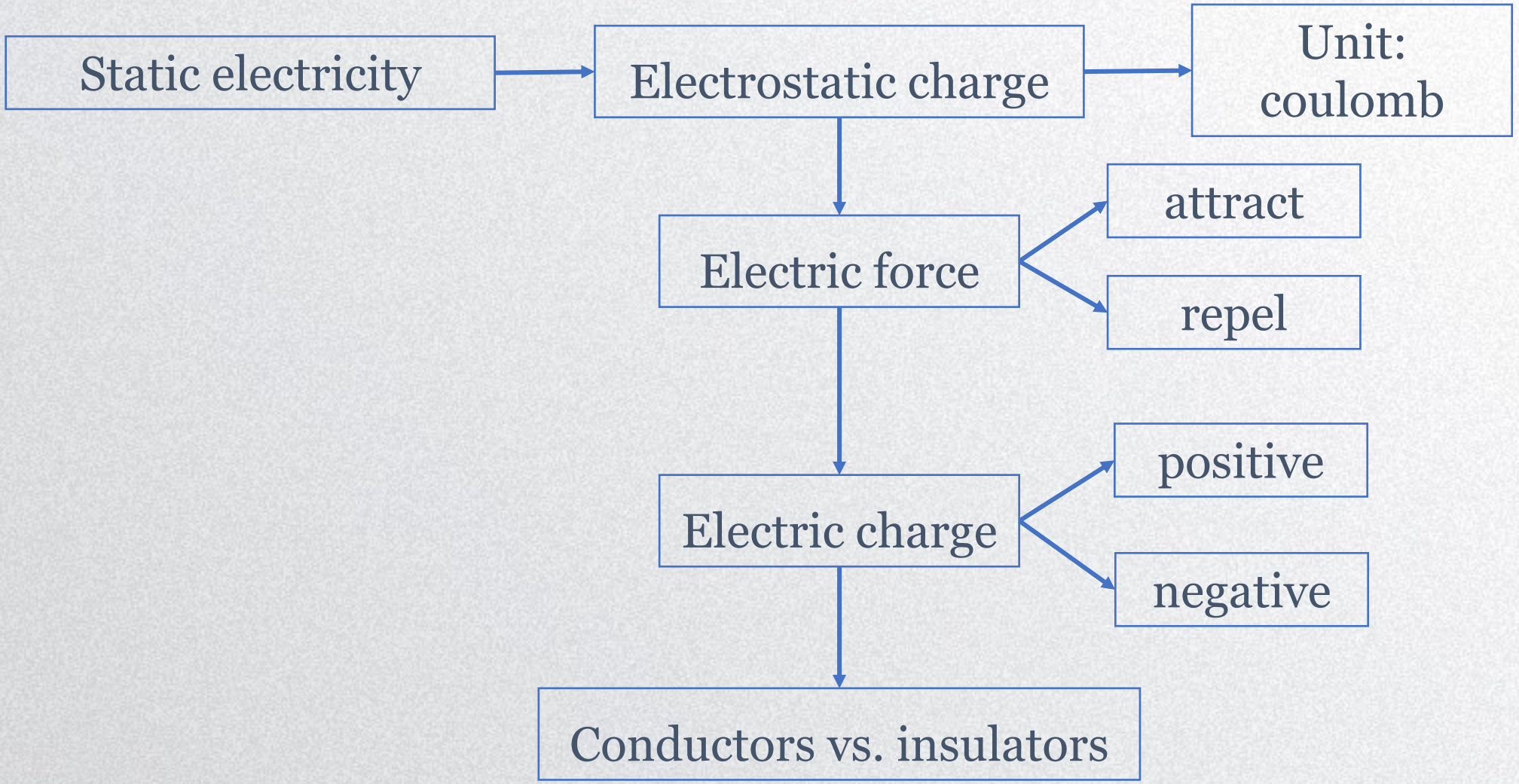
Section
4.2

# Static electricity

4.2.1 Charging and discharging
4.2.2 **Explaining static electricity**
4.2.3 Electric fields and electric charge

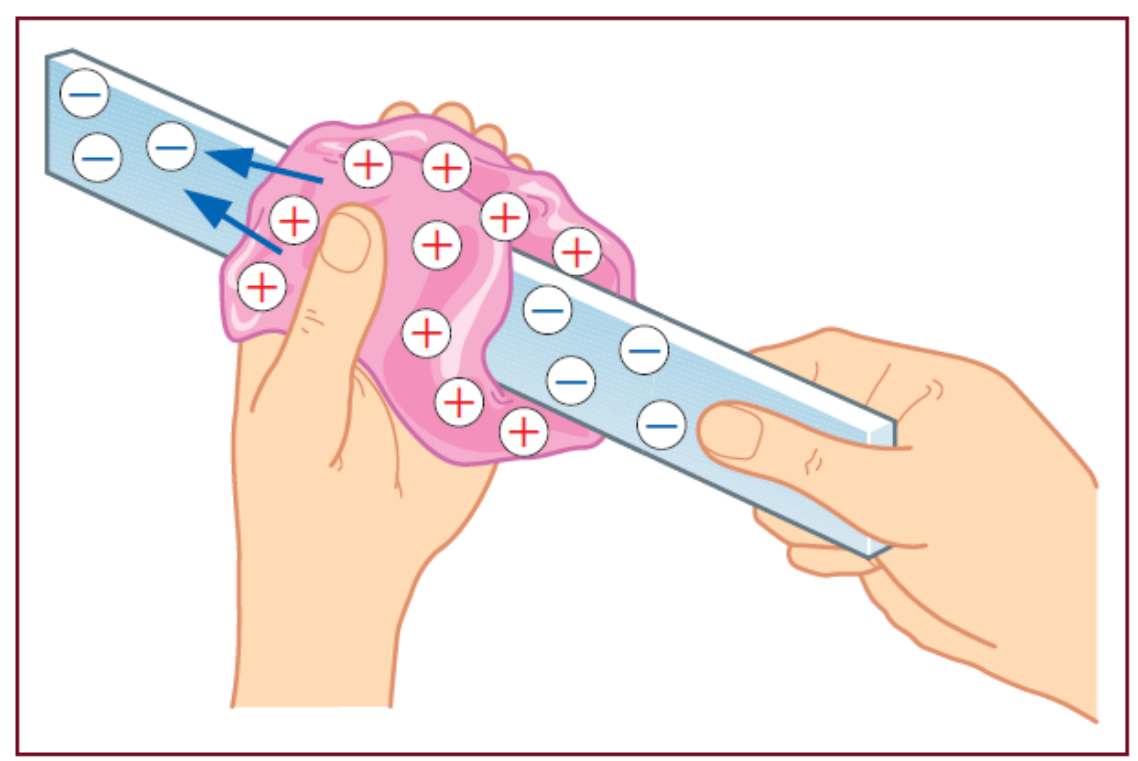
# Review


Static electricity
Electrostatic charge
Unit: coulomb
Electric force
attract
repel
Electric charge
positive
negative
Conductors vs. insulators

# Charging a Body

- Charging a body involves the **addition or removal of electrons**.
- There are 3 main ways that we can charge a body:
  - ✓ **Friction**
  - ✓ **Conduction**
  - ✓ **Induction**

# Charging by Friction



When a polythene rod is rubbed with a silk cloth, electrons are transferred from the silk to the polythene.

The silk is left with a positive charge.

# Charging by Friction

It is **the force of friction** that causes **charging**. When a plastic rod is rubbed on a cloth, friction transfers **electrons** from one material to the other. If the rod is made of *polythene*, it is usually the case that **electrons are rubbed off the cloth and onto the rod**. Electrons are a part of every atom. They are negatively charged, and they are found outside of the nucleus. Since they are relatively weakly held in the atom, they can be readily **pulled away by the force of friction**. When an atom has **lost an electron**, it becomes **positively charged**.

*Note: It takes *two different materials to generate static electricity*. One material becomes *positive*, the other *negative*.

