges attract and like charges repel.

- Charging a body involves the addition or removal of electrons.
- Conductors such as metals allow electrons to flow through them whereas insulators such as plastics impede the flow of electrons.
  - When two insulators are rubbed together, electrons move from one to the other and they become charged. For example, when a rod is rubbed with a cloth, electrons are transferred from the rod onto the cloth and the rod becomes positively charged.

Electrostatic phenomena caused by the movement of electrons have many useful applications but also pose many risks.

- Dangers of electrostatic charges include:
  - When fuelling aircraft and tankers, if enough charge builds up it can create a spark, igniting fuel and causing a fire or explosion. A wire can be attached so that the charge instead flows into the earth.
- Uses of electrostatic charges include:
  - In an inkjet printer, droplets of ink are charged and pass between two charged metal plates, one of which has a positive charge and the other a negative charge. The droplets are attracted to the plate with the opposite charge and repelled by the plate which the same charge and deflected towards a specific place on the paper.
  - In a photocopier, the image of a document is projected onto a positively charged plate; where light falls onto the plate, the charge leaks away. Negatively charged toner particles are attracted to the remaining positive areas. Paper is then placed over the plate and the toner is transferred to it, making the photocopy.