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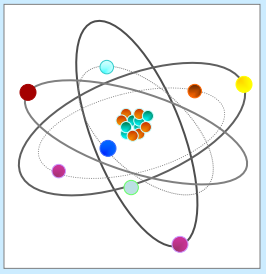
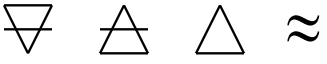
Atomic History



The Greeks

- The idea of the atom
- In 400 B.C the Greeks tried to understand matter (chemicals) and broke them down into earth, wind, fire, and air. (Aristotle's theory)



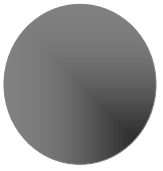
- Democritus vs. Aristotle

Greek Model

"To understand the very large, we must understand the very small."

Democritus

- Greek philosopher
- Idea of 'atomos'
  - Atomos = 'indivisible'
- No experiments to support idea



Democritus's model of atom

No protons, electrons, or neutrons

Solid and INDESTRUCTABLE
Like a Billiard Ball

Who Was Right?

- Greek society was slave based
- Beneath *famous* to work with hands
- Did not experiment
- Greeks settled disagreements by argument
- Aristotle was more famous
- He won!
- His ideas carried through middle ages.

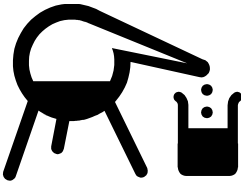
Alchemy

- After that chemistry was ruled by alchemy.
- They believed that that could take any cheap metals and turn them into gold.
- Alchemists were almost like magicians.
  - elixirs, physical immortality

Contributions of alchemists:

Information about elements
- the elements mercury, sulfur, and antimony were discovered
- properties of some elements

Develop lab apparatus / procedures / experimental techniques
- alchemists learned how to prepare acids.
- developed several alloys
- new glassware



Early Ideas on Elements

Robert Boyle stated...

- A substance was not an element if it could be broken down to two or more simpler substances.
- Air therefore could not be an element because it could be broken down in to many pure substances.

=> Democritus was right!

Robert Boyle

Dalton Model of the Atom

Late 1700's - John Dalton- England

Teacher- summarized results of his experiments and those of others

Combined ideas of elements with that of atoms in Dalton's Atomic Theory

Dalton's Atomic Theory

1. All matter is made of tiny indivisible particles called atoms. (Billiard Ball model). Atoms of the same element are identical, those of different atoms are different.
2. Atoms of different elements combine in whole number ratios to form compounds
3. Chemical reactions involve the rearrangement of atoms. No new atoms are created or destroyed.

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The Atomic Theory of Matter

- Dalton's atomic theory is essentially correct, with three minor modifications:

  1. Not all atoms of an element must have precisely the same mass. (Isotopes exist.)

  2. Atoms of one element can be transformed into another through nuclear reactions. (Nuclear decay)

  3. Under certain circumstances, some atoms can be divided. (split into smaller particles: i.e. nuclear fission: atoms can be broken down into protons, neutrons, and electrons)

Law of Definite Composition

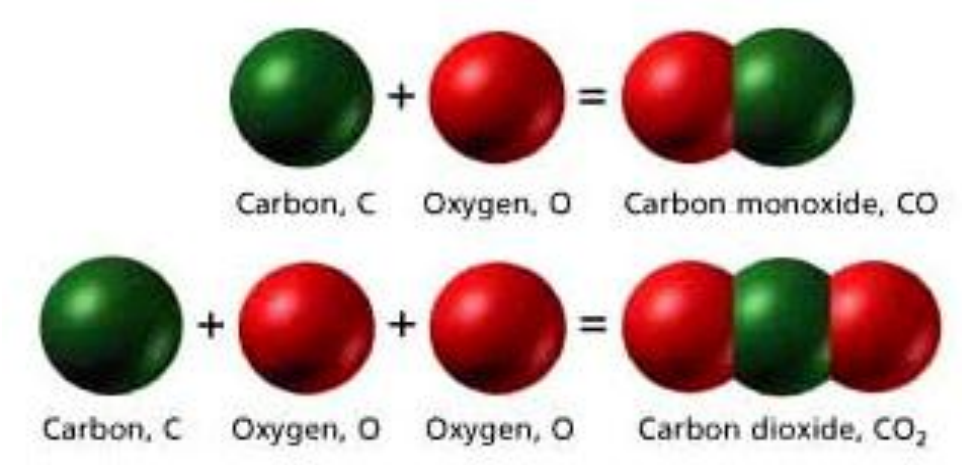
– A given compound always contains the same, fixed ratio of elements.