# Charging by Friction

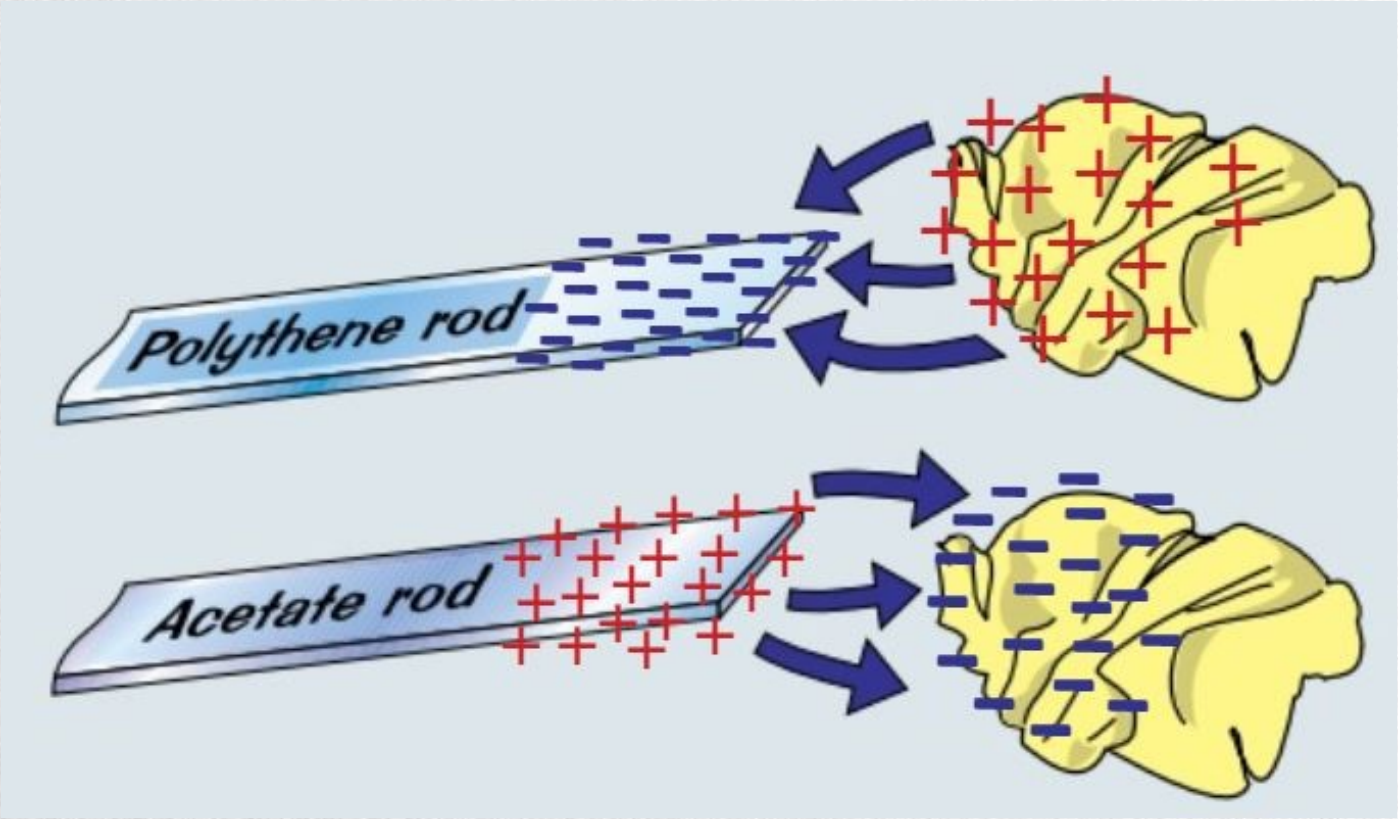
If the rod is made of polythene, the electrons are rubbed off the cloth and onto the rod. Why is that? Why the electrons are not transferring from the rod to the cloth?

# Charging by Friction

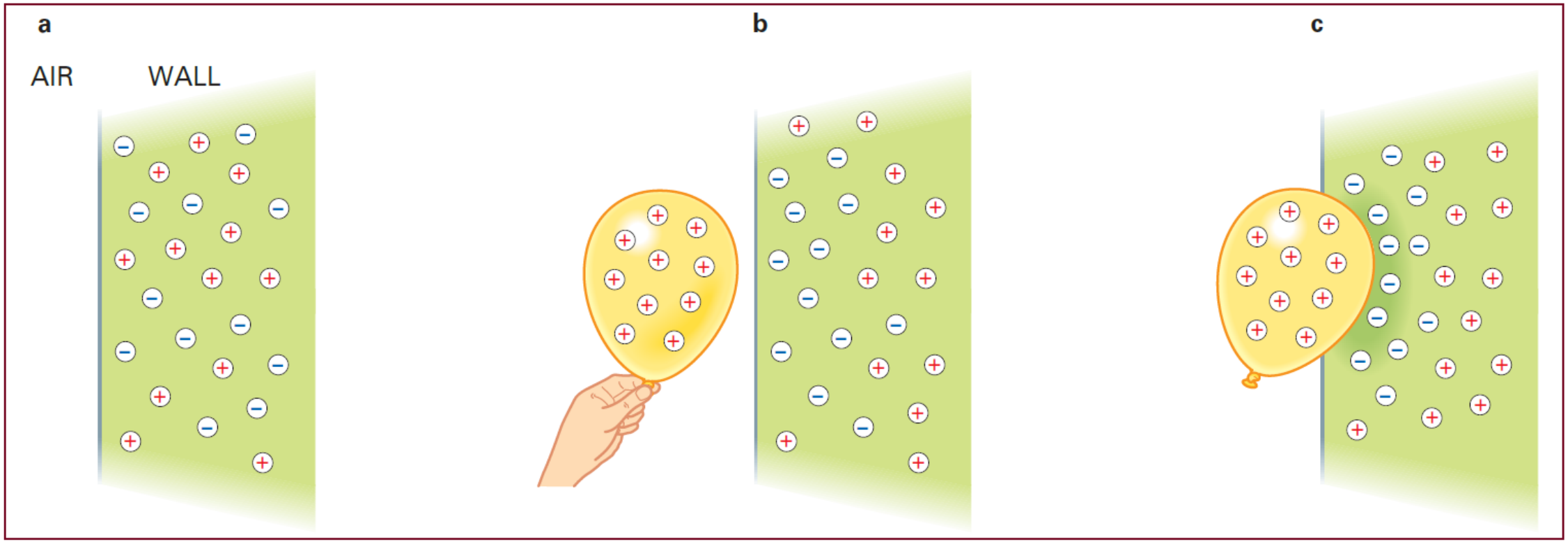
- Different materials have different electron affinities (i.e. love for electrons)
- When an object is rubbed over another object, the **electrons get transferred** from one object to another due to friction
- The electrons will move from the material of lower electron affinity to the material with higher electron affinity
- The object that **loses electrons** becomes **positively charged** and the object that **accepts electrons** become **negative charged**
- Charging by friction only works easily for **insulators**

# Charging by Friction

- Charging of solids by friction involves **only a transfer of negative charge (electrons)**



# Charging by Induction




a. The wall is **neutral**, because it has equal amounts of positive and negative charge.

