

# AQA GCSE Physics

## Topic 2: Electricity

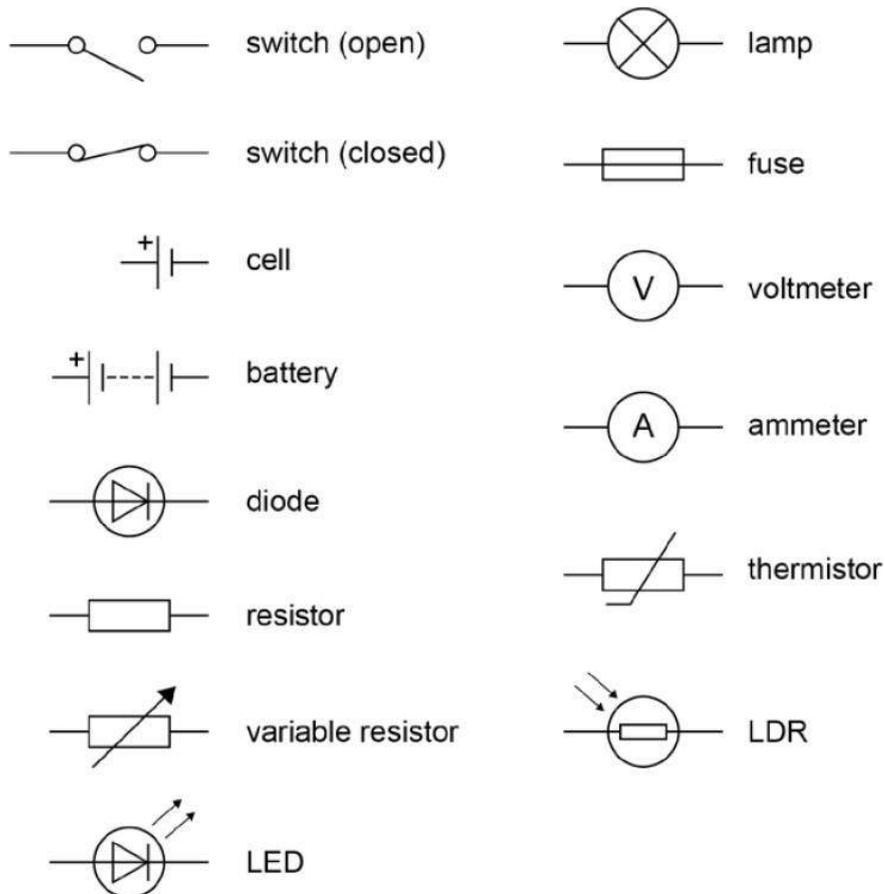
### Notes

(Content in bold is for Higher Tier only)

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## Circuit Symbols:



## Electrical Charge:

- For charge to flow:
  - o Circuit must be closed (no open switches)
  - o There must be a source of potential difference (battery/cell)

## Electrical Current

- **Current is the flow of electrical charge**
- Greater the rate of flow of charge, greater current

$$Q = It$$

Where Q is the charge flow, in coulombs C, I is the current, in amperes A and t is the time in seconds s.

- In a single closed loop, the current has the same value at any point
- The current (I) through a component depends on both the resistance (R) of the component and the potential difference (V) across the component.
- **The greater the resistance of the component the smaller the current for a given potential difference (pd) across the component.**
- Current, potential difference or resistance can be calculated using the equation:

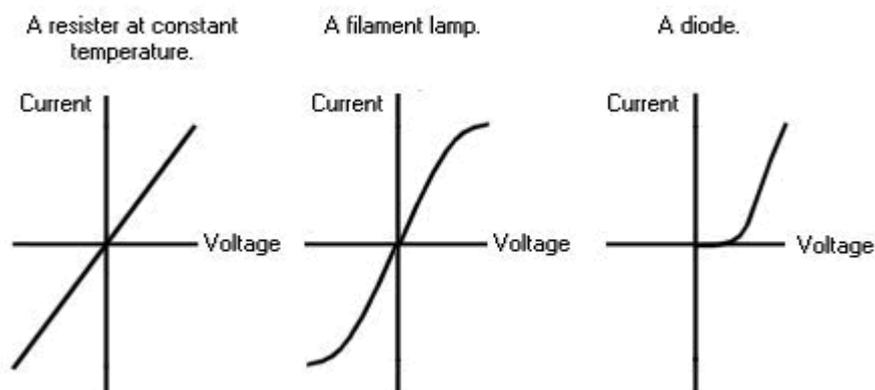
$$V = IR$$

- Where V is the potential difference in volts V, I is the current in amperes A, and R is the resistance in ohms  $\Omega$ .