Ex. Water is always made of two hydrogen atoms and one oxygen atom.

Courtesy Christy Johannesson www.nisd.net/communicationsarts/pages/chem

Law of Multiple Proportions

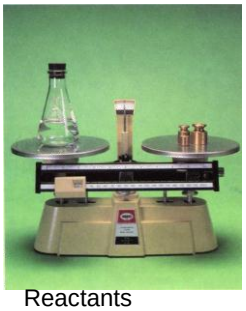
– Elements can combine in different ratios to form different compounds.



Courtesy Christy Johannesson www.nisd.net/communicationsarts/pages/chem

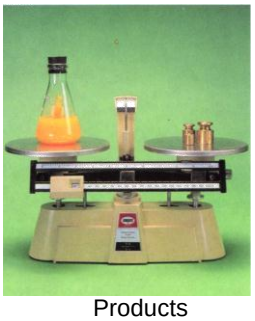
Law of Conservation of Matter

During a chemical change, matter is neither created nor destroyed.



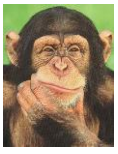
Reactants

yield



Products

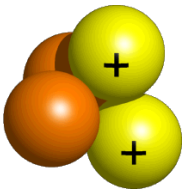
Structure of Atoms

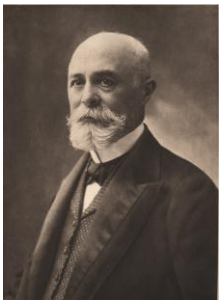


- Scientist began to wonder what an atom was like.
- Was it solid throughout with no internal structure or was it made up of smaller, subatomic particles?
- It was not until the late 1800's that evidence became available that atoms were composed of smaller parts.

Radioactivity (1896)

1. rays or particles produced by unstable nuclei
   a. Alpha Rays – helium nucleus
   b. Beta Part. – high speed electron
   c. Gamma ray – high energy x-ray
2. Discovered by Roentgen and Becquerel – exposed photographic film
3. Further work by Curies





Antoine-Henri Becquerel
(1852 - 1908)

Radioactivity

- One of the pieces of evidence for the fact that atoms are made of smaller particles came from the work of **Marie Curie** (1876 - 1934).
- She studied radioactivity, the spontaneous disintegration of some elements into smaller pieces.

Thomson Model of the Atom

J. J. Thomson - English physicist. 1897

Used a piece of equipment called a cathode ray tube.

It is a vacuum tube – most of the air has been pumped out.

