

Atomic Theory

A theory - **a thoroughly tested explanation.**

With more information the explanations change, hopefully the explanations get better, explain more behaviors.

While the old theory still works, the better explanation is used because it explains more observations.

Atomic Theory

The earliest recorded information about changes in matter come from the early Greeks so it is often referred to as the Greek Model.

Ancient Asians (Korea, Japan, etc) also had the same model.

4 elements from which everything else is made -

earth

air

fire

water

Greek Model

The model of 4 elements, meaning fundamental building blocks is a very sound beginning to describing chemical changes.

It has some flaws, especially that these “elements” are not uniform, their composition changes.

John Dalton

John Dalton (the father of chemistry) was the first (1808) to propose an explanation of behavior of elements based on a fundamental particle called an atom.

The Greek word *atomos* means uncuttable, Dalton adopted this word to mean the smallest part of an element - uncuttable, fundamental.

Atoms - the evidence

Two major pieces of evidence -

The Law of Definite Composition (Proportions):

Whenever a compound is formed it has definite proportions.

Example: Whenever water is formed it is always made from two elements, hydrogen and oxygen, and the mass ratio is always 1 gram of hydrogen to 8 grams of oxygen.

The Evidence

The Law of Multiple Proportions:

Whenever more than one compound (multiple) can be formed by the same elements the ratio of the elements between the compounds are in small whole numbers.

Example: water and hydrogen peroxide. Both are made from hydrogen and oxygen.

Hydrogen peroxide has a ratio of 1 g hydrogen to 16 grams of oxygen.

Water has a ratio of 1 gram of hydrogen to 8 grams of oxygen.

The Evidence

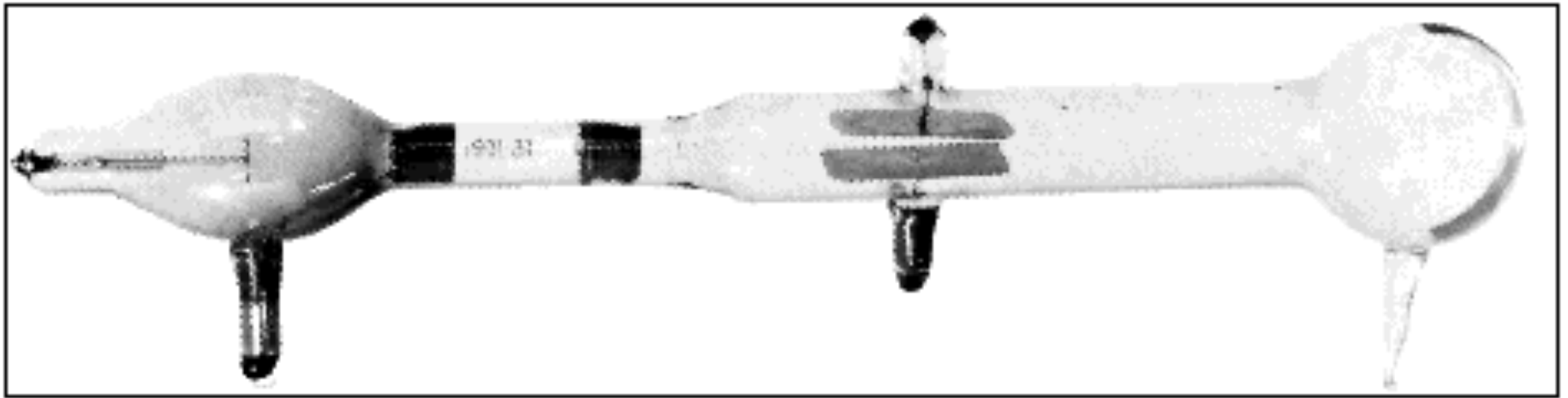
The ratio between the two compounds are small whole numbers.

These two laws (summary statements) can only happen if there are fundamental, unbreakable (uncuttable) parts of elements. Dalton called these parts atoms.

This **explanation** of the behavior of elements in chemical reactions gradually becomes more popular until the next discovery in 1897.