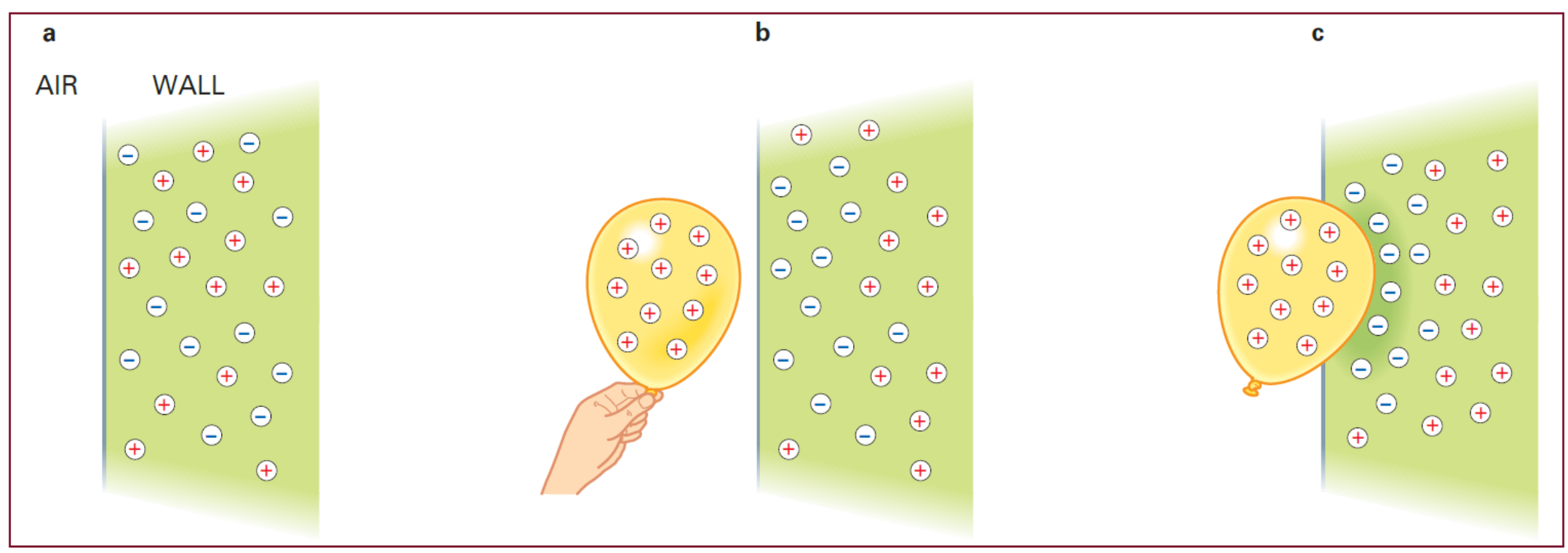
b. The **charged** balloon attracts the negative charges in the wall, so that they move towards it.

c. The positive balloon and the negative surface of the wall stick together.

# Charging by Induction

- **A charged object can attract uncharged objects**. For example, scatter some tiny pieces of paper on the bench. Rub a polythene rod on a woolen cloth. Both the charged rod and the charged cloth will attract the paper.
- This is the same effect as rubbing a balloon on your clothes and sticking it to a wall. An uncharged object (the wall) is attracted by a charged one (the balloon).
- Suppose the balloon has a positive charge. It must be attracted to a negative charge in the wall. The wall itself is neutral (uncharged), but its atoms are made up of positively and negatively charged particles. When the balloon is brought close to the wall, its negative charges (electrons) move towards the balloon, because they are attracted by it.
- They may not move very far, but the effect is enough to give the surface of the wall a negative charge, which attracts the balloon.

