Defining the Atom

All matter is composed of tiny fundamental particles, which we call atoms.

Atom =

The concept of the atom intrigued a number of early scientists. While these early scientists could not observe individual atoms, they still were able to propose ideas about the structure of atoms.

Democritus's Atomic Theory:

- 460 B.C. - 370 B.C.
- Greek philosopher
- First to suggest the existence of atoms
- His ideas lacked experimental support
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The real nature of atoms and the connection between observable changes and events at the atomic level were not established for more than 2000 years after Democritus's death.

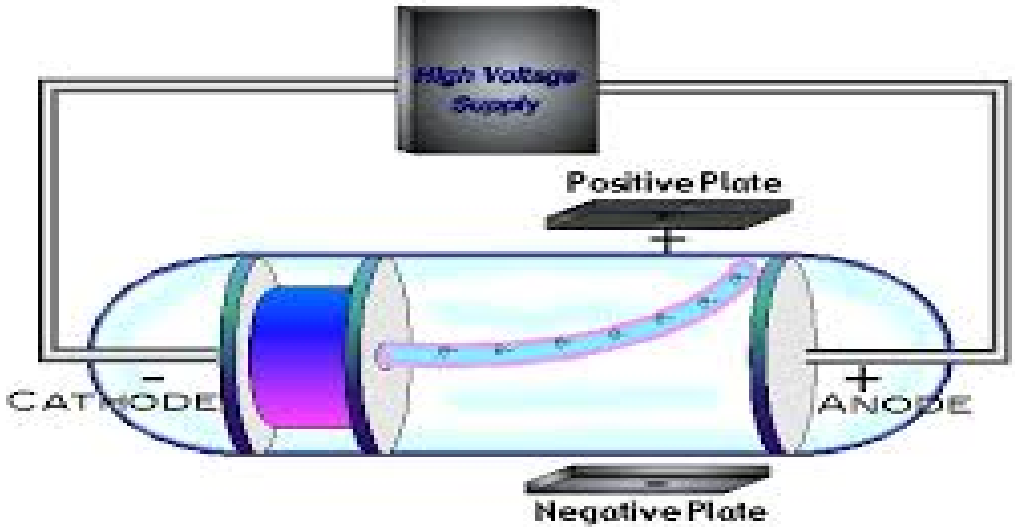
Dalton's Atomic Theory:

- 1766-1844
- English chemists and school teacher
- Through the use of experimental methods, Dalton transformed Democritus's ideas on atoms into a scientific theory.
- Studied the ratios in which elements combine in chemical reactions.
    - Based on the results of his experiments, Dalton formulated hypotheses and theories to explain observations - the result of his work was known as Dalton's Atomic Theory:
        1.
        2.
        3.
        4.

Other scientists have also contributed to our understanding of the atom:

J.J. Thomson's Atomic Theory:

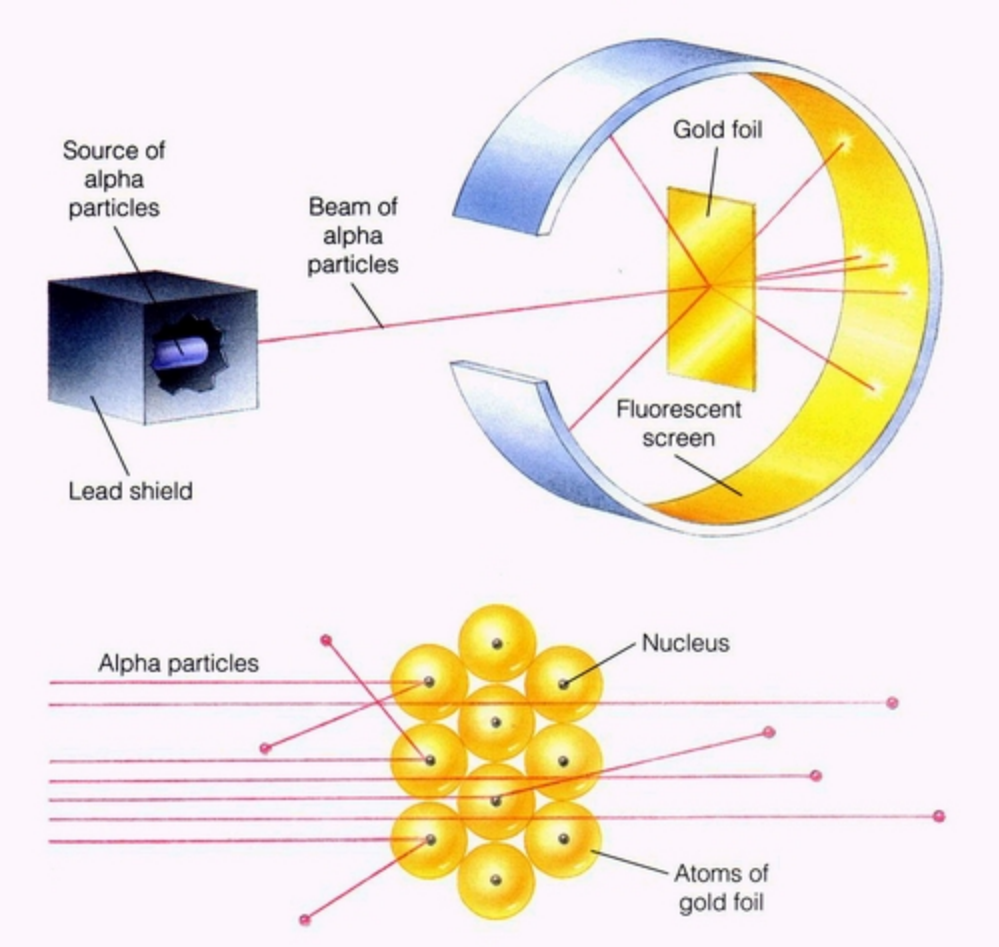
- 1897
- Changed the view of an atom through the discover of _____.
- Thomson's atomic theory suggested that the atom was made of smaller *subatomic* particles:
    -
    -
- Thomson discovered that atoms emit negative particles when zapped with electricity.
    - In an experiment he found that a magnet changed the path of a cathode ray.