Background Information

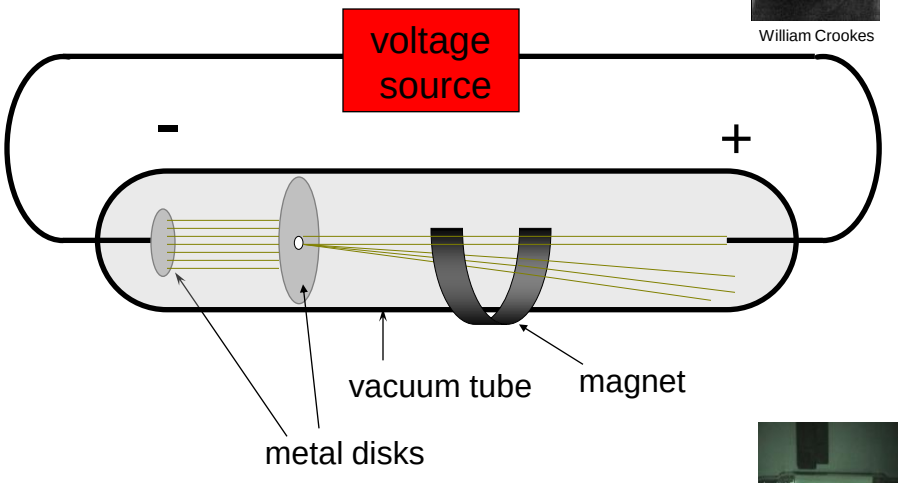
Cathode Rays

- Form when high voltage is applied across electrodes in a partially evacuated tube.
- Originate at the cathode (negative electrode) and move to the anode (positive electrode)
- Carry energy and can do work (therefore must be particles)
- Travel in straight lines in the absence of an external field

Cathode Ray Tube

(AKA Crooke's Tube)

William Crookes



Cathode Ray Experiment

1897 Experimentation

- Using a cathode ray tube, Thomson was able to deflect cathode rays with an electrical field.
- The rays bent towards the positive pole, indicating that they are negatively charged particles… ELECTRONS ARE DISCOVERED!!!

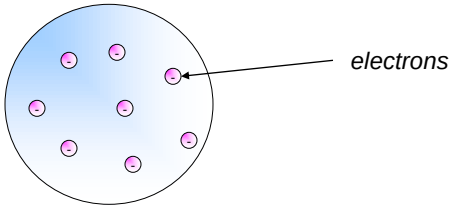
J.J. Thomson

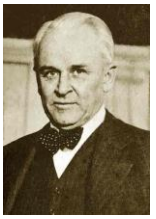
J.J. Thomson

- He proved that atoms of any element can be made to emit tiny negative particles.
- He knew that atoms did not have a net negative charge and so there must be something balancing the negative charge.

Thomson Model of the Atom

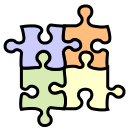
- J.J. Thomson discovered the electron and knew that electrons could be emitted from matter (1897).
- William Thomson (his son) proposed that atoms consist of small, negative electrons embedded in a massive, positive sphere.
- The electrons were like currants in a plum pudding.
- This is called the ‘plum pudding’ model of the atom.





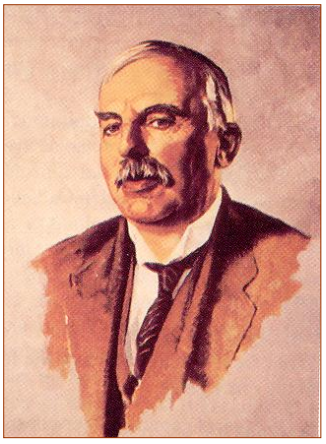
Millikan's Oil Drop Experiment- determined the exact charge and mass of an electron

Other pieces



- Proton - positively charged pieces
  - 1840 times heavier than the electron
- Neutron - no charge but the same mass as a proton.
- How were these pieces discovered?
- Where are the pieces?

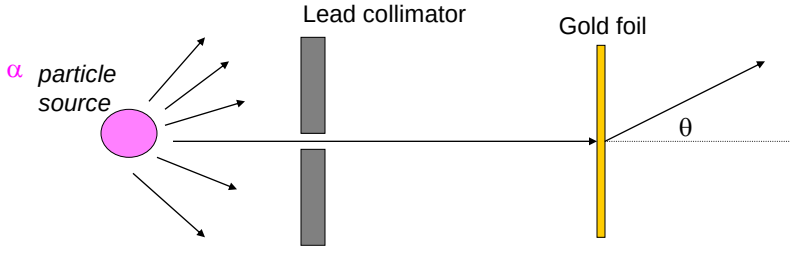
Ernest Rutherford (1871-1937)



