Unit 3 Lesson I (3.1)
Development of Modern Atomic Theory

Objective: The student will be able to (1) contextualize the study of Nuclear Chemistry and (2) describe the process of how the modern definition of the atom came to be.

The Development of the Modern Atomic Theory

The journey to the Modern Atomic Theory begins in 490 B.C.E.

Empedocles

Others extended the idea of a fifth element: aether

"quintessential"

Democritus (460 B.C.E)

Termed the word "Atoms" from the Greek *atomos* = indivisible

imagined particles to be indivisible and to be constituents of all matter

Antoine-Laurent de Lavoisier
(1789)

The Law of Conservation of Mass

"Rien ne se perd, rien ne se crée, tout se transforme."

"*Matter (or mass) is neither created nor destroyed but can change its form*"

List of Contributions to Chemistry:

1) Discovered the role of oxygen in combustion and named it. (^{1}H too!)

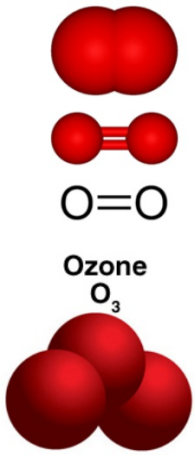
2) Dismantled phlogiston theory

3) Constructed the metric system.

4) Wrote first extensive list of elements.

5) Reformed chemical nomenclature.

John Dalton, England (1802)



1. All matter consists of indivisible particles called atoms.

2. Atoms of the same element are similar in shape and mass, but differ from the atoms of other elements.

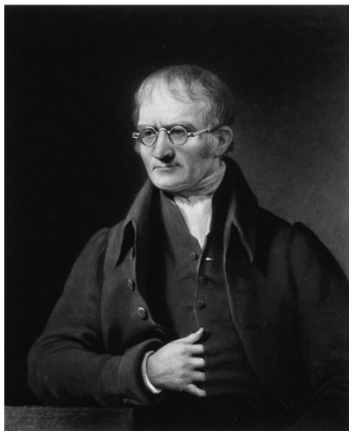
3. Atoms cannot be created or destroyed.

4. Atoms of different elements may combine with each other in a fixed, simple, whole number ratios to form compound atoms.

5. Atoms of same element can combine in more than one ratio to form two or more compounds.

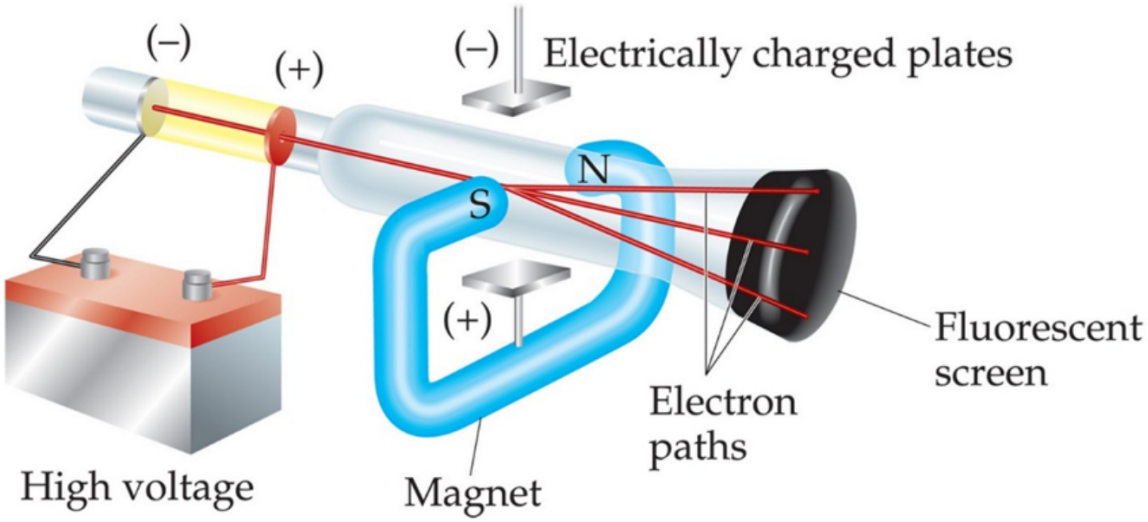
6. The atom is the smallest unit of matter that can take part in a chemical reaction.

No longer true today



William Crookes (1879), Eugen Goldstein (1886)
(do not include in condensed timeline)

Crookes and Goldstein studied cathode-ray tubes to show their negative nature.

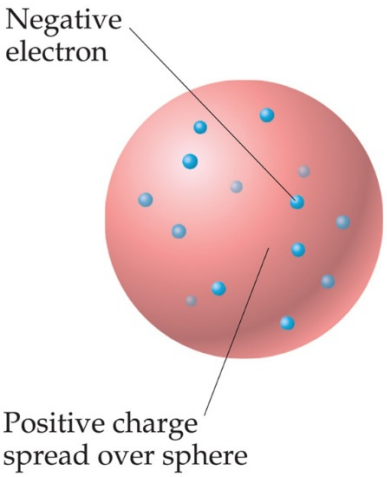


J.J. Thomson (1897 and 1904)

England

1897 -- J.J. Thomson identified the electron based on his three experiments with cathode-ray tubes. Studied the charge-mass ratio.

