Edexcel GCSE Physics

Your notes

Static Electricity

Contents

Electric Charge

Your notes

Charging by Friction

- When certain insulating materials are rubbed against each other they become **electrically charged**
  - This is called **charging by friction**
- The charges remain on the insulators and cannot immediately flow away
  - One becomes positive and the other negative
- An example of this is a plastic or polythene rod being charged by rubbing it with a cloth
  - Both the rod and cloth are insulating materials

A polythene rod may be given a charge by rubbing it with a cloth

- This occurs because negatively charged electrons are **transferred** from one material to the other
- The material, in this case, the rod, loses electrons
- Since electrons are negatively charged, the rod becomes **positively** charged
  - As a result, the cloth has **gained** electrons and therefore is left with an equal **negative** charge

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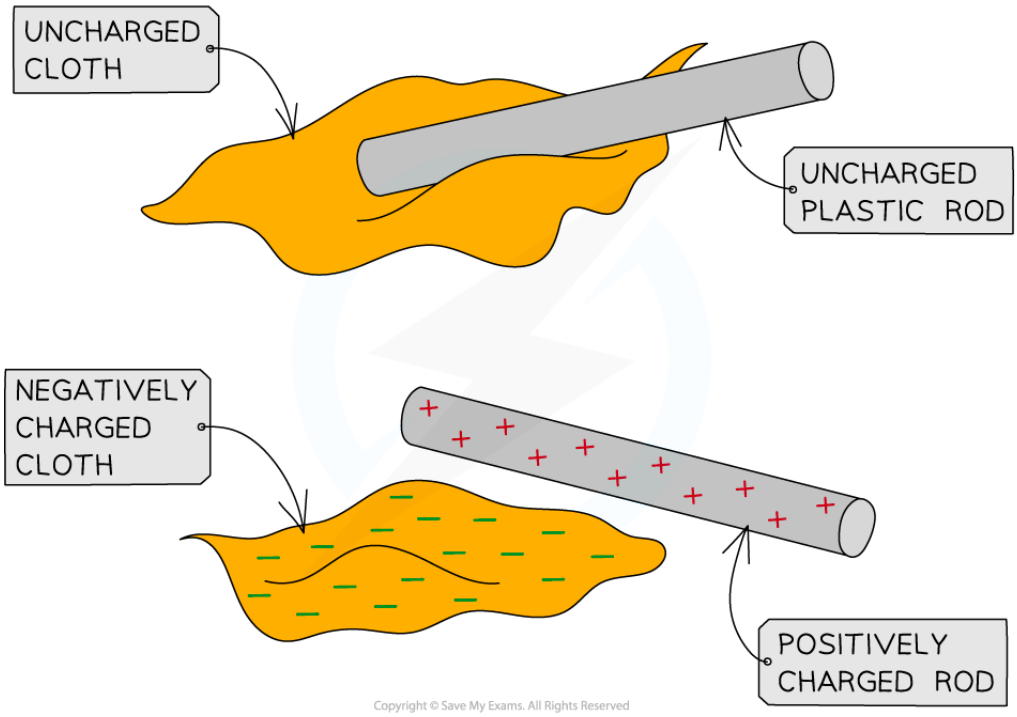
Examiner Tips and Tricks

At this level, if asked to explain how things gain or lose charge, you must discuss **electrons** and explain whether something has gained or lost them. Remember when charging by friction, it is only the **electrons** that can move, not any 'positive' charge, therefore if an object gains a negative charge, something else must have gained a positive charge

Charge & Electrons

- All objects are initially electrically **neutral**, meaning the negative (electrons) and positive charges are evenly distributed
- However, when the electrons are transferred through friction, one object becomes **negatively** charged and the other **positively** charged
  - The object to which the electrons are transferred becomes **negatively charged**
  - The object from which the electrons **leave** becomes **positively charged**
- This difference in charges leads to a force of **attraction** between itself and other objects which are also electrically neutral, by attracting the opposite charge to the surface of the objects they are attracted to
- In the example below, when the cloth and rod are rubbed together, the electrons are **transferred to** the **cloth** and **leave from** the **rod**



Electrons are rubbed onto the cloth leaving the cloth negatively charged and the rod positively charged

Electric Forces Between Charges

- The charge of a particle is either:
  - Positive
  - Negative
  - Neutral (no charge)
- Electrons are **negatively** charged particles, whilst protons are **positive** and neutrons are **neutral**
- This is why in a neutral atom, the number of electrons is equal to the number of protons
  - This is so the equal (but opposite) charges cancel out to make the overall charge of the atom zero

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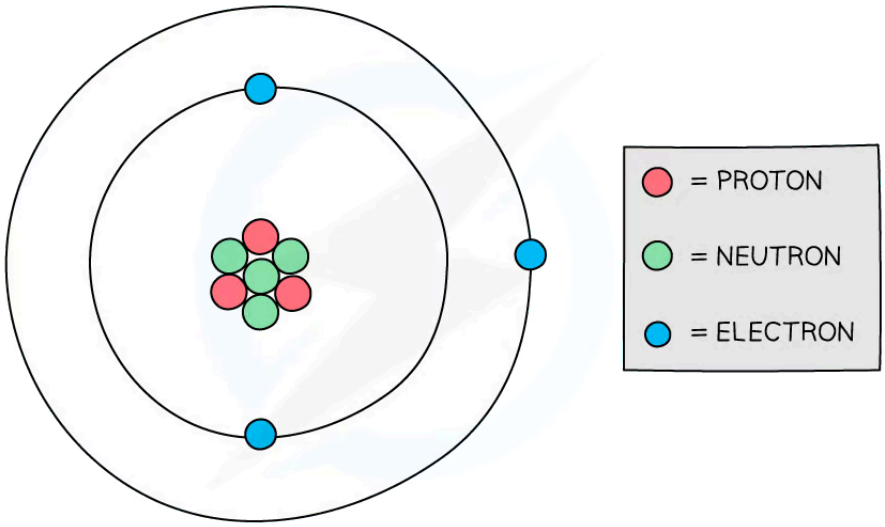