- Thomson believed:
    - An atom consisted of a sphere of positive charges with negatively charged electrons embedded in it.
    - The positive and negative charges are equal (overall net charge is neutral).

Ernest Rutherford:

- 1909
- Gold Foil Experiment
- Shot thin gold foil with alpha particles (big and positively charged).
    - Rutherford concluded that atoms have a dense, positively charged nucleus (which balances the electrons negative charge).



- While the nucleus contains virtually all of the mass of an atom, it only takes up one-billionth of the volume of the atom.
    - Much smaller particles (_____) orbit the nucleus at a great distance.

Neils Bohr:

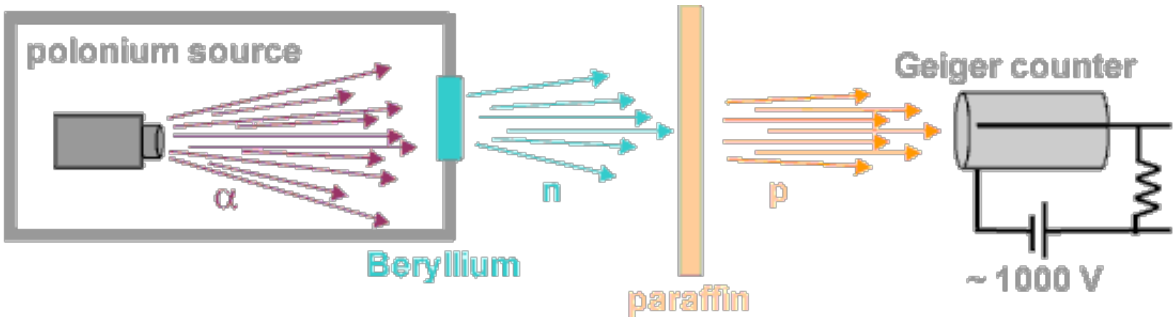
- 1913
- Refined Rutherford's model by proposing that electrons:
    - Orbit the nucleus without losing energy.
    - Could move only in fixed orbits of specific energies.
    - Electrons with _____ _____ would orbit closer to the nucleus while electrons with _____ _____ orbit further from the nucleus.

James Schrödinger:

- 1926
- Suggested that electrons were found in “probability clouds”, not orbits.
    - The densest area of the cloud is where you have the greatest probability of finding the electron.

James Chadwick:

- 1932
- Identified the neutron.
    - Shot alpha particles at beryllium foil.
    - The electrically neutral particles ejected.
        - Provided evidence for the existence of neutrons in the nucleus.



Sizing Up the Atom

Atoms are incredibly small:

A pure copper coin the size of a penny contains _____ atoms.

Earth’s population is only about _____ people.

If you were to line up 100,000,000 atoms of copper side by side how long do you think they would be?

Structure of the Nuclear Atom

Much of Dalton’s atomic theory is still accepted today; however, there is one important change:

Atoms can be broken down into even smaller, more fundamental particles, called

_____.

- The three kinds of subatomic particles are:

-
-
-

Particle	Symbol	Charge	Actual Mass (amu)

Where are all of the subatomic particles located in an atom?

Distinguishing Among Atoms:

If all atoms are made up of protons, neutrons, and electrons, how are atoms of hydrogen different than oxygen atoms?