- Learned physics in J.J. Thomson' lab.
- Noticed that 'alpha' particles were sometime deflected by something in the air.
- Gold-foil experiment

Rutherford 'Scattering'

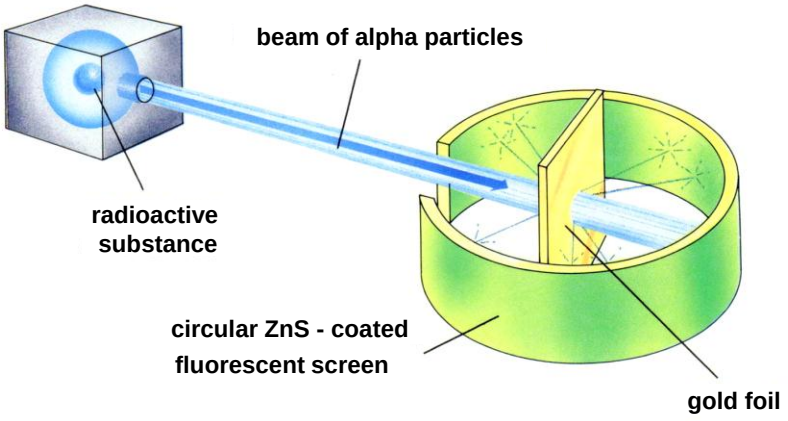
- In 1909 Rutherford undertook a series of experiments
- He fired α (alpha) particles at a very thin sample of gold foil
- According to the Thomson model the α particles would only be slightly deflected
- Rutherford discovered that they were deflected through large angles and could even be reflected straight back to the source



Rutherford's Apparatus


Ernest Rutherford

Rutherford received the 1908 Nobel Prize in Chemistry for his pioneering work in nuclear chemistry.



Dorin, Demmin, Gabel, Chemistry The Study of Matter , 3rd Edition, 1990, page 120

What He Expected

- The alpha particles to pass through without changing direction (very much)
- Because the positive charges were spread out evenly, they would not be enough to stop the alpha particles

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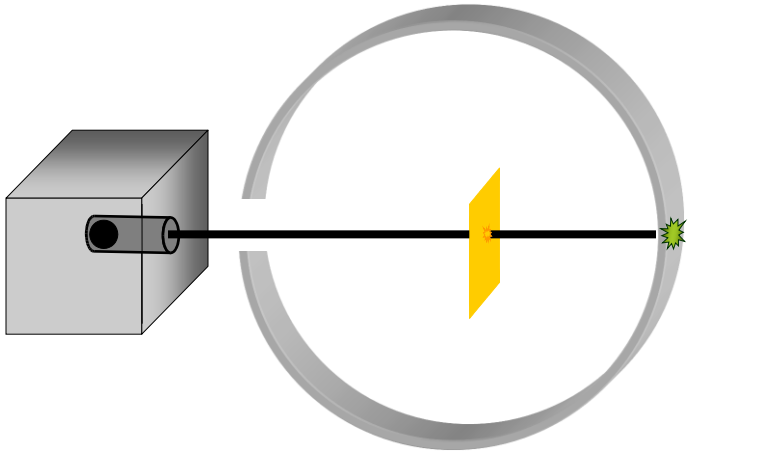
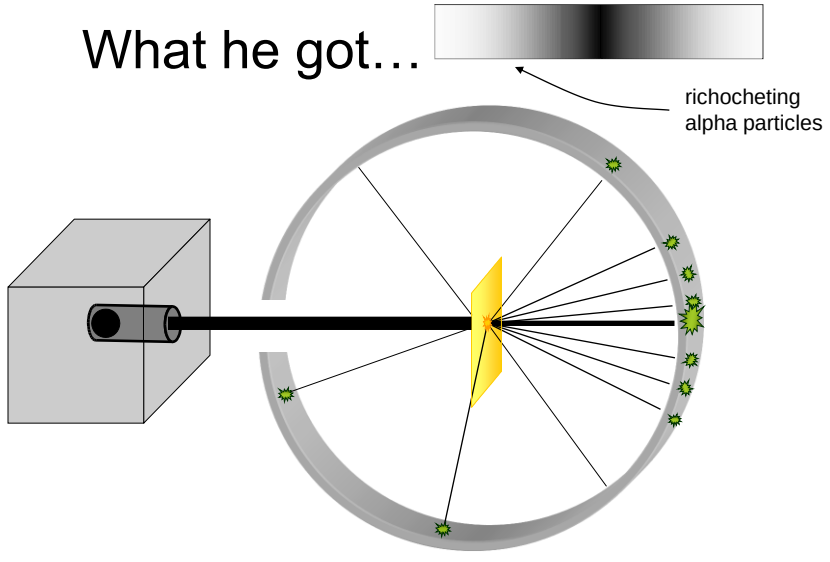
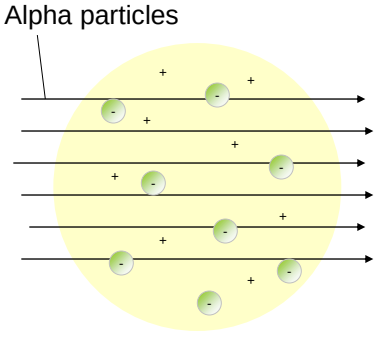
What he expected…



