Origin of the Atom

Democritus – Greek thinker who named the "atom" in 400 BC

- Atom comes from "atomos", a Greek word meaning "unable to be cut or divided".
- He believed movements in atoms caused changes in matter he observed
- He did not have enough evidence to convince people atoms existed.

Aristotle – did not believe in atoms, believed that all matter was continuous. Idea lasted 2000 years.

Earth, Wind, Water, Fire, etc.

1

Late 1700s – Study of reactions led to new ideas...

Law of Conservation of Mass – Mass can't be created or destroyed by ordinary chemical or physical reactions.

Law of Definite Proportions – a compound contains the same proportions of mass regardless of size or source.

Ex. NaCl will always be 39.3% Na and 60.1% Cl

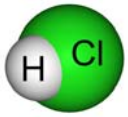
Law of Multiple Proportions – if two or more compounds of the same two elements exists, then the ratio of masses are ratios of whole numbers

Ex. C and O can combine to form both CO and CO_2

2

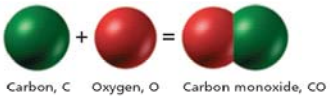
Law of Definite Proportions

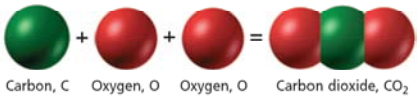
H and Cl will always be found in a 1:1 ratio



Law of Multiple Proportions

C and O can be found in different ratios





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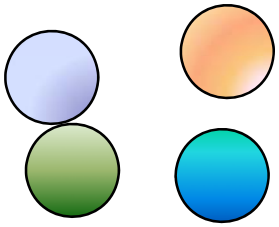
John Dalton 1766 - 1844

Dalton came up with the Billiard Ball Model (1803)
John Dalton viewed the atom as a small solid sphere.



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Dalton's Atomic Theory (Early 1800s)

1) All matter is made of atoms
2) Atoms of an element are all the same, atoms of a different element will differ
3) Atoms can't be subdivided, created, or destroyed
4) Atoms of different elements form compounds in whole number ratios
5) In reactions, atoms are combined separated, or rearranged

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Modern Atomic Theory

Slight changes to Dalton's Theory…

1) Atoms of the same element can differ (isotopes and ions)
2) Nuclear reactions can split an atom

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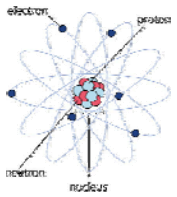
Models of the Atom

atom – the smallest particle of an element that retains the chemical properties of that element

An atom is composed of…

- Nucleus
  - Protons
  - Neutrons
- Electrons

} Subatomic Particles



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Discovery of the Electron

Cathode Ray Tubes (CRT) were experimented with in the late 1800s.

How they work…

Gases at very low pressures can conduct electrical current. (vacuum tubes)

Cathode ray tubes are still used today

- TVs and computer monitors
- Neon Lights

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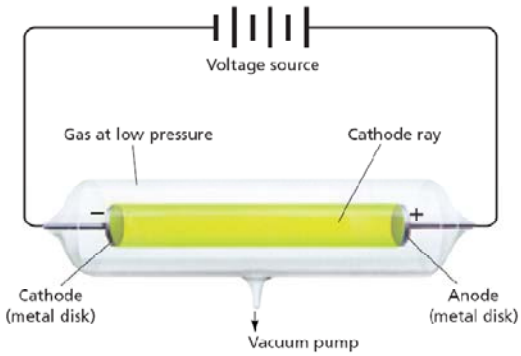
Cathode Ray Tube



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Knowledge about Cathode Rays

1) Cathode rays could be deflected using a magnet
   - A wire carrying current, known to be negative, could also do the same thing
2) Rays were deflected by negatively charged objects
3) A paddle wheel placed on rails moved from the cathode to the anode
   - Cathode rays have mass

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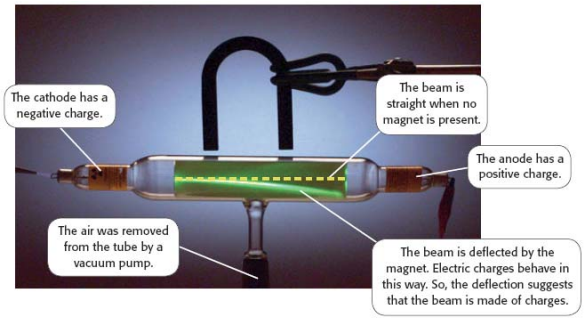
Cathode Ray Tube with a Magnet



Cathode rays are deflected by magnets

Do not try this with a TV!

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Thomson's Experiments (1897)

Thomson measured the charge / mass ratio of cathode ray particles

He found this ratio to be the same for all metals he tested as a cathode and any gas used.

Thomson concluded that cathode rays were made of identical negatively charged particles

Thomson discovered the Electron!!