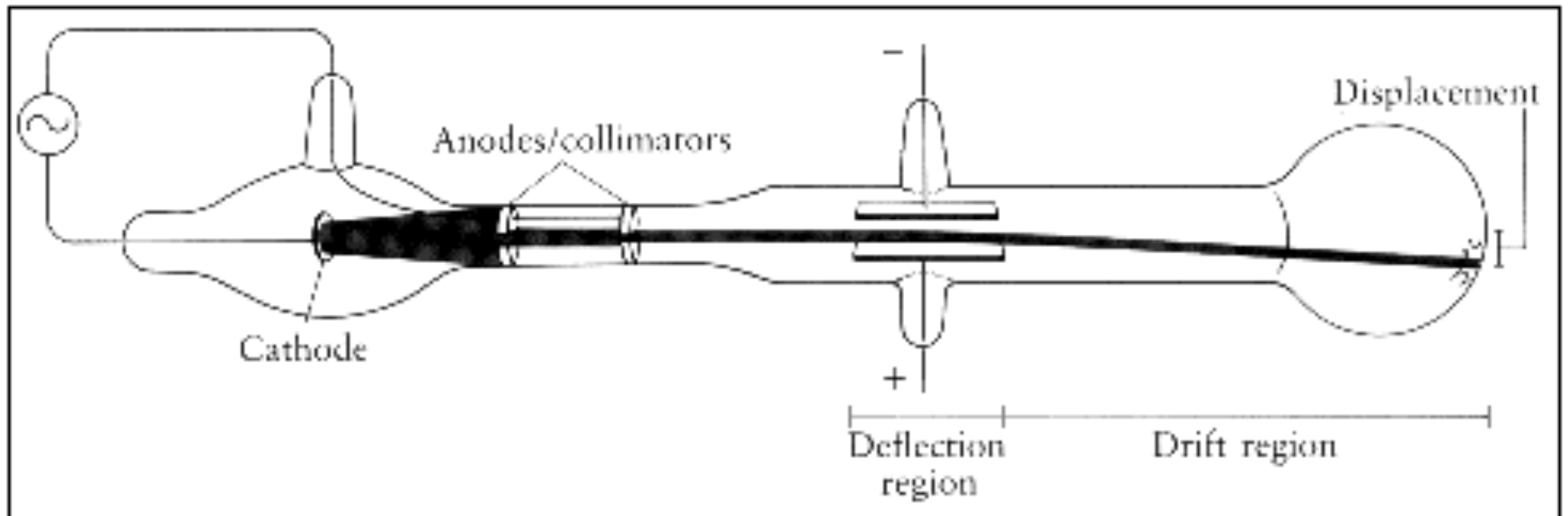
John Joseph Thomson

In the late 1800's J. J. Thomson invented a device known as the cathode ray tube or CRT. It is a special vacuum tube coated on one end with a substance that would glow when hit by charged particles.



John Joseph Thomson

When high voltage electricity was applied at one end “stuff” would move in a glowing stream to the other end. This stuff had a negative charge, and was identical for all different elements that Thomson tested.

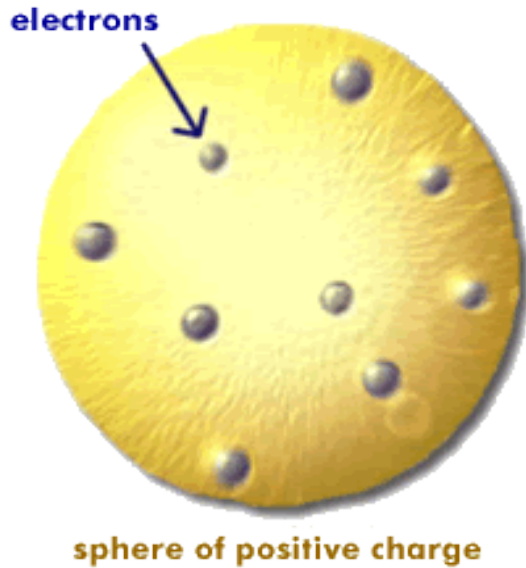


CRT

Cathode Ray Tube

This new discovery of parts of atoms that Thomson called electrons means that to get a better “picture” (model, theory, explanation) of atoms, scientists had to admit that atoms had parts and one of these parts were negative particles called electrons.