The number of negative electrons in an atom balances the number of positive protons

- Therefore, an object becomes negatively charged when it **gains** electrons and positively charged when it **loses** electrons
- When two charged particles or objects are close together, they also exert a **force** on each other
- This force could be:
  - **Attractive** (the objects get closer together)
  - **Repulsive** (the objects move further apart)
- Whether two objects attract or repel depends on their **charge**
  - If the charges are the **opposite**, they will **attract**
  - If the charges are the **same**, they will **repel**

Opposite charges attract, like charges repel

Attraction or Repulsion Summary Table

Charge of Object 1	Charge of Object 2	Attract or repel?
Positive	Positive	Repel
Positive	Negative	Attract
Negative	Positive	Attract
Negative	Negative	Repel

- Attraction and repulsion between two charged objects are examples of a **non-contact force**
  - This is a force that acts on an object without being physically in contact with it

Examiner Tips and Tricks

Remember the saying: "**Opposites attract**" Materials only become positively charged because of the **loss** of electrons, rather than the 'gain' of any positive charge, which is a common misconception.

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Examples of Static Electricity

- Common electrostatic phenomena include:
  - Shocks from everyday objects
  - Lightning
  - A charged balloon sticking to a wall
  - Charged comb picking up small pieces of paper

Shocks From Everyday Objects

- The build-up of electrostatic charge can be quite dangerous and can cause **sparking** (also known as an electric shock)
- A static electric spark occurs when:
  - Two objects are charged by friction
  - They become oppositely charged
  - The large surplus of electrons causes electrons to 'jump' across to an object that is neutral
- Since a current is the flow of electrons, this causes a small **current** to flow between the objects, called a **spark**
- An example of sparking is the small electric shock felt from touching a door handle, or another person, after walking on a vinyl floor or nylon carpet with rubber shoes or socks
  - Sparks can become quite dangerous and can cause a fire by igniting flammable gases and liquids, such as petrol

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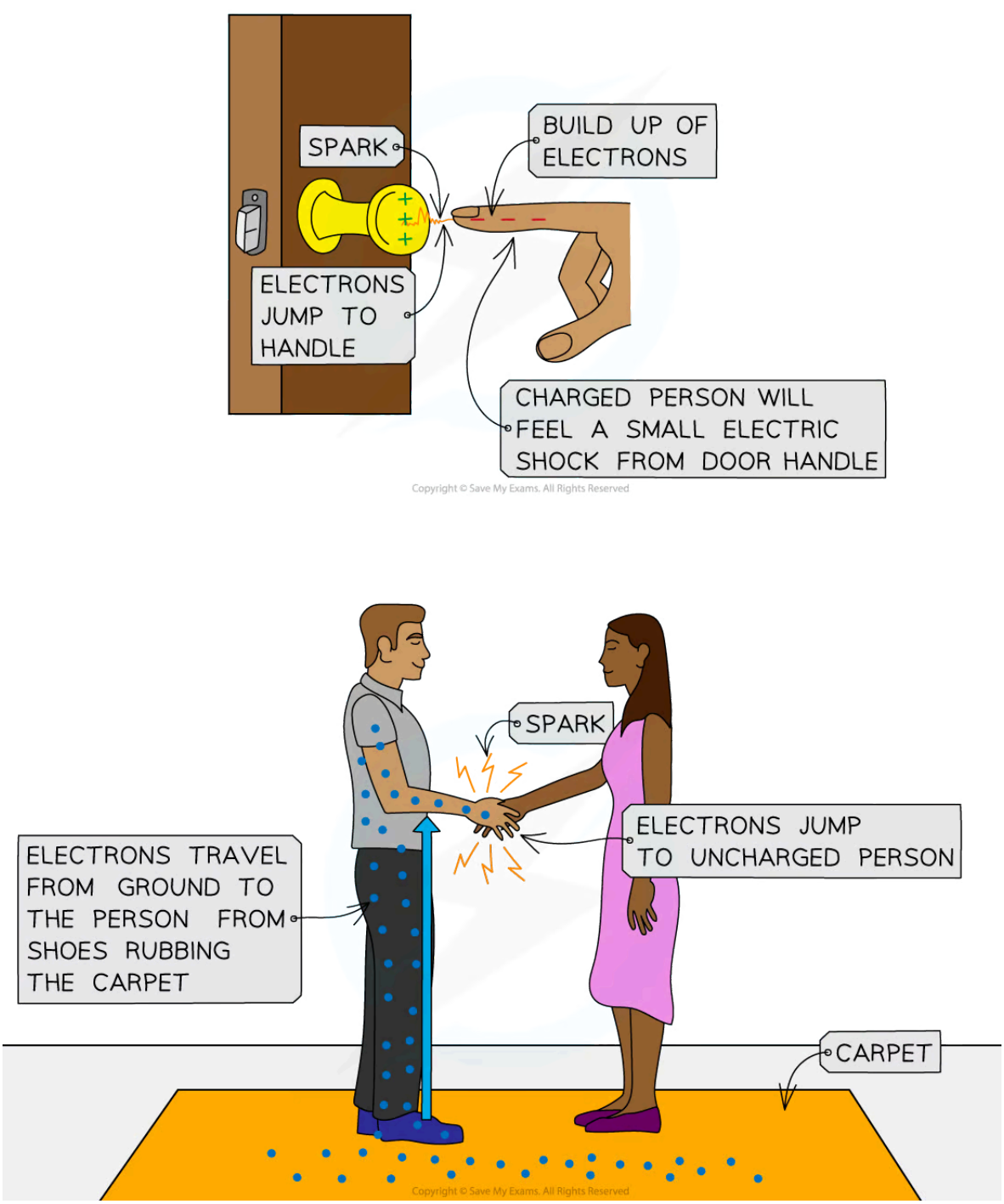
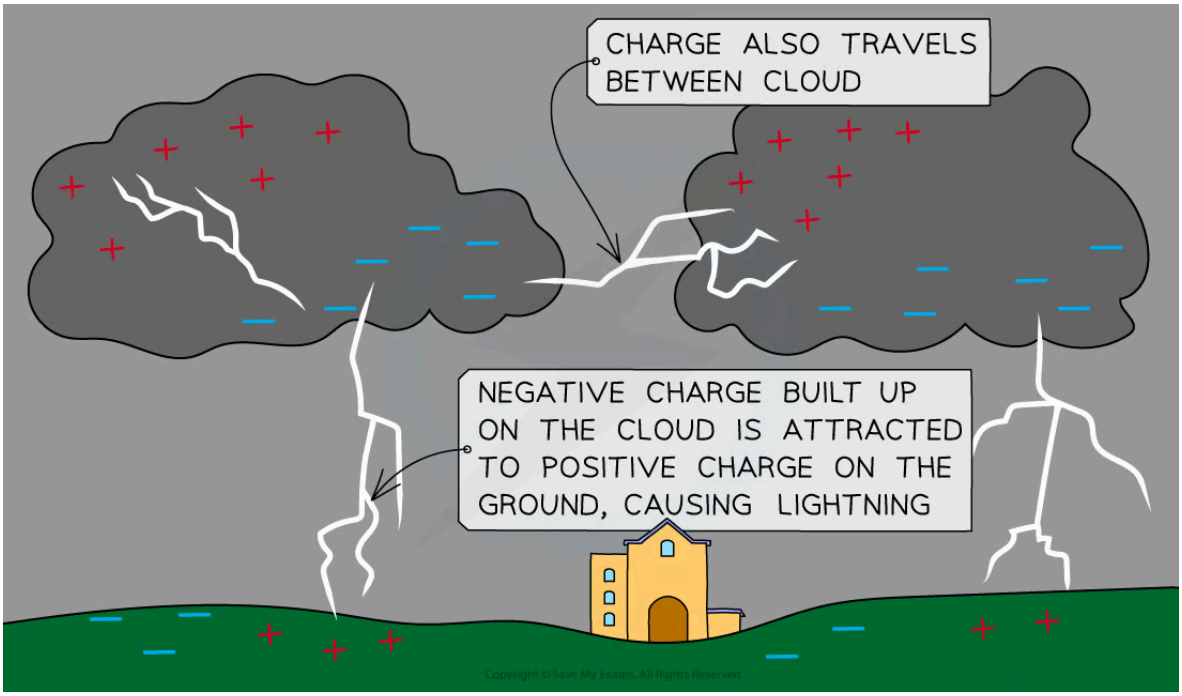


