

Fri: HW by 5pm

Read 8.4-8.6

Electric forces and charges

Certain objects have the physical property that they are electrically charged. This is an intrinsic property of the object just like mass is an intrinsic property. For example, any proton always has the same charge regardless of its circumstances.

Quiz 1 mixed

All experimental evidence indicates:

electron \rightarrow negative \rightarrow charge $-1.6 \times 10^{-19} \text{C}$

proton \rightarrow positive \rightarrow charge $+1.6 \times 10^{-19} \text{C}$

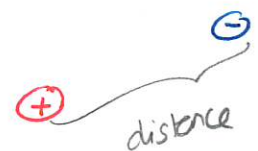
The basic rules for the forces exerted by charges are:

Like charges repel. Opposite charges attract

The detailed rule for the forces shows that

1) the size of the force increases with the size of the charge

2) the size of the forces increases as the separation decreases.



Quiz 2 ~80%

Quiz 3 80%

Quiz 4

Demo: Electroscope ~ glass rod + dishcloth

Electric forces and atoms

The beginnings of our modern understand of atoms involves electrical forces. The first step is to note that all atoms are built from the same basic subatomic particles:

- 1) electrons ~ discovered by J.J. Thomson 1897
- 2) protons ~ inferred at the time of electron discovery.
- 3) neutron ~ neutral particle, discovered Chadwick 1935.

[Image on Wikipedia](#)

We can use these to explain the workings of an individual atom and also interactions between atoms. This requires an understanding of the configuration of these particles within atoms.

However, regardless of their configuration, there is a basic constraint:

* any atom is neutral \Rightarrow in a neutral atom number of protons = number of electrons.

The actual arrangement was determined via a series of experiments due to Ernest Rutherford (done 1910-1911).


DEMO: PHET Rutherford scattering.

* Plum Pudding Model

One could bombard atoms (of gold) with high-energy subatomic particles and observe how these scattered. The results of this demonstrated that the positive charge and mass of any atom reside in a small nucleus

DEMO: PHET Rutherford Scattering.



- electrons (very distant compared to size of nucleus)
-  positive nucleus (very small compared to atom)

This is called the nuclear model:

- * protons and neutrons in a central nucleus - radius $\approx 10^{-15}\text{m}$
- * electrons on the periphery \sim typically 10^{-10}m from center.
- * most of the atom is empty space!

Concepts of Physics: Group Exercise 4

18 October 2023

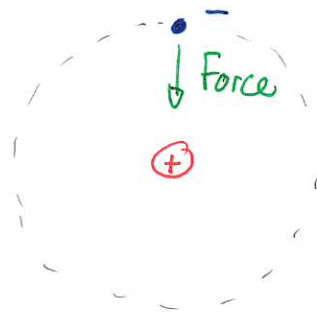
Names: _____

1 Rutherford model of the atom

The Rutherford model of the atom consists of a nucleus, which contains all the protons and neutrons at the center, surrounded by distant electrons. Consider first the simplest such atom, the hydrogen atom, which contains one proton and one electron.

- What force will the proton exert on the electron? Can you predict how the electron will behave under this force?
- Can you predict how the electron could move so that the force exerted by the proton provides the necessary force and yet the atom does not collapse? *Hint: Consider the motion of the Moon and the forces that enable it to move in a circle around Earth!*

Answer: a)



The force is attractive.
How the electron moves depends
on its state of motion at one instant

- The electron could move in a circle. Then the attractive force would provide a radially inward force. This is exactly like the Moon orbiting Earth. Gravity provides an inward attractive force that keeps the Moon moving in a circle.

2 Sodium and chlorine atoms and ions

The chemical element sodium, one of the constituents of table salt, is a highly reactive metal. A single sodium atom contains 11 protons, 12 neutrons and electrons. The chemical element chlorine, the other constituent of table salt, is a highly reactive toxic gas. A single chlorine atom contains 17 protons, 18 neutrons and electrons.

- How many electrons does a neutral sodium atom contain?
- How many electrons does a neutral chlorine atom contain?
- Suppose that two neutral sodium atoms are held near each other. Will they attract or repel each other?

An ion is an atom that has gained or lost electrons.

- Sodium readily forms ions by losing one electron. Will such an ion be positively or negatively charged or neutral?
- Chlorine readily forms ions by gaining one electron. Will such an ion be positively or negatively charged or neutral?
- Consider two such sodium ions. Will they attract or repel each other?
- Consider two such chlorine ions. Will they attract or repel each other?
- Consider such a chlorine and sodium ion. Will they attract or repel each other?
- Imagine trying to assemble a collection of sodium and chlorine ions in a regular arrangement so that the forces that they exert hold them together but prevent them from collapsing. Can you construct such an arrangement?

a) 11 same as protons

b) 17 " " "

c) Neither, they are neutral

d) Positively charged, 11 protons, 10 electrons \Rightarrow charge $+1.6 \times 10^{-19} \text{ C}$


e) Negatively " 17 protons, 18 electrons \Rightarrow " $-1.6 \times 10^{-19} \text{ C}$

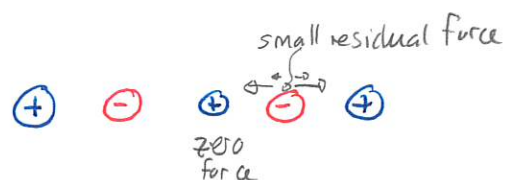
f) Like charges \Rightarrow repel

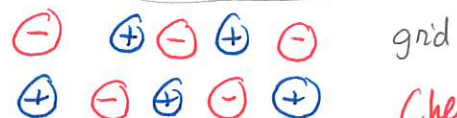
g) Like " \Rightarrow repel

h) opposite charges attract

i)  collapses

 outside ones collapse
zero force

 small residual force
zero force

 grid

Chem Tube 3D