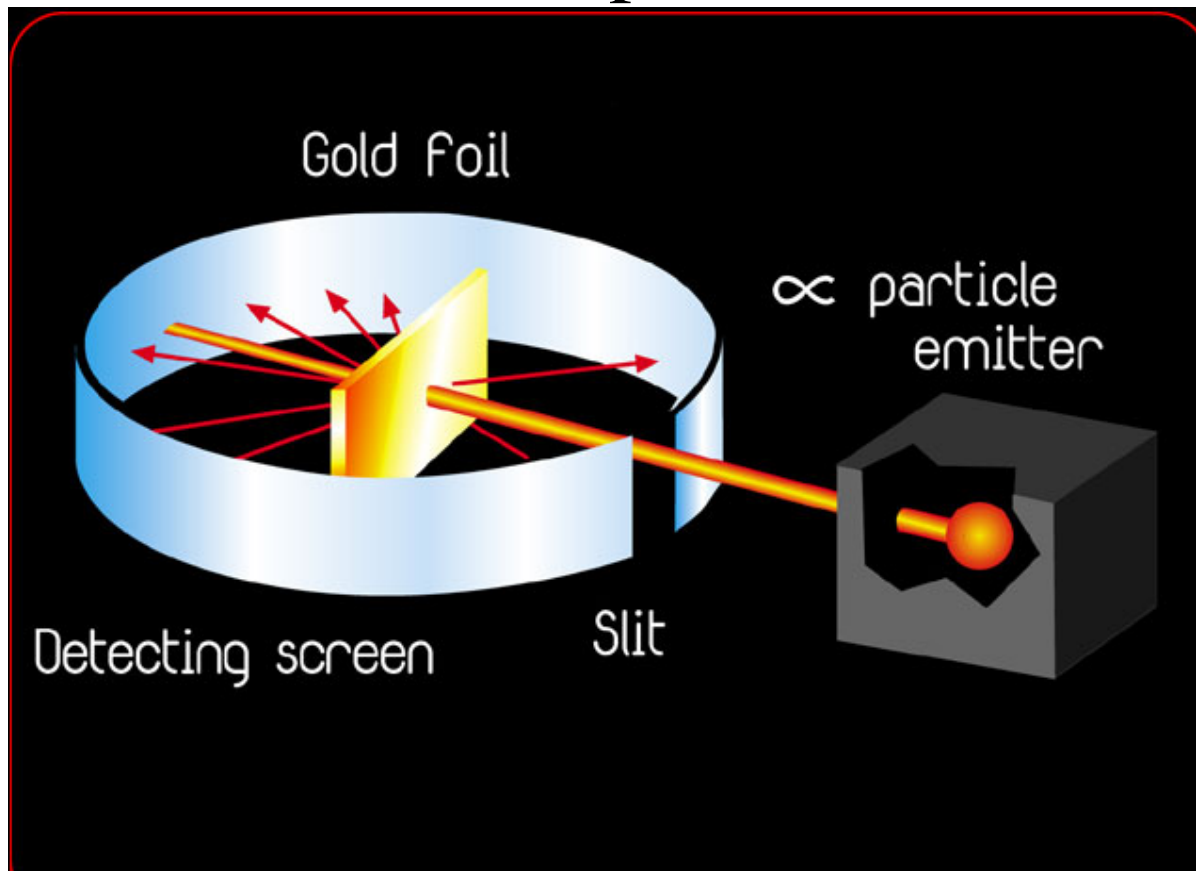
Plum Pudding Model



In order to explain this Thomson described what is called the Plum Pudding Model. The atom is a sphere of positive charged pudding with negative plums (electrons) floating in it.

The Plum Pudding Test

Ernest T. Rutherford devised a test for Thomson's Plum Pudding Model. This test is called the Gold Foil Experiment and was first performed in 1909.

