Static Electricity Notes

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Static electricity: the charge that insulating objects get because of the loss or gain of electrons.

What is an insulating object? It's an object that will not allow charge to move across or through it. For example, the rubber of a balloon.

So, static electricity is an area of charge that is stuck in place until something that conducts electricity touches the charged area and the charge can then flow, this is what a static shock is.

If an object loses electrons, it becomes positively charged. If an object gains electrons, it becomes negatively charged. There are two ways that an object may become charged, **friction** and **induction**.

Important note: it is only ever the electrons which move to give us a positive or negative charge. As the electrons are in electron shells outside the nucleus, they are much easier to get to the electrons rather than the protons.

How can an object get a static charge? – Friction and Induction 😊

Friction

What is friction? Friction is a contact force. It happens when two rough surfaces slide over each other.

What is a "contact force"? A force that only occurs when objects are in contact.

How does friction charge an object? When friction occurs, there is a physical transfer of electrons from one object to another.
The object that gains electrons becomes negatively charged and the object that has lost electrons becomes positively charged.

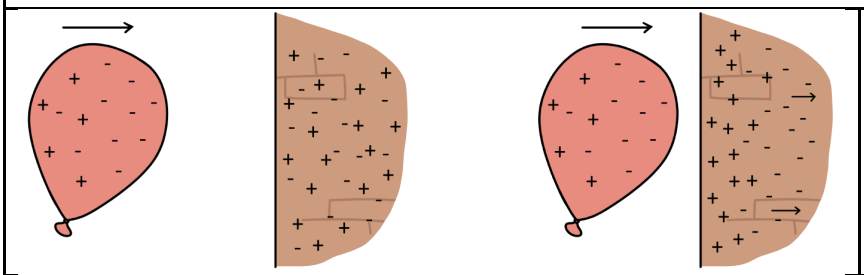
Induction also known as static induction

What is induction? Induction is using an already charged object to induce (cause) a charge on an uncharged object.

How does induction charge an object? Induction uses the law of charges. The law of charges says that like charges repel each other and that opposite charges attract.

When a positively charged object is brought near a neutral object, it attracts the free moving negative electrons within the neutral object. These electrons move towards the side of the object that is closer to the positive object.

This means the one side of the neutral object now has a negative charge 😊 we have **induced** a charge on one object using an already charged object 😊



Note: we can see in this diagram we can see that an already charged object has repelled the negative charges in the wall. This leaves the wall positively charged 😊

Where is induction used? Induction is used to cause a charge in the following:

1. **Spray paint** – induction is used to cause the paint to become charged. Most paint used in spray painting is positively charged.
2. **Printer ink and toner** – induction is used to cause the ink or toner to become charged. Most toners are positively charged.

Uses of Static Electricity

When it comes to the uses of static electricity it really doesn't matter what the use is, they all work on the same concept! That like charges repel and that opposite charges attract 😊 That's all really. Let's look at two places static electricity is used to do something, in electrostatic spray painting and in electrostatic precipitators.

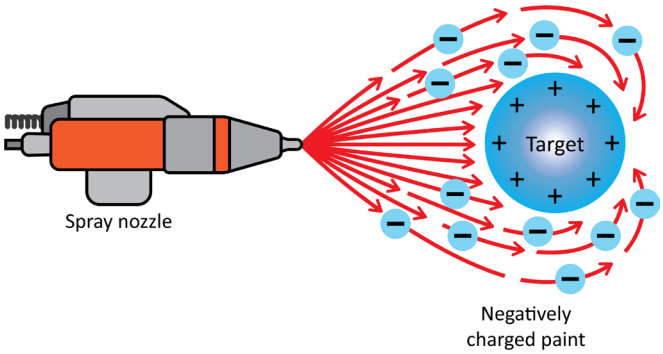
Note: remember that electrostatic just means that there are two different charges present (positive and negative).

Electrostatic Spray Painting

What is electrostatic spray painting? It's a method of painting objects 😊 It is usually used on metal objects like metal things like car bodies, bicycle frames or filing cabinets.

Why is electrostatic spray painting used? For two main reasons, it creates a perfectly even finish with no bumps or drips. This happens as every paint droplet is given the same electrical charge, they repel each other. This forces the paint to spread out into a very fine, even mist which covers the object perfectly.