Examples of sparking from touching a door handle or another person

Lightning

- In a storm, clouds move over each other
  - This causes them to become charged when **electrons** are transferred between them
- Since the ground is neutral, the **negative** charges from the cloud jump to meet the **positive** charges on the ground creating a giant **spark** (a current from a transfer of charge)
  - This phenomenon is known as **lightning**



Lightning is caused by the build-up of charge in clouds

Sticking a Balloon to the Wall

- Rubbing a balloon on a woollen jumper **transfers** electrons onto the balloon by friction
- The balloon is now **negatively** charged whilst the jumper is left **positively** charged
- The wall is still neutral, however, when the balloon is placed near the wall, the negative electrons in the wall are **repelled** by the **negative** balloon
  - This leaves a region of wall with a net **positive** charge
- Since opposite charges attract, the balloon sticks to the wall from only the **electrostatic attraction**

Charged Comb Picking up Paper

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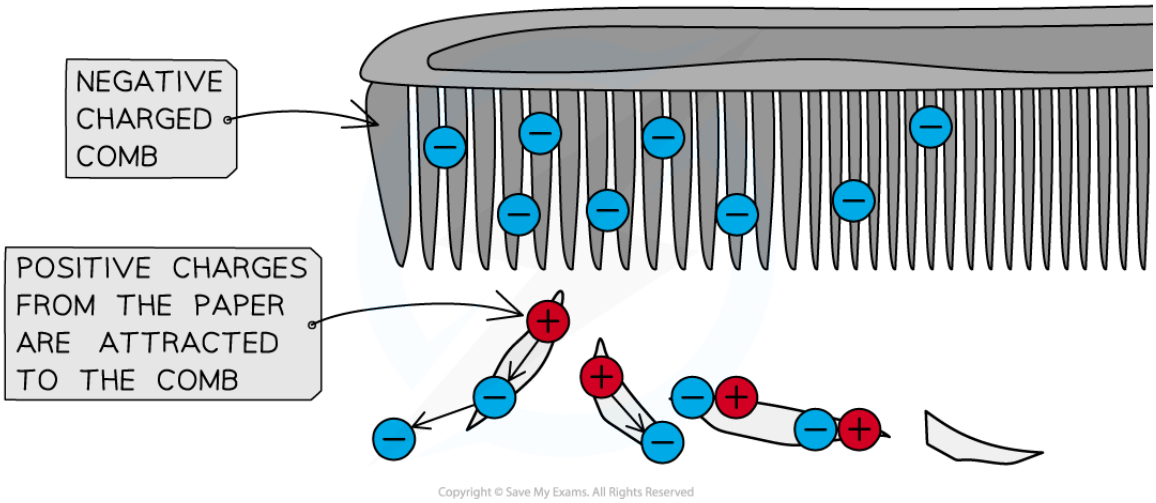
- Static electricity can be observed when running a plastic comb through hair then placing the comb near small pieces of paper
  - The pieces of paper can be observed to jump up and stick to the comb
- The comb becomes charged by friction from the hair so it is left with a **negative** charge as the **electrons** are transferred to it
  - This also means the hair strands become **positively** charged and they begin to **repel** each other
- Pieces of paper are neutral but as the comb comes close to them, the **positive** charges are brought to the surface of the paper and are **attracted** to the **negative** charges on the comb
  - Therefore, the papers '**stick**' to the comb through static electricity



A negatively charged comb can attract small pieces of paper

Examiner Tips and Tricks

Answers to exam questions in this topic are mainly looking for the words '**friction**' and the transfer of '**electrons**'. Avoid saying the transfer of 'charge' since this is too vague and will not get you full marks.