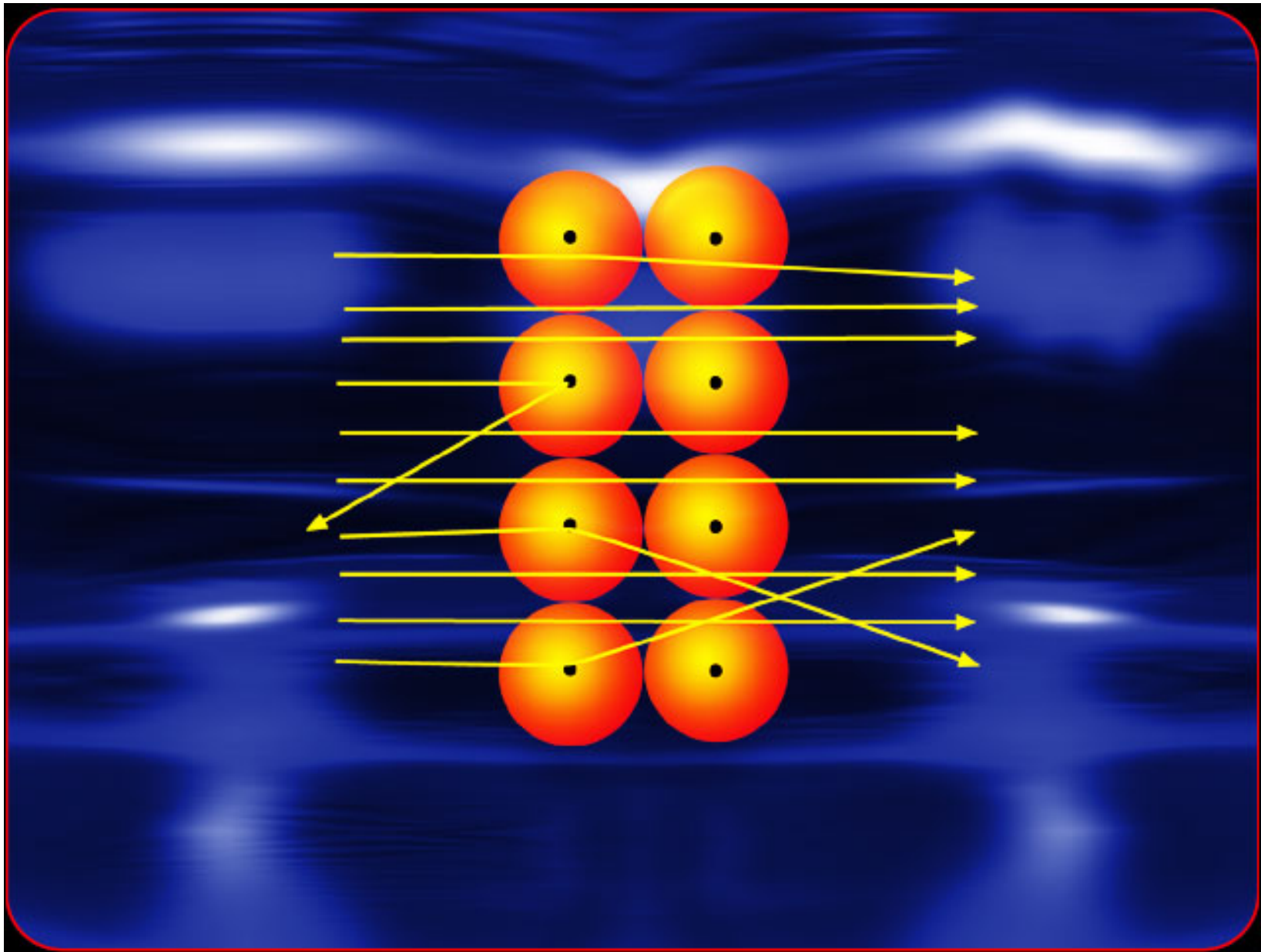


Gold Foil Experiment

The expected results of the Gold Foil Experiment is that the particles would all pass through the gold foil with very little or no change in direction.

While most of the particles did pass through, some of the particles bounced back like a super ball hitting a brick wall.

Observed Results



What does this mean?

This was an astonishing discovery, totally unexpected. From Rutherford “It was about as incredible as if you fired a 16 inch gun at a piece of tissue paper and it came back and hit you!”

The Plum Pudding Model could not be correct. Rutherford, Geiger and Marsden had discovered what we call the nucleus of an atom.

The Nucleus

To explain the observations of the Gold Foil Experiment the atom must have a very small (less than 0.0001 % of the volume) and very dense (over 99.999% of the mass) particle inside the atom.

This particle is called the nucleus (meaning center). It has a positive charge.

Outside the nucleus in mostly empty space are the negatively charged electrons.

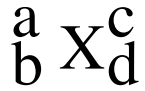
The Nucleus

The discovery of the proton in 1914 by Henry Mosely (doing x-ray analysis of metals) and the neutron by James Chadwick in 1930 provided the explanation for the properties of the nucleus.

The Atom

Particle	Found where	Volume occupied	mass	charge
electron	outside nucleus	$>99.99\%$	$\approx 0 \text{ u}$	-1
proton	inside nucleus	$<0.001\%$	1 u	+1
neutron	inside nucleus	$<0.001\%$	1 u	neutral

Atomic Notation



X - Symbol of the element - one or two letters, the first always uppercase, the second never uppercase.

a - the mass number - equal to the number of protons plus the number of neutrons, the number of nucleons.

b - the atomic number - equal to the number of protons

c - the charge

d - the number of atoms