What he got…

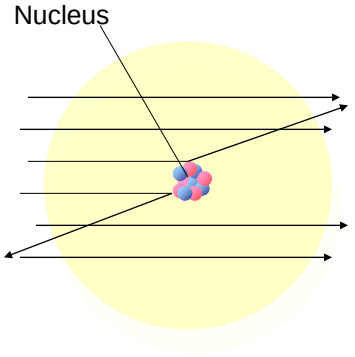


Explanation of Alpha-Scattering Results- the atom must have a nucleus!



Plum-pudding atom

Thomson's model



Nuclear atom

Rutherford's model

Density and the Atom

- Since most of the particles went through, the atom was mostly empty.
- Because the alpha rays were deflected so much, the positive pieces it was striking were heavy.
- Small volume and big mass = big density
- This small dense positive area is the nucleus

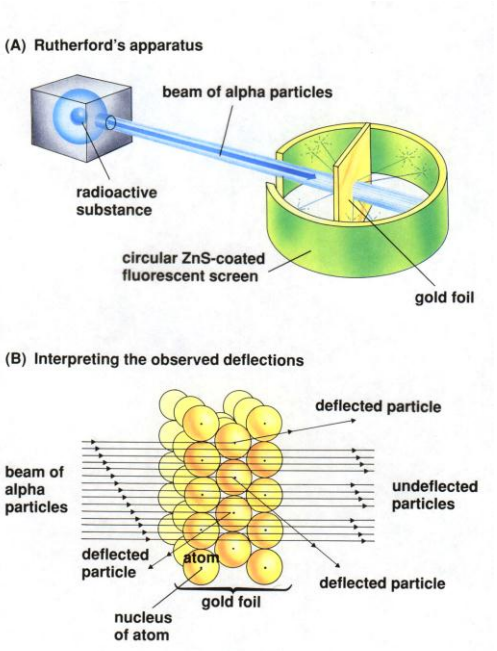
Rutherford's Gold-Leaf Experiment

Conclusions:

Atom is mostly empty space

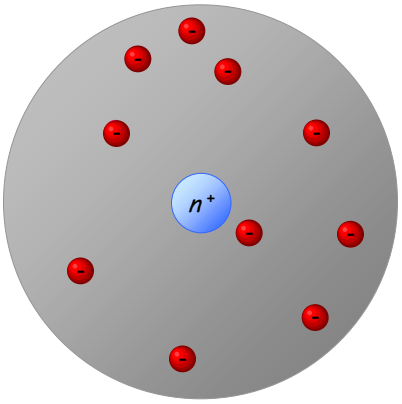
Nucleus has (+) charge

Electrons float around nucleus



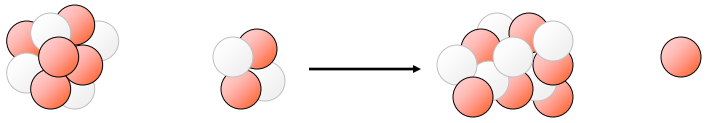
Dorin, Demmin, Gabel, Chemistry The Study of Matter , 3rd Edition, 1990, page 120

The Rutherford Atom



Zumdahl, Zumdahl, DeCoste, World of Chemistry 2002, page 57

Discovery of the Neutron



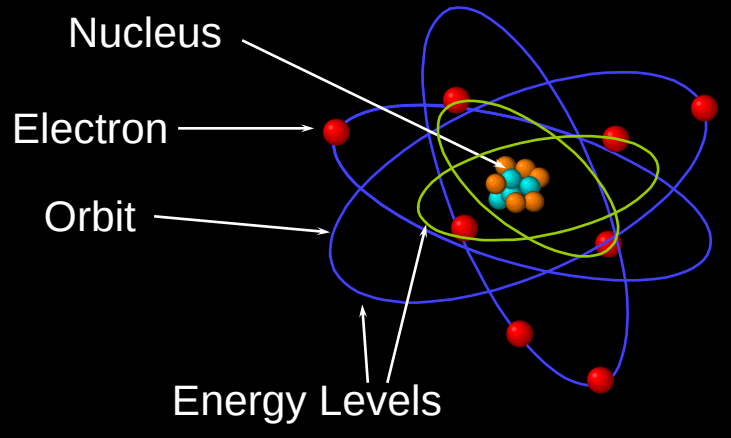
$^{9}_{4}Be + {}^{4}_{2}He \longrightarrow {}^{12}_{6}C + {}^{1}_{0}n$

James Chadwick bombarded beryllium-9 with alpha particles, carbon-12 atoms were formed, and neutrons were emitted.

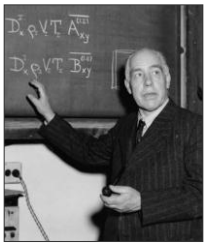
Dorin, Demmin, Gabel, Chemistry The Study of Matter 3rd Edition, page 764

*Walter Boethe

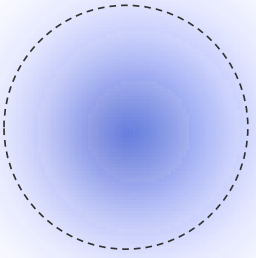
Bohr's Model- Planetary Model



- Bohr's contributions to the understanding of atomic structure:
    1. Electrons can occupy only certain regions of space, called ***orbits.***
    2. Orbits closer to the nucleus are more stable — they are at lower energy levels.
    3. Electrons can move from one orbit to another by absorbing or emitting energy, giving rise to characteristic spectra.
- Bohr's model could not explain the spectra of atoms heavier than hydrogen.



Quantum Mechanical Model



Modern atomic theory describes the electronic structure of the atom as the *probability of finding electrons within certain regions of space (orbitals)*.

Structure of the Atom

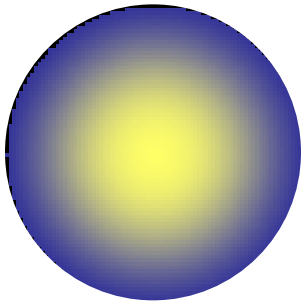
There are two regions

The nucleus

- With protons and neutrons

– Positive charge

– Almost all the mass



Electron cloud

– Most of the volume of an atom

– The region where the electron can be found

Most of the atom is empty space.