Chapter Twelve: Atoms and the Periodic Table

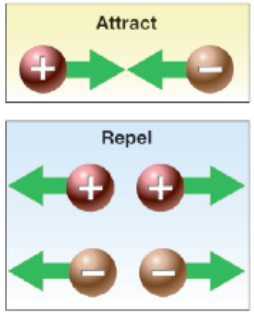
- 12.1 The Structure of the Atom
- 12.2 Electrons
- 12.3 The Periodic Table of Elements
- 12.4 Properties of the Elements

Chapter 12.1 Learning Goals

- Apply an understanding of electric charge to describe the structure of atoms.
- Identify and describe particles which comprise atoms.
- Compare and contrast forces inside atoms.

12.1 Structure of the Atom

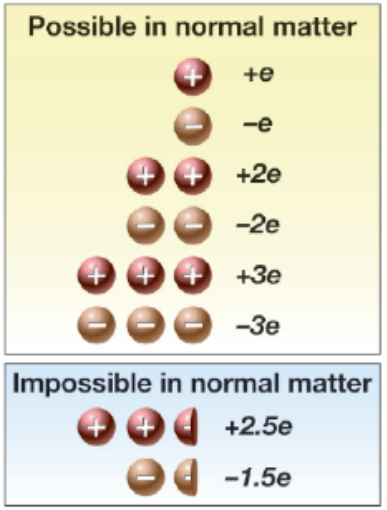
- In order to understand atoms, we need to understand the idea of electric charge.



- We know of two different kinds of electric charge and we call them positive and negative.

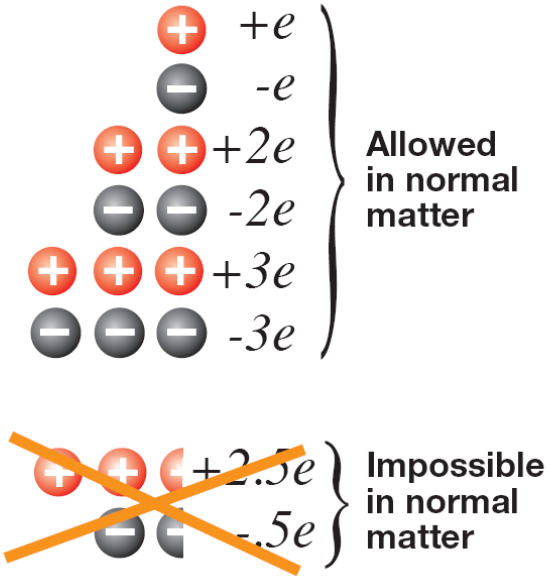
12.1 Electric charge in matter

- Scientists use the letter e to represent the elementary charge.
- At the size of atoms, electric charge always comes in units of +e or –e.
- Electric charge appears only in whole units of the elementary charge.



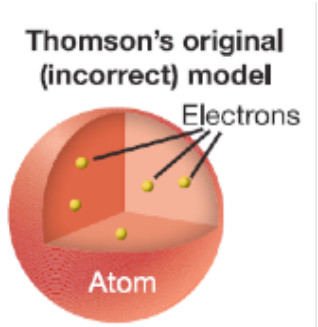
Units of Elementary Charge

Electric charge only appears in multiples of the elementary charge, e.



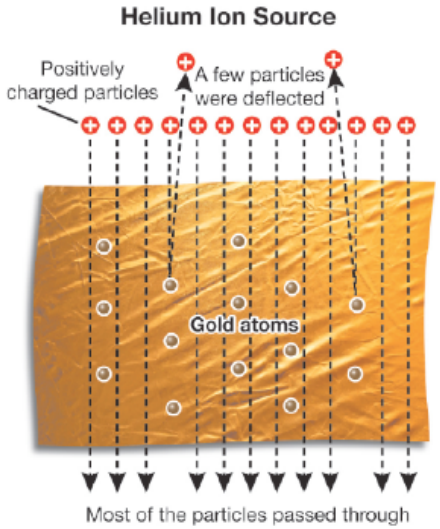
12.1 An early model

- In 1897 English physicist J. J. Thomson discovered that electricity passing through a gas caused the gas to give off particles that were too small to be atoms.
- These negative particles were eventually called "electrons."



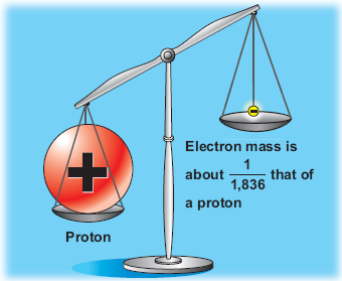
12.1 The nuclear model

- In 1911, Ernest Rutherford, Hans Geiger, and Ernest Marsden did a clever experiment to test Thomson's model.
- We now know that every atom has a tiny nucleus, which contains more than 99% of the atom's mass.



12.1 Inside an atom

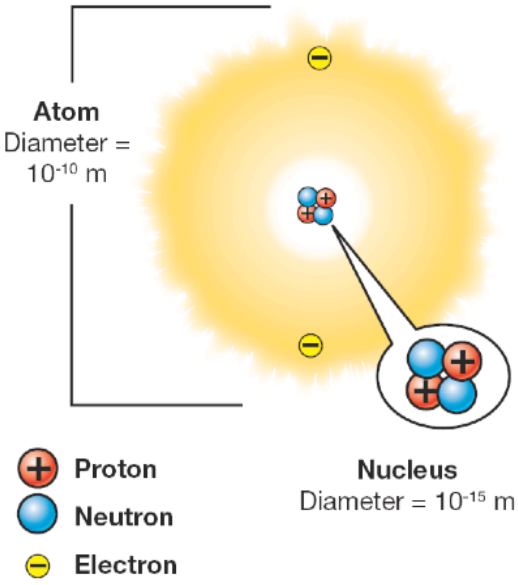
- The mass of the nucleus determines the mass of an atom because protons and neutrons are much larger and more massive than electrons.
- In fact, a proton is 1,836 times heavier than an electron.