## Resistors

- If the resistance is constant, an ohmic conductor, current is directly proportional to the potential difference, in this case the graph is linear.
- If the resistance of components such as lamps, diodes, thermistors and LDRs is not constant it changes with the current through the component, so the graph is nonlinear, for example, the resistance of a filament lamp increases as the temperature of the filament increases and the current through a diode flows in one direction only, so it has a higher resistance in the reverse direction.



*The gradient of each is  $1/\text{resistance}$ , so a sharper gradient means a lower resistance (inteleducationresources.intel.co.uk)*

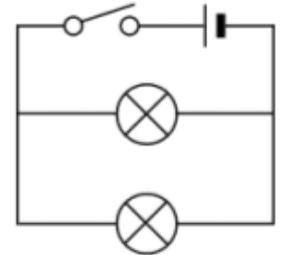
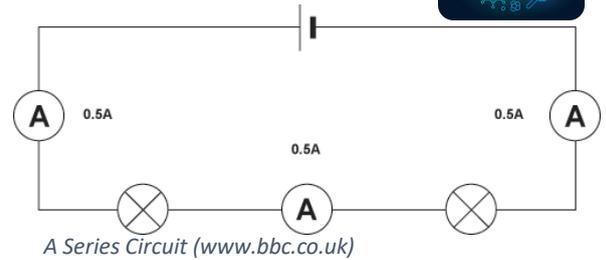
### How does the resistance change?

- With current
  - o As current increases, electrons (charge) has more energy
  - o When electrons flow through a resistor, they collide with the atoms in the resistor
  - o This transfers energy to the atoms, causing them to vibrate more
  - o This makes it more difficult for electrons to flow through the resistor
    - So resistance increases, and current decreases
- With temperature
  - o Normal wires - See above, the same process occurs as atoms vibrate when hot
  - o Thermistor
    - In hotter temperatures the resistance is lower
    - These are often used in temperature detectors/thermostats
- With length
  - o The greater the length, the more resistance and the lower the current
  - o Electrons have to make their way through more resistor atoms, so it is harder than using a shorter wire
- With light
  - o LDR (Light Dependent Resistor)
    - The greater the intensity of light, the lower the resistance
    - So the resistance is greatest when it is dark
    - These are used in automatic night lights.
- With voltage
  - o Diodes
    - Diode allows current to flow freely in one direction
    - In the opposite direction, it has a very high resistance so no current can flow

## Series and Parallel Circuits

### Series and Parallel

- Series Circuits
  - Closed circuit
  - Current only follows a **single path**
  - The current is the same everywhere
  - Total Resistance =  $R_1 + R_2 + \dots$
- Parallel Circuits
  - Branched circuit
  - Current splits into **multiple paths**
  - Total current into a junction = total current in each of the branches
  - The potential difference is the same across each "branch"



So this means, the total resistance for two resistors in parallel is less than the resistance of the smallest resistor

- Series
  - Components are connected end to end
  - All the current flows through all the components
  - Can only switch them all off at once
    - **Potential difference is shared** across the whole circuit
      - PD of power supply = sum of PD across each component
    - **Current is the same** through all parts of the circuit
      - Current at one point = current at any other point
    - Total Resistance is the **sum** of the resistance in each component
      - Resistance of two components is bigger than just one of them, because the charge has to push through both of them when flowing round the circuit
- Parallel
  - Components are connected separately to the power supply
  - Current flows through each one separately
  - You can switch each component off individually
    - **Potential difference is the same** across all branches
      - PD of power supply = PD of each branch
      - Because charge can only pass through any one branch
    - **Current is shared** between each of the branches
      - Current through source = sum of current through each branch
    - Total resistance is less than the branch with the smallest resistance
      - Two resistors in parallel will have a smaller overall resistance than just one
      - Because charge has more than one branch to take, so only some charge will flow along each branch



