Introductory Chemistry, 2nd Edition
Nivaldo Tro

Chapter 4 Atoms and Elements

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4.2 The Divisibility of Matter

- Infinitely Divisible
  - ✓for any two points there is always a point between
- Ultimate Particle
  - ✓upon division eventually a particle is reached which can no longer be divided

"Nothing exists except atoms and empty space; everything else is opinion." - Democritus 460–370 B.C.

Dalton's Atomic Theory

1. Elements are composed of atoms
   - ✓ tiny, hard, unbreakable, spheres
2. All atoms of an element are identical
3. Atoms combine in simple, whole-number ratios to form molecules of compounds
   - ➢ Law of Constant Composition
   - ➢ Chemical Formulas

John Dalton
(1766-1844)

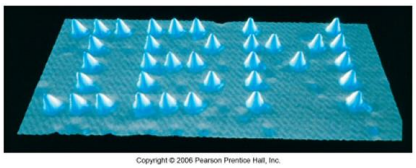
Dalton's Atomic Theory

4. In chemical reactions, atoms are not broken or changed into another type.
   - ✓ atoms are not created or destroyed, just rearranged
     - – Law of Conservation of Mass

Sizes of Atoms

- using compositions of compounds and assumed formulas, Dalton was able to determine the **relative** masses of the atoms
  - ✓Dalton based his scale on H = 1 amu
  - ✓unit = **atomic mass unit**
- absolute sizes of atoms
  - ✓mass of H atom= 1.67×10^{-24}g
  - ✓Diameter ~ 1×10^{-10} m
  - ✓volume of H atom = 2.1×10^{-25}cm^3

Modern Evidence for Atoms



nanotechnology

4.3 The nuclear atom

- Work done by J.J. Thomson and others proved that the atom had pieces called **electrons**

cathode ray tube

- Thomson found that electrons are much smaller than atoms and carry a negative charge
  - ✓ the mass of the electron is 1/1836th the mass of a hydrogen atom
  - ✓ the charge on the electron is the fundamental unit of charge which we will call –1 charge units

Thomson's Interpretation - the Plum Pudding Model

There must be a positive charge in the atom!

Some Notes on Charge

Two Kinds of Charge called + and –

- Opposite Charges Attract


Positive (red) and negative (yellow) charges attract.

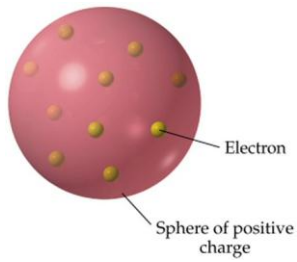
- Like Charges Repel


Positive-positive or negative-negative charges repel.

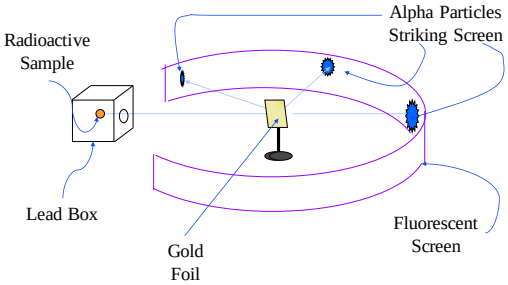
- To be Neutral, something must have no charge or equal amounts of opposite charges

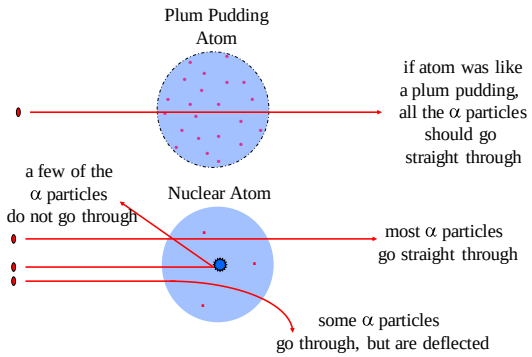
Positive and negative charges cancel.

Plum Pudding Atom



Rutherford's Experiment





Rutherford's Results

- Over 98% of the α particles went straight through
- About 2% of the α particles went through but were deflected by large angles
- About 0.01% of the α particles bounced off the gold foil
  - ✓"...as if you fired a 15" canon shell at a piece of tissue paper and it came back and hit you."

Rutherford exp

Rutherford's Conclusions

- Atom mostly empty space
- Atom contains a dense particle that was small in volume compared to the atom but large in mass
- This dense particle was positively charged

Rutherford's Interpretation – the Nuclear Model

1) The atom contains a tiny dense center called the **nucleus**
   - ✓ Nucleus = baseball; atom = 2.5 mi, electron = period
2) The nucleus has essentially the entire mass of the atom
3) The nucleus is positively charged
4) The electrons move around in the empty space of the atom surrounding the nucleus

4.4 Structure of the Atom

- Rutherford proposed that the nucleus had a particle that had the **same amount of charge as an electron** but opposite sign a **"proton"**
- For the ***atom to be neutral there must be equal numbers of protons and electrons***
- The nucleus also contains neutrons…mass and proton repulsion.

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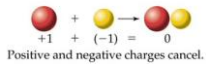
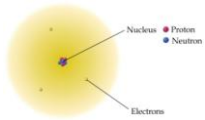


Positive and negative charges cancel.

The Modern Atom



- Protons, neutrons and electrons
- The nucleus – protons and neutrons
- The electrons move outside the nucleus

Subatomic Particle	Mass g	Mass amu	Location in atom	Charge	Symbol
Proton	1.67×10^{-24}	1	nucleus	+1	p, p^+, H^+
Electron	0.0009×10^{-24}	~0	empty space	-1	e, e^-
Neutron	1.67×10^{-24}	1	nucleus	0	n, n^0