Earthing

- Earthing is the process of **removing excess charge** from a body or object via the movement of electrons

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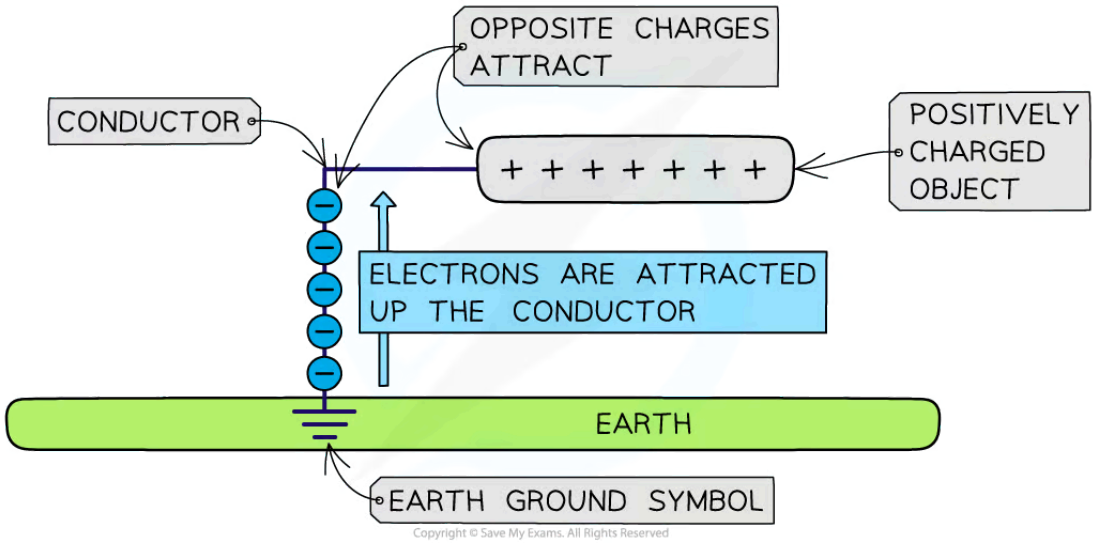
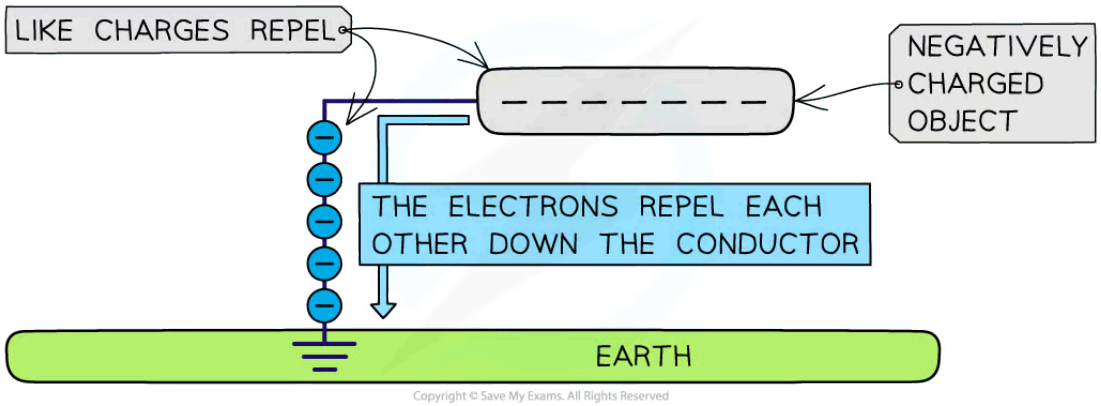
- This is used when an object becomes charged and the charge needs to be removed to avoid sparking
- It is sometimes called **grounding**

- The Earth can be imagined to be a giant reservoir of electrons, so it can give and take excess electrons
- Earthing is done by **connecting** the charged object to the Earth using a **conductor** such as a wire
  - A conductor is used since charge can flow through it
- If a positively charged object is connected, electrons will be attracted **up** through the conductor towards the positive charge, cancelling out the net positive charge
  - This is because opposite charges **attract**



A positively charged object when earthed will attract electrons via the conductor

- If a negatively charged object is connected to the earth, electrons travel **down** the conductor away from the object
  - This is because, like charges **repel**



A negatively charged object when earthed will move electrons down the conductor

Your notes

Uses & Dangers of Static Electricity


Your notes

Uses of Static Electricity

- Electrostatic charges are used in everyday situations such as photocopiers and inkjet printers

Photocopiers

- Photocopiers use static electricity to copy paper documents, most commonly in black and white
- An image of the document is projected onto a positively charged copying plate
- The plate loses its charge in the light areas and keeps the positive charge in the dark areas (i.e the text)
- A negatively charged black toner powder is applied to the plate and sticks to the part where there is a positive charge
- The toner is then transferred onto a new blank sheet of white paper
- The paper is heated to make sure the powder sticks (hence why photocopied paper feels warm)
    - The photocopy of the document is now made
- Inkjet printers work in a similar way, but instead of the black toner powder, a small jet of coloured ink is negatively charged and attracted to the correct place on the page