# Charging by Induction



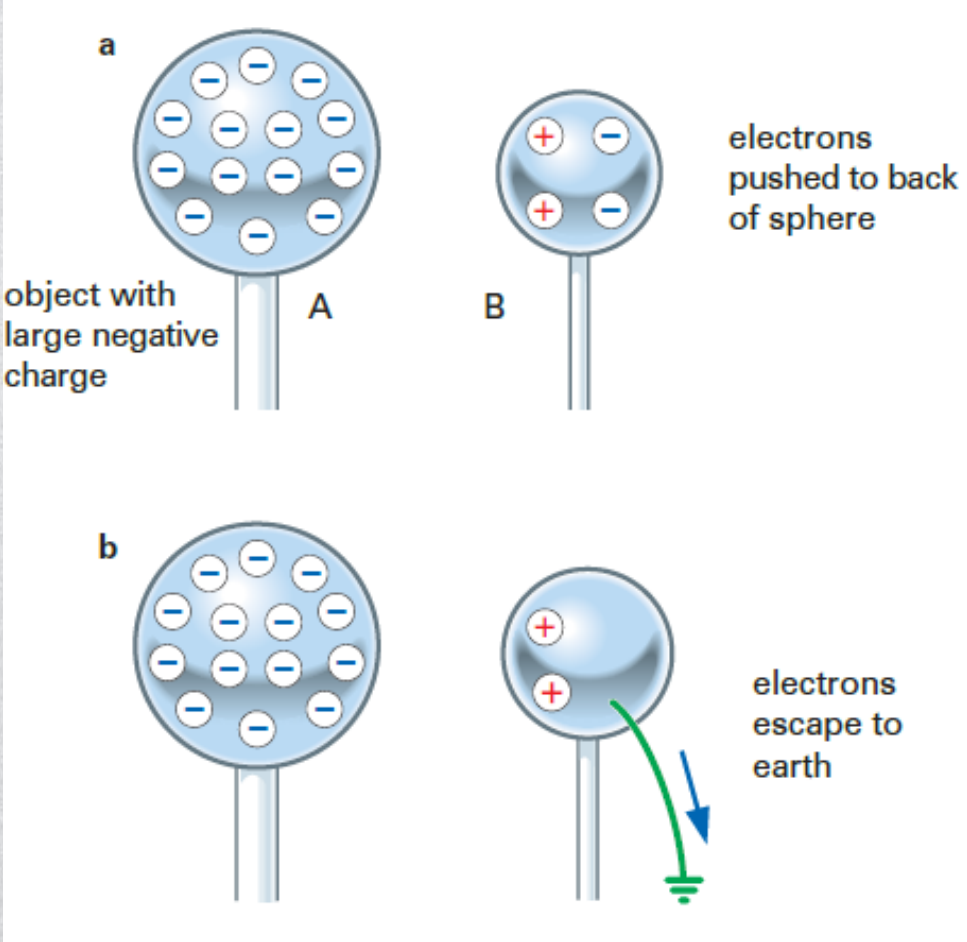

We say that a negative charge has been **induced** on the surface of the wall. This process is known as **charging by induction**. The same process occurs when the charged rod and cloth attract scraps of paper. The negative rod induces a positive charge on the paper, by repelling electrons away. The positive cloth attracts the electrons.

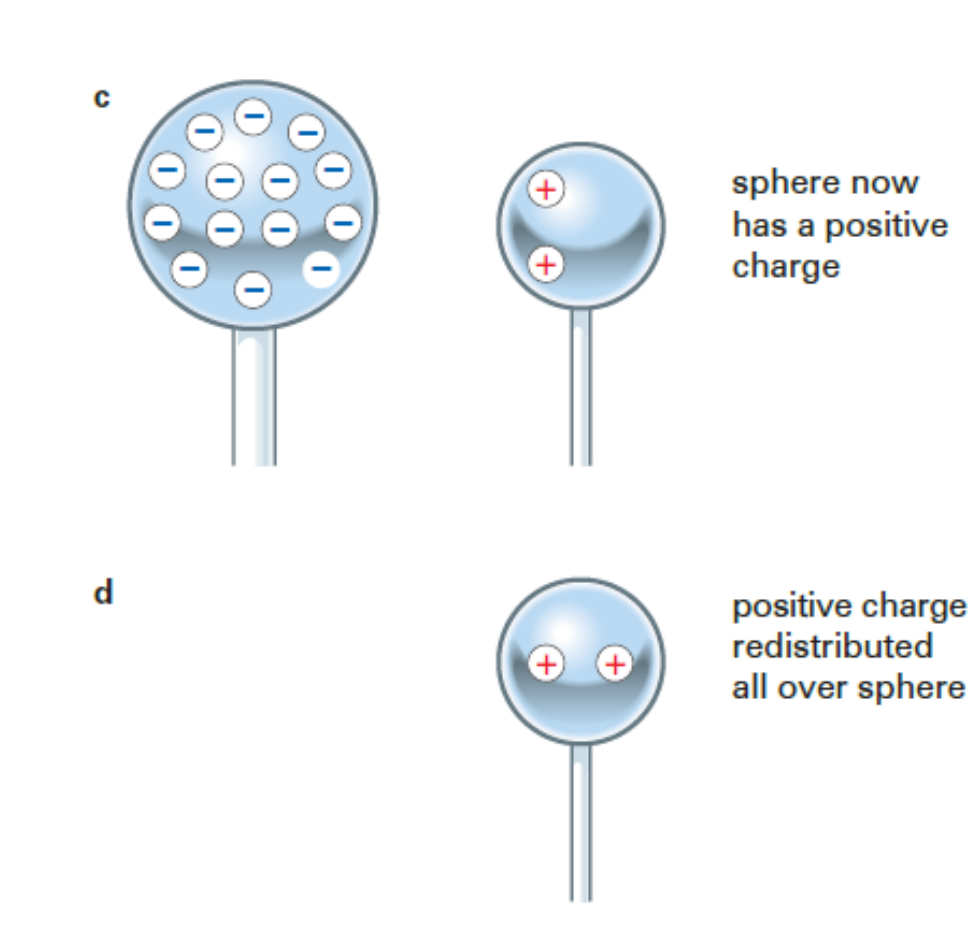
# Charging by Induction

Can we use charging by induction to charge a metal object?