It really reduces paint waste, remember that the paint droplets and the object have opposite charges, so they attract each other. This means that the paint is attracted to the object. The figure below shows spray painting happening.



How does spray painting work? Let's do this step by step!

Step 1: Charging the paint – As the paint leaves the nozzle of the spray gun, it passes a high voltage needle. This gives all the individual paint droplets the same electrical charge**.**

Step 2: Creating a fine mist – all the paint droplets have the same charge, they repel each other.

Step 3: Charging the object – The object being painted (let's say a car door) is given the opposite electrical charge.

Note: Sometimes the object is simply connected to the Earth (earthed), which has a similar effect.

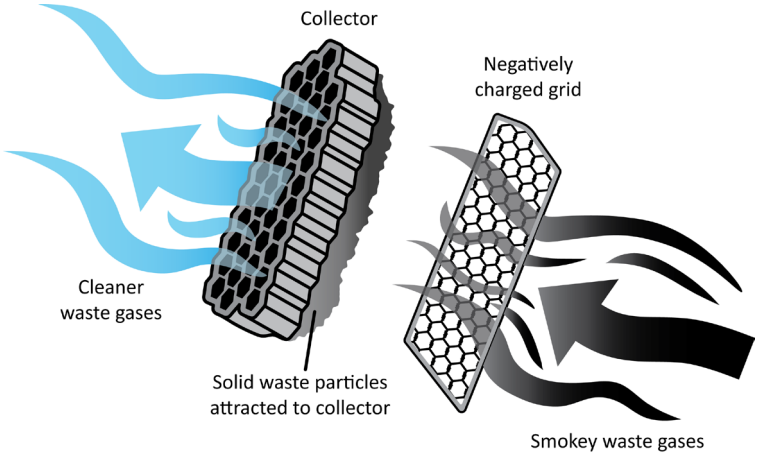
Step 4: Attraction – The negatively charged paint droplets are strongly attracted to the positively charged car door as opposite charges attract 😊 .

The result: The paint droplets move straight towards the metal and because of the electrostatic attraction, the paint will even move to hit the back of the object and coat hard to reach surfaces.

Electrostatic Precipitators

What is an electrostatic precipitator? It's a large piece of equipment fitted inside the chimneys of factories and fossil fuel power stations. It uses static electricity to trap solid waste particles such as soot, ash, and dust and removes them from the exhaust gases. So, it's a device that filters exhaust gases using static electricity.

What is an electrostatic precipitator used for? It's used to do three things really, the first is to reduce air pollution which is their main role their other roles are to protect human health and collect any useful materials before they are lost was waste gases. The figure below shows an electrostatic precipitator.



How does an electrostatic precipitator work? Again, let's look at this in stages 😊

Step 1: Charging the grid – A high voltage is applied to the metal grid, to give the grid a strong negative charge.

Step 2: The smoke particles become charged – As the smoke rises up the chimney, it passes through this negative metal grid. The ash and dust particles gain electrons from the grid, meaning the smoke particles become negatively charged.

Step 3: Smoke particles attracted to collecting plate and sticking to it – The smoke particles continue to rise and pass between the large metal collecting plates. These plates are given a strong positive charge.

Because opposite charges attract, the negatively charged smoke particles are pulled sideways and stick to the positively charged metal plates. The materials can be collected and sold or reused depending on the material.

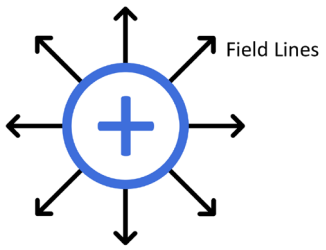
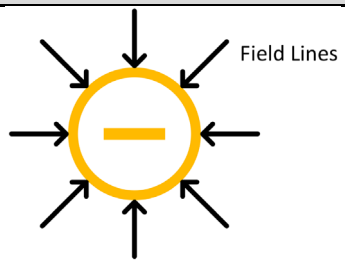
Step 4: Clean air escapes – The harmful particles are now trapped on the plates, allowing only clean, safe gas to exit the top of the chimney.