## Domestic Uses and Safety

### Mains:

- Mains electricity is an AC supply. In the United Kingdom the domestic electricity supply has a frequency of 50 Hz and is about 230 V.
- AC is alternating current, which comes from the mains
  - o Current continuously varies, from positive to negative (charge changes direction)
- DC, direct current, is the movement of charge in one direction only
  - o Cells and batteries supply direct current

### Cabling:

- In a plug there are 3 wires
- Live wire
  - o Brown, at 230V
  - o Carries the alternating potential difference from the supply.
  - o This may be dangerous even if mains circuit is off, as current may still be flowing through it
- Neutral Wire
  - o Blue, at 0V
  - o Completes the circuit
- Earth wire
  - o Green and Yellow stripes, at 0V. It only carries a current if there is a fault.
  - o Safety wire to stop the appliance becoming live
  - o It is connected to the earth and to the casing
  - o If the live wire touches the metal casing of the appliance, it will become live (you'll get a serious electric shock if you touch it, as current flows through you to the ground)

### Power

- **Power is the energy transferred per second.** It is directly proportional to current and voltage.
- Power loss is proportional to resistance, and to the square of the current.
- Energy is transferred from chemical potential in batteries to electrical energy in wires to any form of useful energy in the devices they power.

$$E = Pt \quad \text{Energy transferred} = \text{Power} \times \text{time}$$

$$E = QV \quad \text{Energy transferred} = \text{Charge} \times \text{potential difference}$$

The power,  $P$ , in watts  $W$ , the potential difference,  $V$ , in volts  $V$  and the current,  $I$ , in amperes  $A$  and the resistance,  $R$ , in ohms  $\Omega$ .

### Energy Transfers in everyday appliances

Electrical energy may be transferred by the appliance in different ways:

- Kinetic energy for a motor, thermal energy in a kettle
- Work done is when charge flows through a circuit, and is also equal to energy transferred, as all the electrical energy (ideally) gets transferred to the appliance
- Power rating of an appliance shows the power it uses in Watts, so greater power rating means it uses more energy



## National Grid

- The National Grid is a system of cables and transformers linking power stations to consumers across the UK.
- Electrical power is transferred from power stations to consumers using the National Grid
- **Transformers:**
  - **These change the potential difference**
  - **Step-up Transformers**
    - **Increase the pd from the power station to the National Grid**
    - **So as the power is constant ( $P = IV$ ) current decreases so less energy is lost.**
  - **Step-down Transformers**
    - **Decrease the pd**
    - **From the National Grid to consumers**
    - **For consumer safety**

## Charge

- A property of all matter
- Positive and negative charges exist
  - If a body has the same amount of positive and negative charge, they cancel out, forming a neutral body (i.e. protons and electrons in a neutral atom)
- Like charges repel
- Opposite charges attract

Insulators do not conduct electricity

- Their electrons cannot flow throughout the material, they are fixed

Conductors can conduct electricity

- Their electrons can flow, and are not fixed (they are delocalised)

## Static Electricity (Physics only)

- When two insulators are rubbed together
  - Electrons are transferred from one object to the other
  - Forming a positive charge on one object and a negative charge on the other
- If conductors were rubbed, electrons will flow in/out of them cancelling out any effect, so they stay neutral
  - Insulators become charged because the electrons cannot flow
  - A positive static charge forms on object which loses electrons
  - A negative static charge forms on object which gains electrons
- Which object loses/gains electrons depends on the materials involved

Sparking occurs when enough charge builds up, and the objects are close but not touching

- The “spark” is when the charge jumps through the air from the highly negative object to the highly positive object, to balance out the charges

## Forces exerted

- The charged objects experience a force – electrostatic force (of attraction/repulsion)
- Greater charge = greater force (e.g. a more positive object, a more negative object)
- Closer together = greater force (force is proportional to the inverse square of the distance)
  - It is a noncontact force, as force can be felt even when the objects are not touching



## Electric Fields

- Like magnetic fields for magnets, electric fields are for charges
  - o They point in the direction a positive charge would go i.e. away from positive charges, and towards negative charges.
  - o They point to charges at right angles to the surface
- Stronger the charge, the more field lines present and the stronger the force felt
- Closer to the charge, the stronger the force felt

## Diagrams