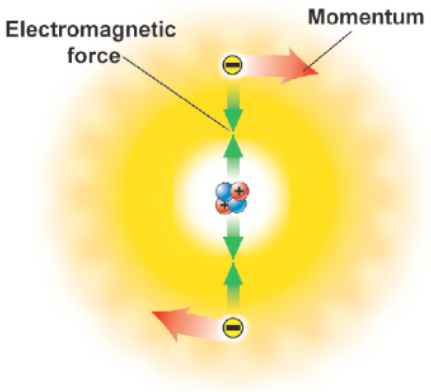
Electron, Proton, and Neutron Table

	Occurence	Charge	Mass (g)	Relative Mass
Electron	Found outside of nuclei	-1	9.109×10^{-28}	1
Proton	Found in all nuclei	+1	1.673×10^{-24}	1,836
Neutron	Found in almost all nuclei (exception: most H nuclei)	0	1.675×10^{-24}	1,839

Size and Structure of an Atom

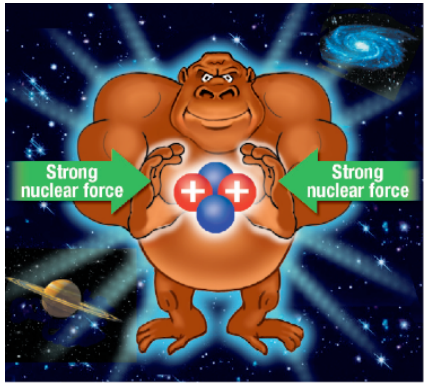


12.1 Force inside atoms



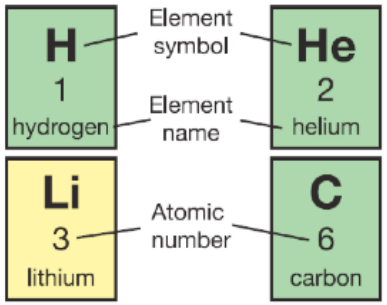
- Electrons are bound to the nucleus by the attractive force between electrons (–) and protons (+).

12.1 Force inside atoms



- What holds the nucleus together?
- There is another force that is even stronger than the electric force.
- We call it the strong nuclear force.

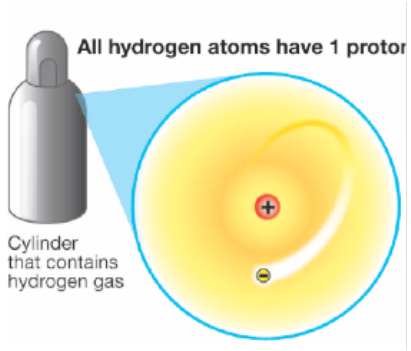
12.1 How atoms of various elements are different



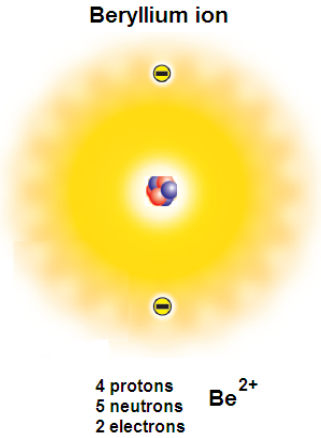
- The atoms of different elements contain different numbers of protons in the nucleus.
- Because the number of protons is so important, it is called the atomic number.

12.1 Atomic number and protons

- Each element has a unique atomic number.
- Atoms of the same element always have the same number of protons in the nucleus.

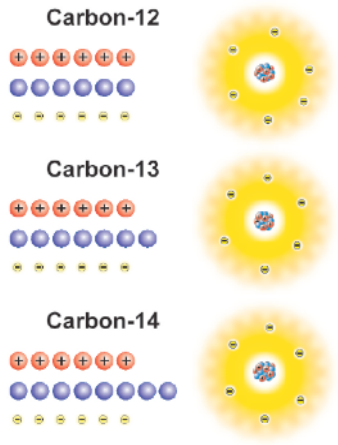


12.1 Ions



- Complete atoms have a net zero charge.
- Ions are atoms that have a different number of protons than electrons and so they have a positive or negative charge.

12.1 How atoms of various elements are different



- Isotopes are atoms of the same element that have different numbers of neutrons.
- The mass number of an isotope tells you the number of protons plus the number of neutrons.

How are these carbon isotopes different?

Solving Problems

- **How many neutrons are present in an aluminum atom that has an atomic number of 13 and a mass number of 27?**

Aluminum-27

13 protons
? neutrons

Solving Problems

1. **Looking for:**
   - …number of neutrons in aluminum-27
2. **Given**
   - … atomic no. = 13; mass no. = 27
3. **Relationships:**
   - Periodic table says atomic no. = proton no.
   - protons + neutrons = mass no.
4. **Solution**
   - neutrons = mass no. – protons
   - neutrons = 27 – 13 = **14**