# Charging by Induction

We can **use charging by induction to charge a metal object.**



# Charging by Induction

We can **use charging by induction to charge a metal object**. We start with two objects: an object A with a large negative charge, and an uncharged metal sphere B on an insulating stand.

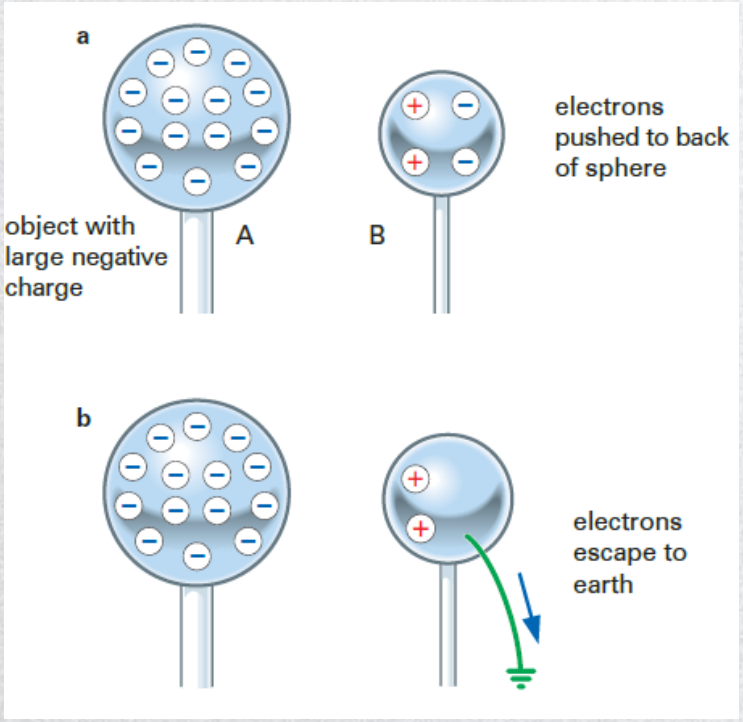
a. Object A has a large negative charge. When the metal sphere B is placed near it, electrons in the sphere are repelled away. The front of the sphere (near A) has an induced positive charge.

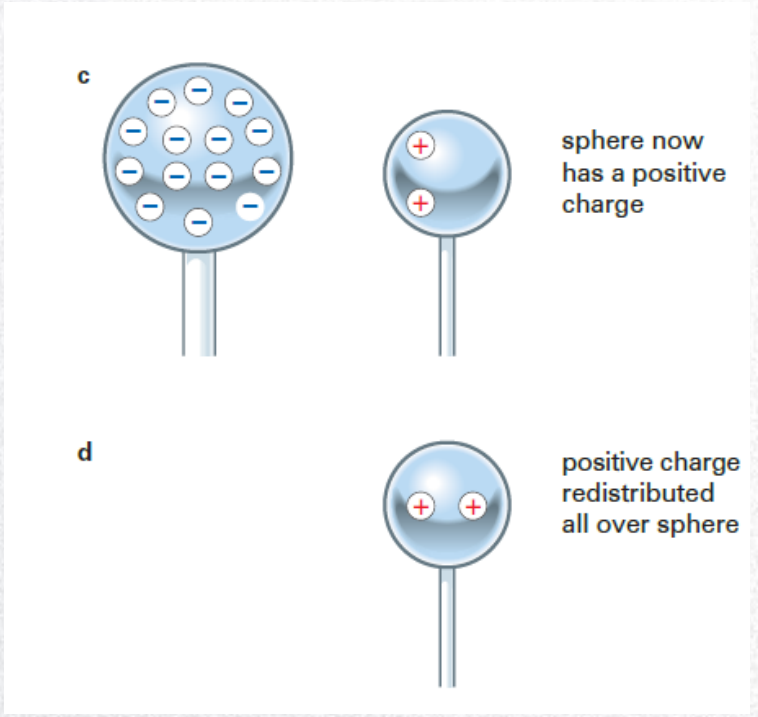
b. Now the sphere is touched, either by a hand or by a wire connected to earth. This allows electrons to escape from the sphere.

c. The connection is removed. Now the sphere has a positive charge.

d. Finally, the sphere B is taken away from object A. Sphere B has a uniformly distributed positive charge all over it.