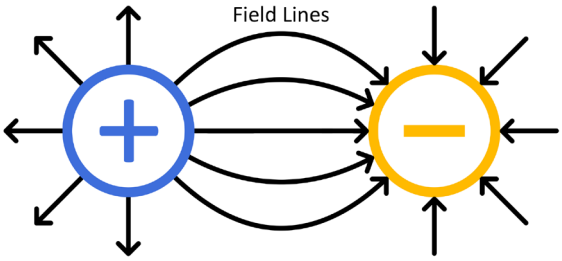
Both of these uses just work on the basis of opposite charges attracting and like charges repelling 😊

Electric Fields

An electric field: a region produced by charged particles or objects, where charged particles or objects experience a force. The field is strongest closest to the charged object, and gets weaker the further away we get.

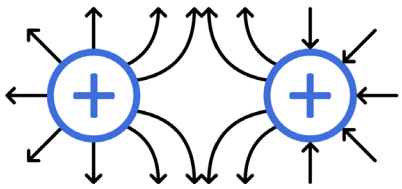
Reminder: a particle or object becomes positively charged if it loses electrons and a particle or object becomes negatively charged if it gains electrons.

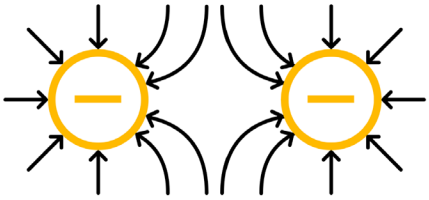
A Positive Electric Field	A Negative Electric Field
	
The field lines always point away from a positive charge.	The field lines always **point towards** a negative charge.



Here we can see a the electric field lines merging and a force of attraction between the oppositely charged particles.

Reminder: the law of charges says that like charges repel and that opposite charges attract.





Like charges repelling 😊

An electrostatic force: the force that charged particles experience in an electric field.

When we talk about an electrostatic attraction, we are talking about the force of attraction between two oppositely charged objects in an electric field 😊 we also see this in ionic bonding in Chemistry.

We could say the same for an electrostatic repulsion and while that is the correct way to describe when like charges repel, we don't use this phase very often.

Sparking

We know that static charge can build up on an insulator, but what happens when that charge needs to escape? It can cause a spark! Let's look at exactly how this happens. But, first of all w**hat is a spark?**

A spark: a sudden flow of current (electrons) through the air.

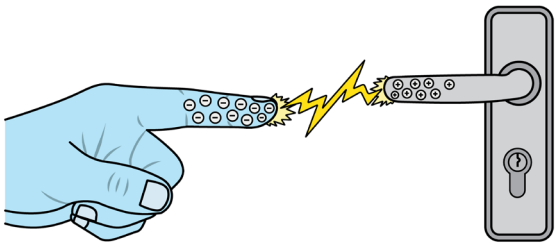
How does a spark actually happen? AQA loves to ask this in the exam! 😊 Let's break it down step-by-step:

Step 1: **a charge builds up** – A large amount of static charge builds up on an object. This creates a very large potential difference between the charged object and the Earth (or an earthed object, like a metal door handle).

Step 2: **a strong electric field is created** – Because the potential difference is so large, a very strong electric field is created between the charged object and the earthed object.

Step 3: **ionisation of the ai**r – Normally, air is an electrical insulator. However, the strong electric field causes electrons to be ripped away from the air molecules. This process is called ionisation.

Step 4: **conduction** – When the air is ionised, it becomes a conductor. This allows a current to flow through the air, giving us the spark! 😊



The figure shows a spark occurring.

Why do we only get a shock when we are very close to the handle? Remember the law of charges and the fact that electric fields are stronger the closer we get to them. Well… opposite charges attract 😊

Earthing

Static electricity isn't just annoying; it can be **very** dangerous. If a spark occurs in a place with flammable gases or fuel vapours, it can cause an explosion.

Where is this a problem? The most common example is refuelling vehicles, especially airplanes or tankers. As the liquid fuel flows rapidly through the pipes, friction occurs between the fuel and the pipe. This can cause a massive build-up of static charge on the vehicle.

How do we prevent a spark? We use earthing.

What is earthing? It is the process of connecting a charged object to the ground using a conductor like a copper wire.

How does earthing keep us safe? The copper wire provides a low-resistance path for the electrons to flow safely away to the ground. Because the charge safely flows away as soon as it builds up, no large potential difference can form. No potential difference means no strong electric field, which means no spark! 😊