Atomic Number

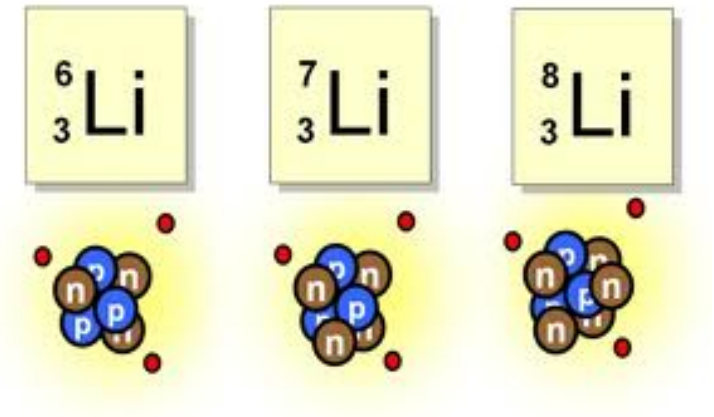
Mass Number

The composition of an atom can be represented in shorthand notation using the atomic number and mass number.

Practice:
How many protons, electrons, and neutrons are in each atom?

Isotopes
Atoms that have the _____number of _____ but different numbers of _____.
If elements have different numbers of neutrons what else is different?

Despite isotopes having different numbers of neutrons, isotopes are chemically alike because they have identical _____.



Calculating Atomic Mass

The atomic mass of an element is a weighted average mass of the atoms in a naturally occurring sample of the element.

- A weighted average mass reflects both the mass and the relative abundance of the isotopes as they occur in nature.

Atomic mass is measured in _____ (amu).

- One twelfth of the mass of a carbon-12 atom = 1 amu

To calculate the atomic mass of an element, multiply the mass of each isotope by its natural abundance, expressed as a decimal, and then add the products.

Practice:
Find the atomic mass of a sample of chlorine atoms. Assume that 75.77% of the sample is Cl-35 and 24.23% of the sample Cl-37.

Carbon has two stable isotopes: carbon-12, which has a natural abundance of 98.89%, and carbon-13, which has a natural abundance of 1.11%. The mass of carbon-12 is 12.000 amu; the mass of carbon-13 is 13.003 amu. Find the atomic mass of carbon.

The Mole-A Measurement of Matter:

We can use conversion factors to convert between the count, mass and volume.

By count: 1 dozen apples: 12 apples

By mass: 1 dozen apples: 2.0 kg apples

By volume: 1 dozen apples: 0.20 bushel apples

Practice:
What is the mass of 90 average-sized apples if 1 dozen of the apples has a mass of 2.0 kg?

Assume 1 dozen oranges has a mass of 1.5 kg and that there are 14 orange slices in each orange. How many slices are in 6 kg of oranges?

What is a Mole?

The term _____ _____ refers to the species present in a substance, usually atoms, molecules, particles, or formula units.

Converting Between Number of Particles and Moles:

1 mol =

Practice:
Magnesium is a light metal used in the manufacture of aircraft, automobile wheels, and tools. How many moles of magnesium is 1.25×10^{23} atoms of magnesium?

How many moles is 2.80×10^{24} atoms of silicon?

How many moles is 2.17×10^{23} representative particles of bromine?

Molar Mass

Quantities measured in grams are convenient for working in the laboratory, so chemists have converted the relative scale of masses of the elements in amu to a relative scale of masses in grams.

- The atomic mass of an element expressed in grams is the mass of a mole of the element.
    - The mass of one mole of an element is the _____ of the element.

To calculate the molar mass of a compound, find the number of grams of each element in one mole of the compound. Then add the masses of the elements in the compound.

Practice:
What is the molar mass of 1 molecule of SO_3?

The decomposition of hydrogen peroxide (H_2O_2) provides sufficient energy to launch a rocket. What is the molar mass of hydrogen peroxide?

Find the molar mass of PCl_3.

Mole-Mass Relationship

Suppose you need a given number of moles of a substance for a laboratory experiment. How can you measure this amount?

To convert between moles and mass you must use the molar mass of an element or a compound. The conversion factors for these calculations are based on the relationship:

Practice:
Items made out of aluminum, such as aircraft parts and cookware, are resistant to corrosion because the aluminum reacts with oxygen in the air to form a coating of aluminum oxide (Al_2O_3). This tough, resistant coating prevents any further corrosion. What is the mass, in grams, of 9.45 mol of aluminum oxide?

Find the mass, in grams, of 4.52×10^{-3} mol $C_{20}H_{42}$.

When iron is exposed to air, it corrodes to form red-brown rust. Rust is iron (III) oxide (Fe_2O_3). How many moles of iron (III) oxide are contained in 92.2 g of pure iron (III) oxide?

Find the number of moles in 3.70×10^{-1} g of boron.

Calculate the number of moles in 75.0 g of dinitrogen trioxide.