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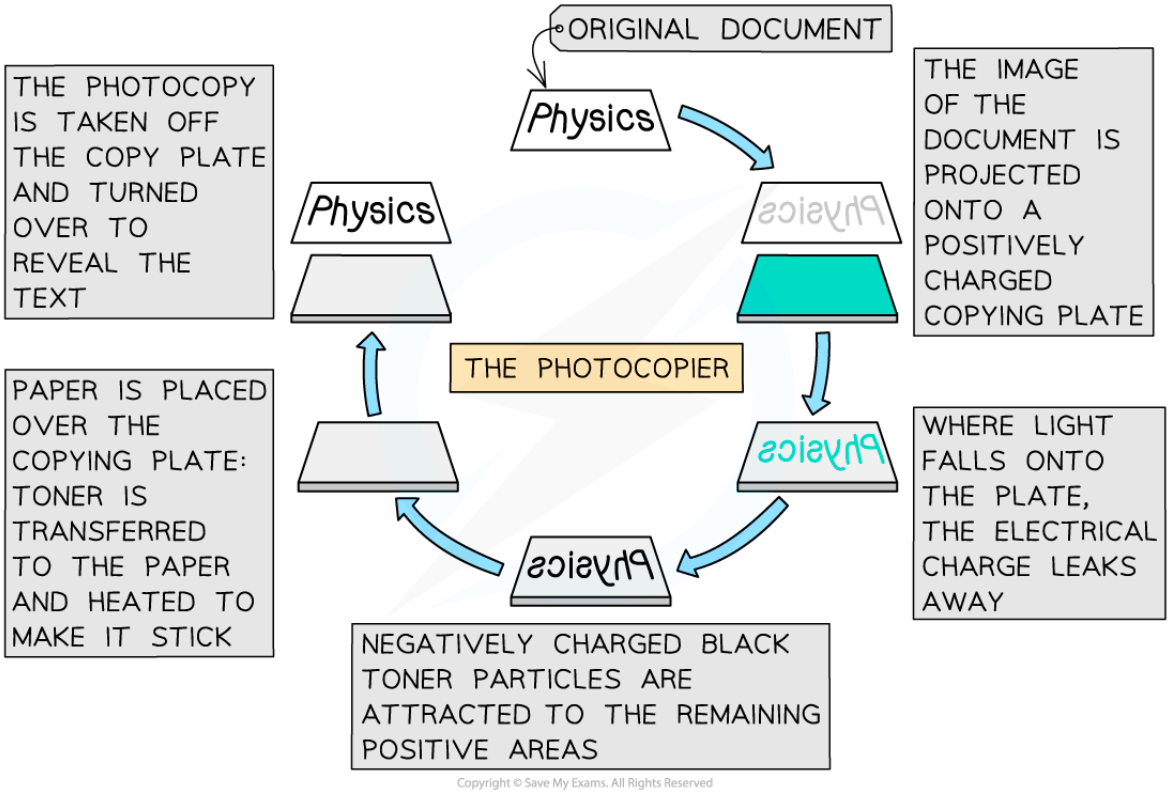
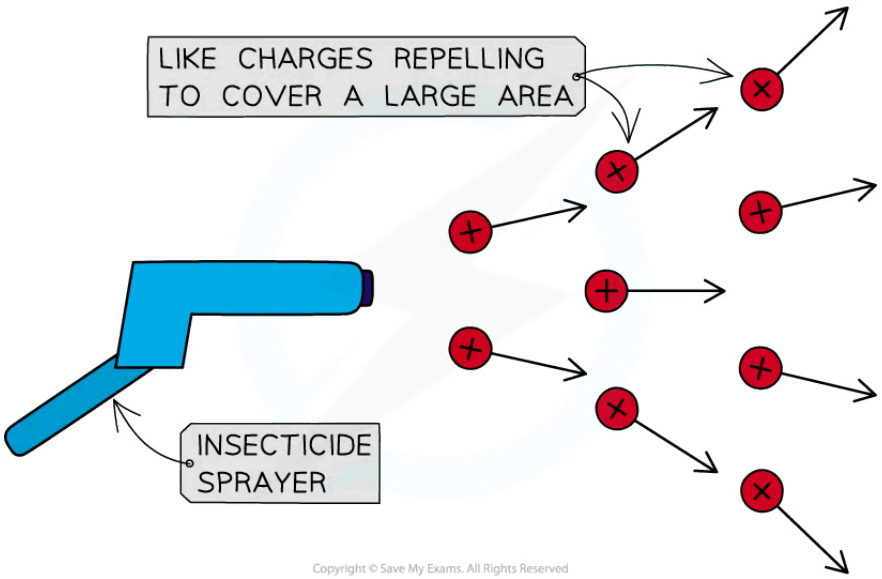


How a photocopier uses static electricity

Insecticide Sprayers

- Insecticides are chemicals used to kill pests in order to protect crops
- In order to spray crops effectively whilst using a minimal amount of chemicals, the sprayer has to deliver the chemicals as a **fine mist** and cover a **large area**
- To achieve this, the insecticide is given an electrostatic charge (e.g. positive) as it leaves the sprayer
- The droplets of insecticide then **repel** each other since they are the same charge
  - This ensures that the spray remains fine and covers a large area
- They are also attracted to the negative charges on Earth, so they will fall **quickly** and are less likely to be blown away
- A similar technique is used in the spray painting of cars

Your notes



How insecticide spray uses static electricity to cover a larger area

Dangers of Static Electricity

- Static electricity can cause **sparking**
- There are various situations where static electricity can pose a hazard, for example:
  - The risk of electrocution (e.g from lightning)
  - The risk of a fire or explosion due to a spark close to a flammable gas or liquid
- There are dangers of sparking in everyday situations such as fuelling vehicles such as cars and planes
- Earthing is used to prevent the dangerous build-up of charge
  - This is done by connecting the vehicles to the Earth with a conductor

Fuelling Vehicles

- A build-up of static charge is a potential danger when refueling aeroplanes
- Fuel runs through pipes at a fast rate
  - This fuel is very flammable
- The friction between the fuel (a liquid insulator) and the pipe causes the fuel to **gain charge**
- If this charge were to cause a spark, the fuel could ignite and cause an explosion