# Charging by Induction



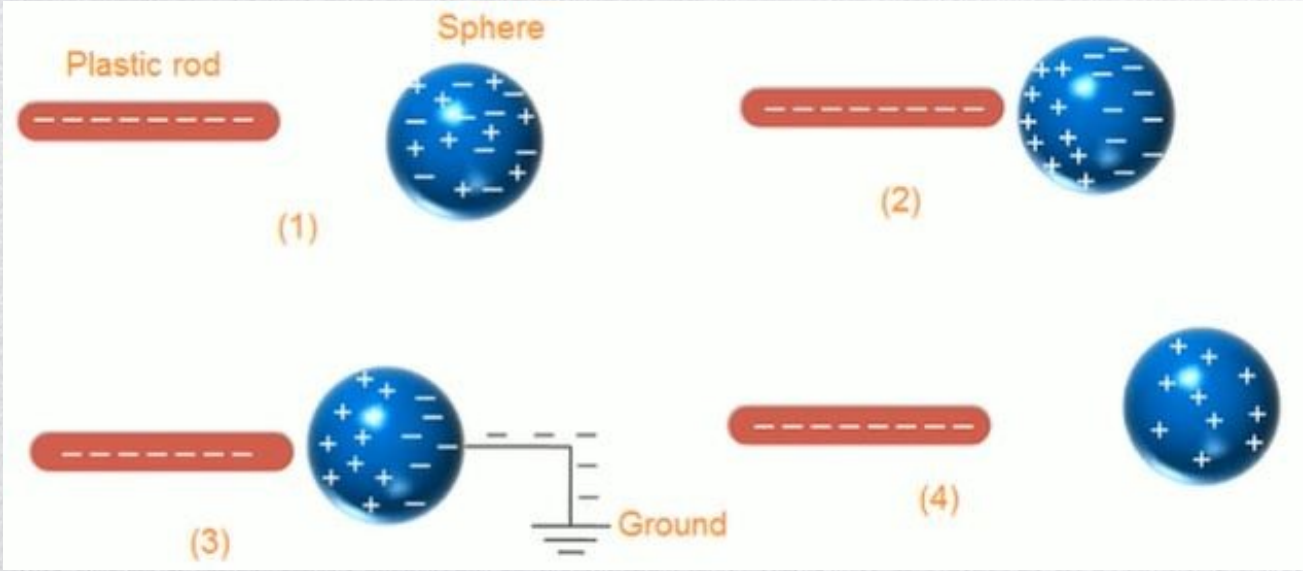




* Note that the connection to earth must be disconnected before B is moved away from A. Otherwise, the electrons would simply run back up to B to neutralize its positive charge.

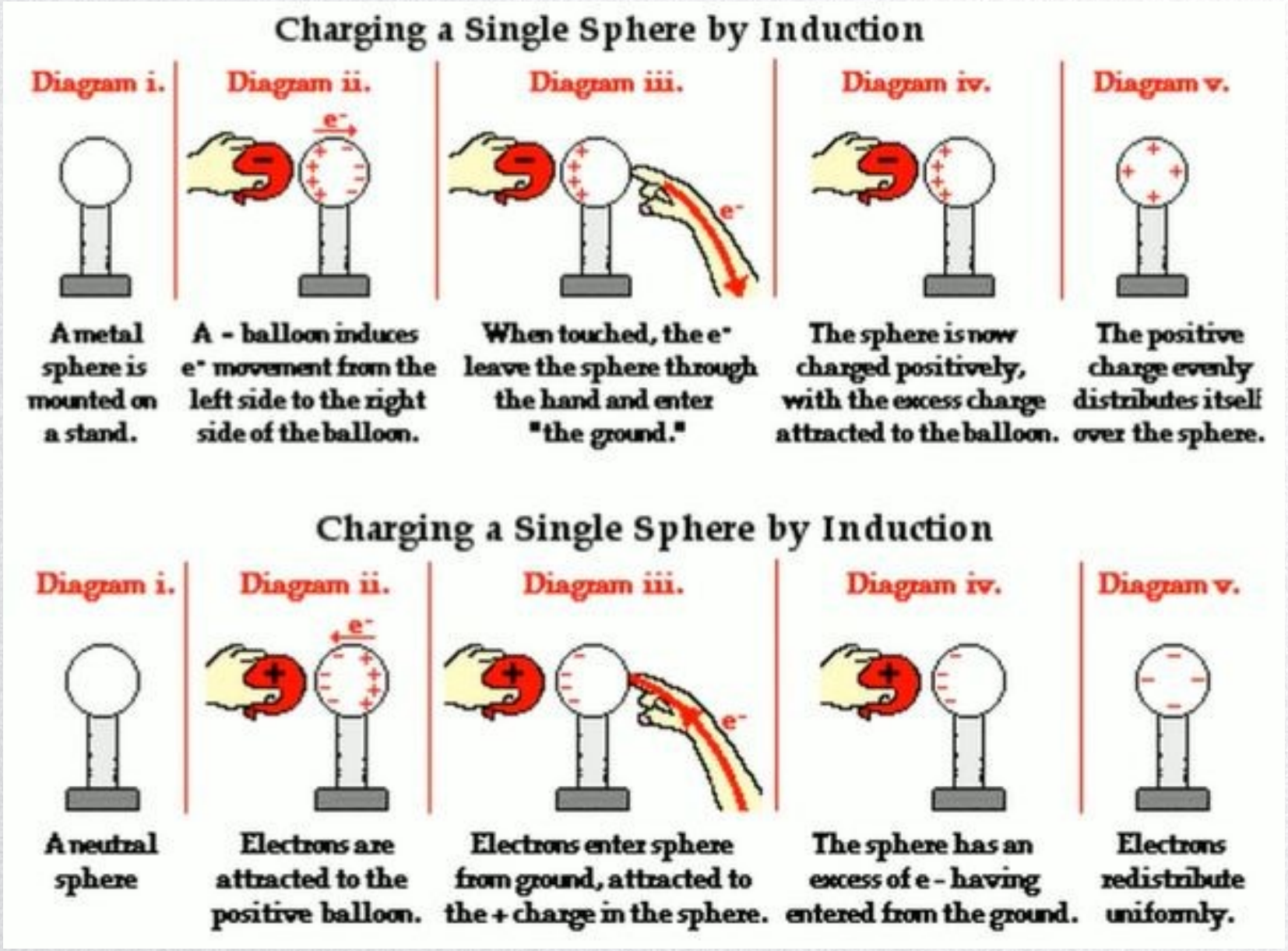
* Note also that the sphere B and the charged object A never touch. Sphere B gets a charge that is opposite in sign to that of object A.