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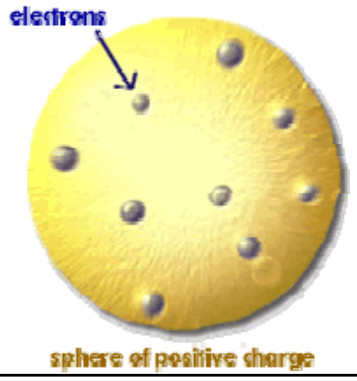
Thomson's Plum Pudding Model



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Rutherford's Experiments (1911)

Hypothesis: Atoms are uniform in structure

Test: Rutherford shot a beam of *alpha particles* (Positively charged particles) into thin gold foil

Expectation: Alpha particles will pass through the gold foil with slight deflection

Result: 1 in 8000 particles were redirected back to the source

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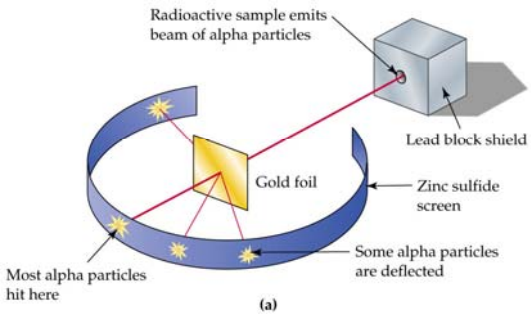
Rutherford's Gold Foil Experiment



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Rutherford's Experiments (1911)

Rutherford's quote about the experience

"as if you fired a 15 inch artillery shell at a piece of tissue paper and it came back and hit you"

After about **2 years** of thinking he came up with his conclusion:

There is a positive, densely packed center

Rutherford discovered the Nucleus!!

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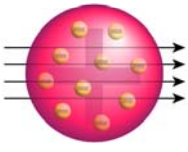
Section 3-2 Structure of The Atom

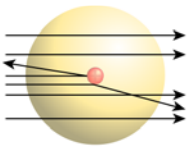
Rutherford's Experiments

Expected Result



Old atomic model

Actual Result



New atomic model

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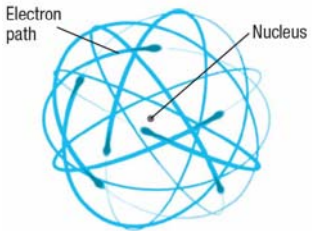
Rutherford's Model

Atoms are mostly empty space. If the nucleus was a marble… then the entire atom would be the size of a football field.



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Subatomic Particles

	Symbol	Charge	Mass
Electron	e^-	-1	0
Proton	p^+	+1	1
Neutron	n^0	0	1

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Atom Basics

1) The number of protons determines the element
2) A neutral atom has the same number of electrons as it has protons.
3) An atom is held together by **electric forces**. This is from the attractive force of the electrons(-) and the protons(+)
4) The nucleus is held together by **nuclear forces**

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Atom Basics - Mass

1) Neutrons and protons are about the same mass
2) An electron is about 1/2000 the mass of a proton
3) A teaspoon full of atom nuclei would weigh more than a battleship!
4) Atoms of the same element can have different masses due to different numbers of neutrons.
5) Elements with different masses are called isotopes. **Nuclide** is a term for an isotope.

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Atom Basics - Size

1) The electrons determine the size of the atom
2) Electrons move so fast in such a tiny area they make the atom seem solid (Like a moving fan blade)
3) Size: If the nucleus was a marble… then the entire atom would be the size of a football field.
4) Sizes of atoms are measured in picometers 1,000,000,000,000 picometers = 1 meter

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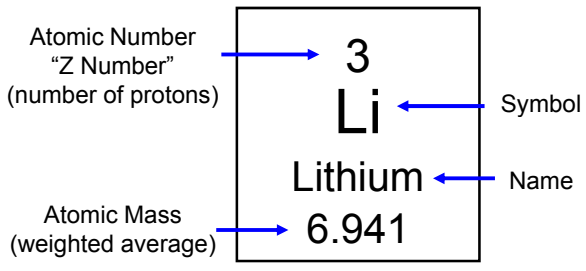
Reading a Periodic Table



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Designating Isotopes

Mass Number = Protons + Neutrons

→ Mass Number – Protons = Neutrons

Example: an isotope of uranium has a mass of 235 and an atomic number of 92. How many neutrons?

235 – 92 = 143
mass protons neutrons

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Designating Isotopes

There are two common ways to present isotopes

Example: an isotope of uranium has a mass of 235 and an atomic number of 92.

Nuclear Symbol	Hyphen Notation
mass → 235, Z → 92 U	Uranium-235

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How to remember Nuclear Symbol

Correct: $^{235}_{92}U$

Incorrect: $^{92}_{235}U$

The nuclear symbol should look like an easy subtraction problem to calculate neutrons.

$$\begin{array}{r} ^{235}_{92}U \\ \hline 143 \end{array}$$

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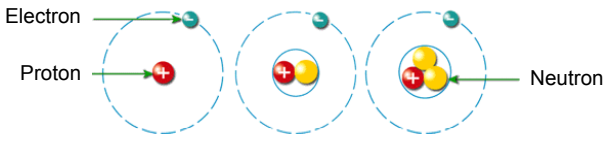
Isotopes of Hydrogen



Protium	Deuterium	Tritium
mass = 1	mass = 2	mass = 3
$^{1}_{1}H$	$^{2}_{1}H$	$^{3}_{1}H$
99.985%	0.015%	Rare & radioactive

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Heavy Water

Water composed of deuterium hydrogen is often labeled D_2O rather than H_2O. Because each molecule is heavier but still the same size, D_2O is more dense.

Ice cubes of D_2O in liquid H_2O will sink!!

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Relative Atomic Mass – a separate unit of measurement is used for mass of individual atoms.

amu – Atomic Mass Unit

1 amu = 1.660540×10^{-27} kg

The amu is based off $^{1}/_{12}^{th}$ the mass of Carbon-12

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Average Atomic Masses

This is not the same as the Mass Number!!

Masses on the periodic table are weighted averages based on the percentage of each nuclide found in nature. (Just like GPA)

Mass of Copper

Nuclide	% Occurring	Mass (amu)	% x Mass
Cu-63	69.15%	62.93	43.52
Cu-65	30.85%	64.93	20.03
			63.55

Average Mass

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