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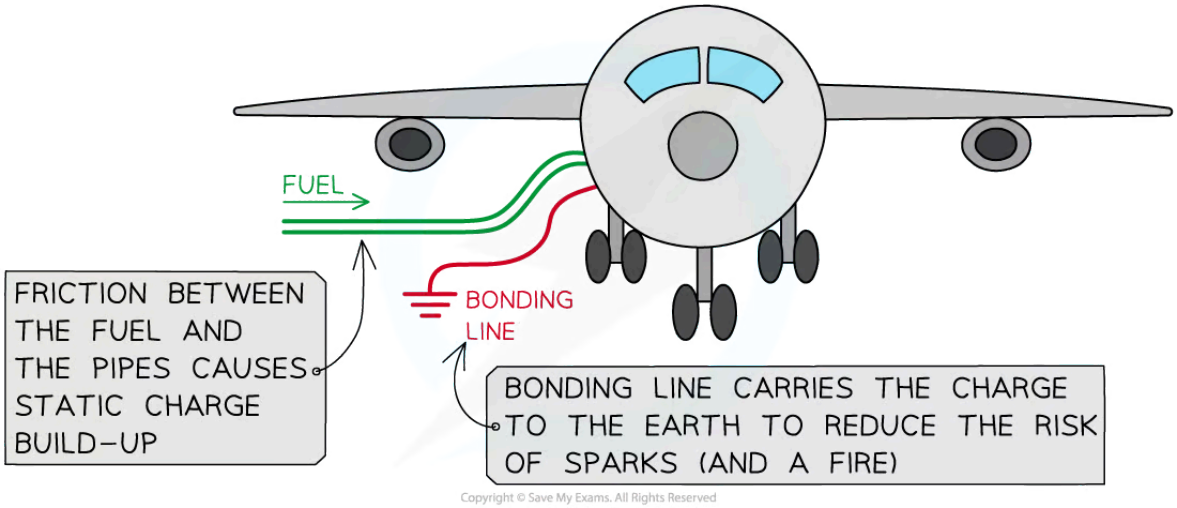


A bonding line is required to reduce the charge build up when fuelling vehicles

- This is prevented by the fuel tank being connected to the Earth with a copper wire called the **bonding line** during the refuelling
- The conductor **earths** the plane by carrying the charge through to the Earth which removes the risk of any sparks

Examiner Tips and Tricks

- You could be asked to explain other dangers and uses in your exams
- They may ask you to explain the movement of charge in terms of **electrons**
- If asked to explain a danger:
  - State what the danger is (electrocution? fire?)
  - Explain how the charge can be **removed** to get rid of the risk i.e earthing (think about which way the electrons have to move)
- If asked to explain a use, think carefully about the forces exerted due to static electricity and what they will do

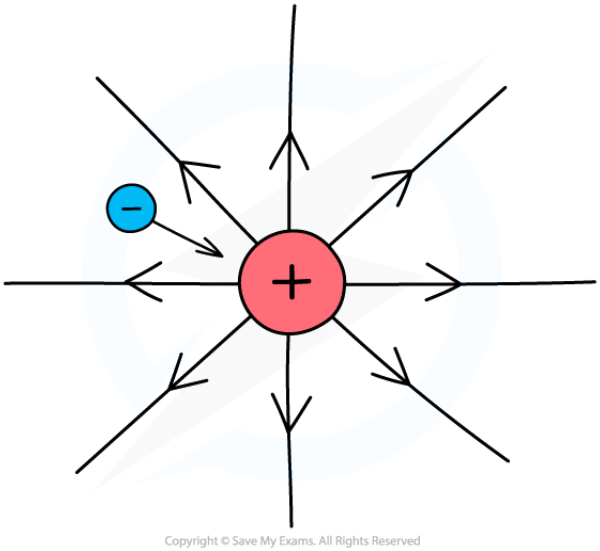
Electric Fields

Your notes

Electric Fields

- A charged object creates an **electric field** around itself
  - This is similar to the way in which magnets create magnetic fields
- An electric field can be defined as:

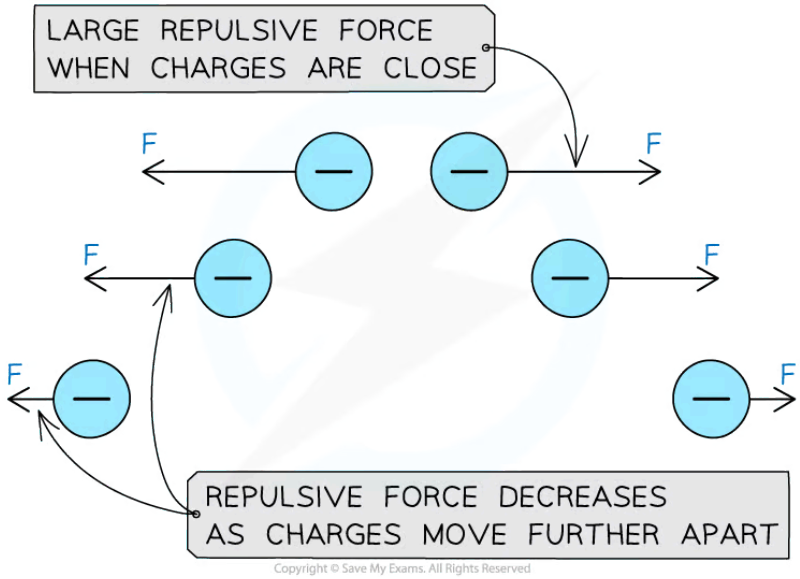
  A region where an electric charge experiences a force
- If other charges enter the field then they will experience an electrostatic force, attracting or repelling them from the object
- Since force is a vector, the direction of this force depends on whether the charges are the same or opposite
- The force is either **attractive** or **repulsive**
  - If the charges are the **same** (negative and negative or positive and positive), this force will be **repulsive** and the second charged object will move away from the charge creating the field
  - If the charges are the **opposite** (negative and positive), this force will be **attractive** and the second charged object will move **toward** the charge creating the field