# Charging by Induction

- The process of charging the **uncharged** object by bringing another **charged** object **near to it, but not touching it**, is called **charging by induction.**
- A **ground** is a large object that serves as an almost infinite source of electrons or sink for electrons. A ground contains such vast space that it is the ideal object to either **receive electrons or supply electrons** to whatever object needs to get rid of them or receive them.



# Charging by Induction

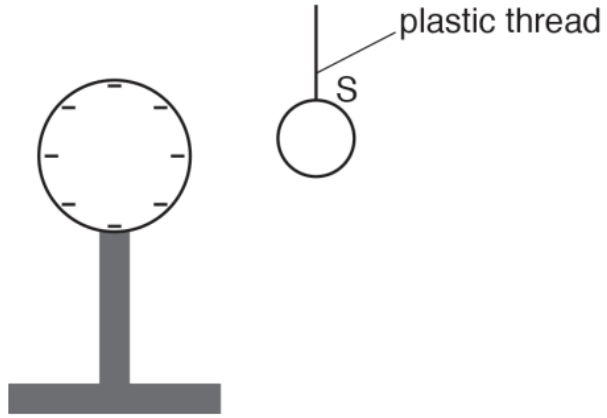


# Study question #1

The diagram shows two spheres.

One of the spheres is negatively charged and attached to a plastic stand.

The smaller, uncharged metal sphere S is suspended by a plastic thread.




The metal sphere S is an electrical conductor. The plastic thread is an electrical insulator.

Explain this difference by referring to the structures of the two materials.

.....

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..... [2]

[Total: 2]

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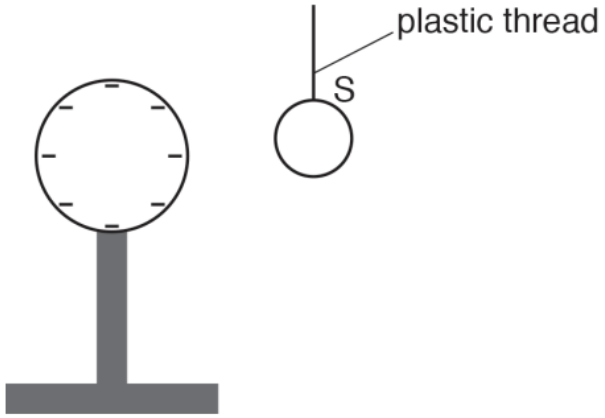


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.....

.....

..... [2]

[Total: 2]

Free (to move) / delocalised / mobile electrons are in metal sphere S (1)

Electrons in plastic / thread are fixed in position (1)

# Study question #2

A conducting sphere is mounted on an insulating stand. Explain how you would use a positively charged rod of insulating material to charge the sphere by induction.

.....

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.....

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..... [3]

[Total: 3]

# Study question #2

A conducting sphere is mounted on an insulating stand. Explain how you would use a positively charged rod of insulating material to charge the sphere by induction.

bring the positively charged rod close to the sphere (1)

earth sphere or equivalent (1) ;

(sphere is touched by a wire connected to earth)

remove earth connection while keeping rod close to the sphere (until earth removed) (1)

(keep the rod close to the sphere, then remove the earth connection) [3]

[Total: 3]

# THANK YOU