When the negative particle enters the electric field, it feels a force of attraction towards the positive charge

Your notes

- The size of the force depends on the strength of the field at that point
- This means that the force becomes:
  - **Stronger** as the distance between the two charged objects **decreases**
  - **Weaker** as the distance between the two charged objects **increases**
- The relationship between the strength of the force and the distance applies to both the force of attraction and force of repulsion
  - Two negative charges brought close together will have a **stronger** repulsive force than if they were far apart



Repulsive forces decrease as like charges move further apart

Examples of Fields

- Electric fields can be shown by electric field lines
- Fields lines always point **away** from **positive** charges and **towards negative** charges

Point Charges

- Electric field lines around **point** charges are spherical:

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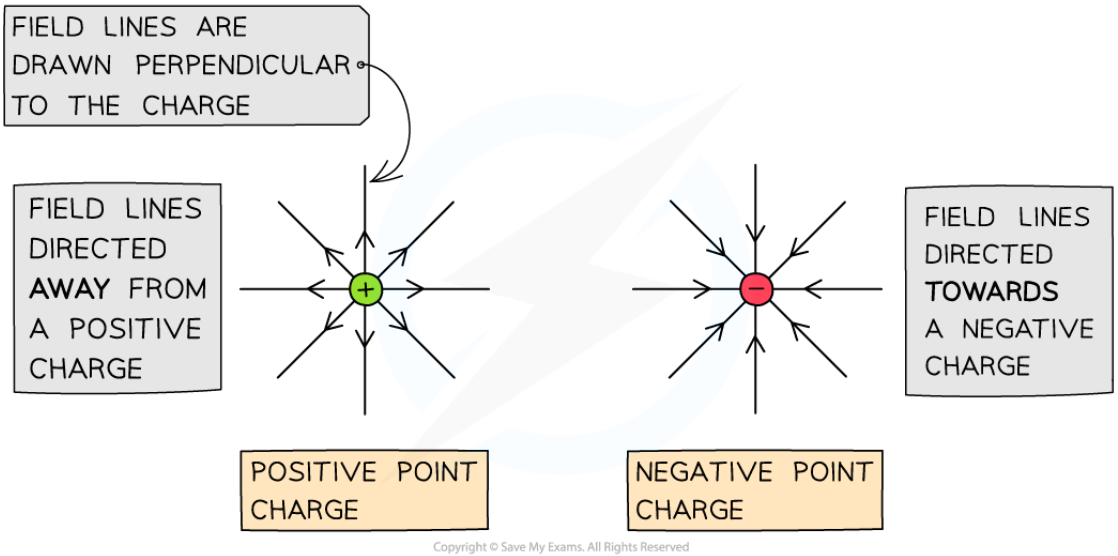
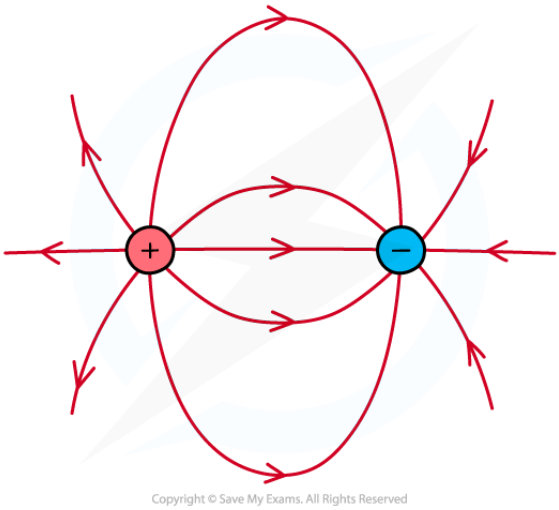


Electric fields lines around point charges

- When two opposite charged point charges are brought close together, their attraction is shown the field lines
- The electric field pattern between two **oppositely** charged spheres (or point charges) looks like:

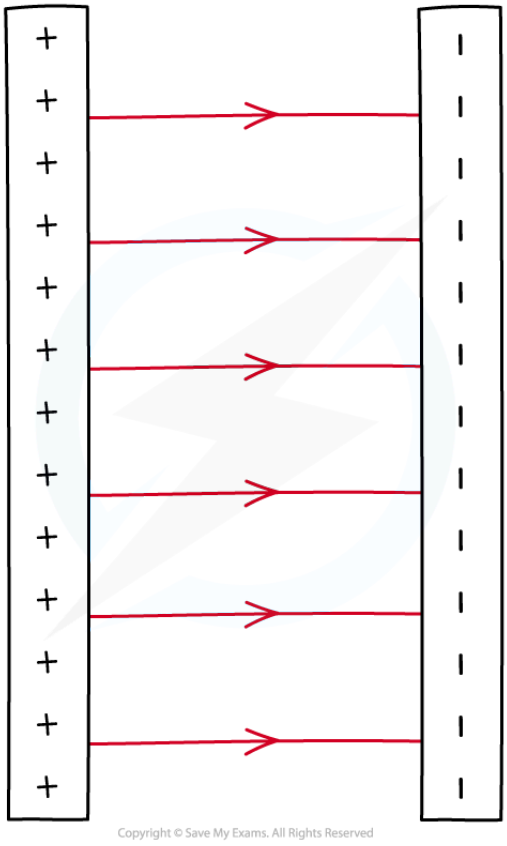


Electric field pattern for two opposite charges

Parallel Plates

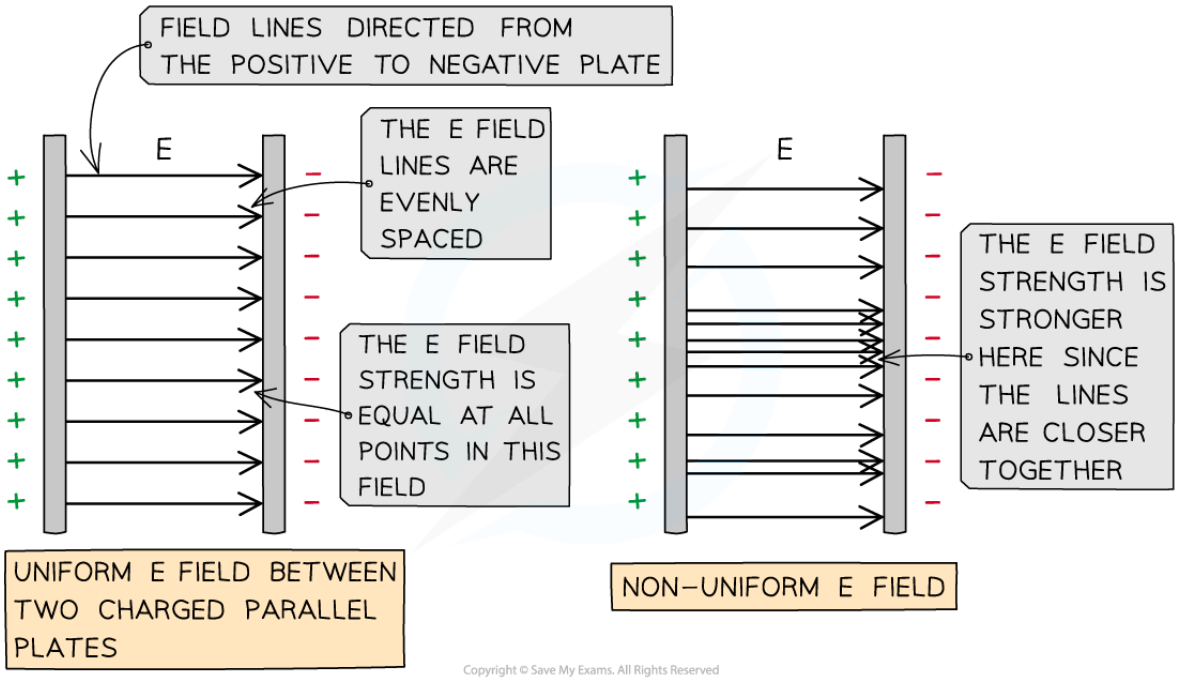
Your notes

- The electric field between two parallel plates is a **uniform electric field**
- The field lines are:
  - Directed from the **positive** to **negative** plate
  - Parallel
  - Straight lines



Electric field lines between two parallel plates

- The strength of an electric field is determined by the spacing (the concentration) of the field lines:
  - A **stronger** field is represented by the field lines **closer together**
  - A **weaker** field is represented by the field lines **further apart**



Strong and weak electric field lines on a parallel plate

Examiner Tips and Tricks

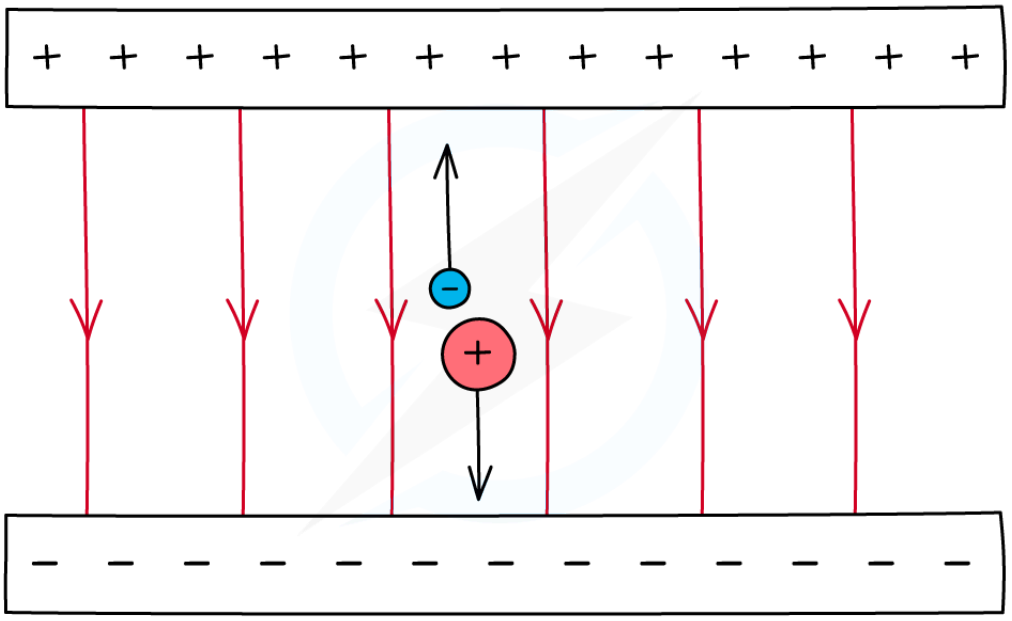
Remember when drawing field lines to always include their direction with **arrows** pointing in the correct direction. If the field lines are straight, always use a ruler or a straight edge to draw them.

Your notes

Your notes

Fields & Static

- Charged objects in an electric field experience a **force**
- The electric field helps to explain the **non-contact force** between charged objects
  - This is because the electric field cannot be seen, but can be detected by another charged object that moves within that field due to the electric force
- This is a non-contact force because the charged objects **do not touch** for the force to be exerted



Positive and negative charges will travel towards the opposite charge, creating a spark

- If an electric field becomes strong enough, the charges are forced through insulators such as air, creating a **spark**
  - This is what happens for example, when a charged person touches a conductor
- The charged particles will travel towards the area with the **opposite charge**