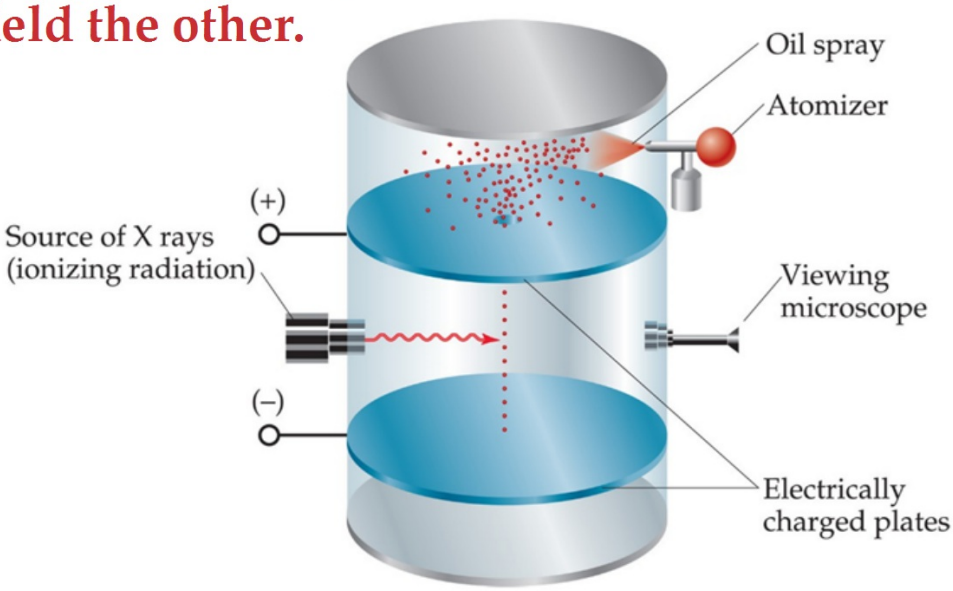
1904 -- Proposes his own model of the atom with little laboratory work. Contemporaries made fun of his "plum pudding" model.



Robert Millikan (1909)
United States

Discovered the charge on the electron by using the work of Thomson.

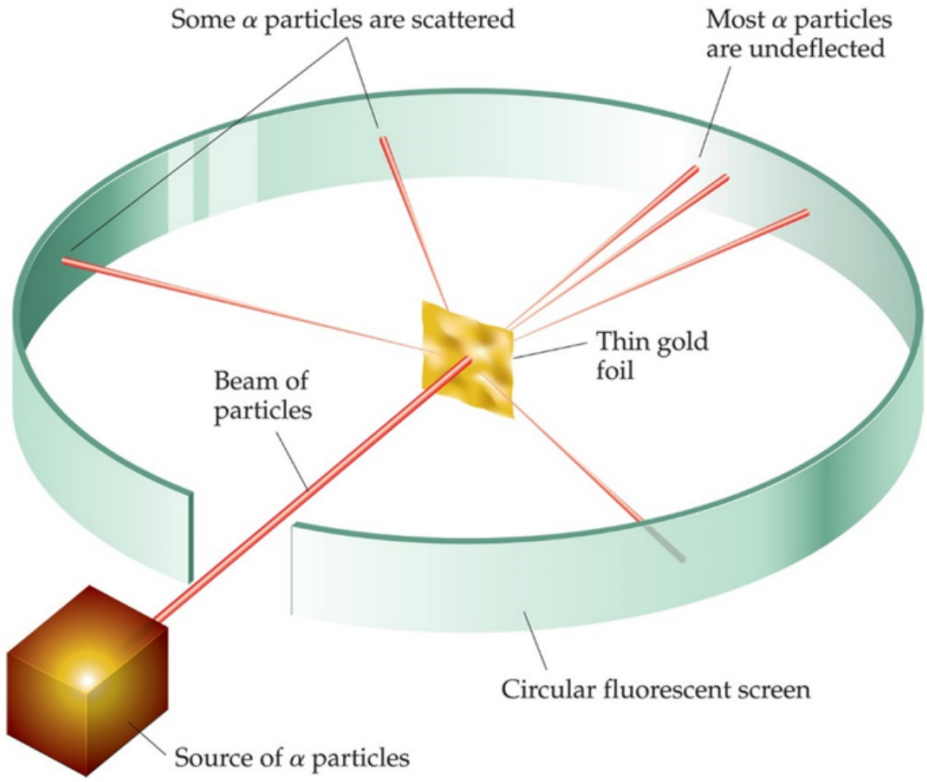
Once the charge/mass ratio of the electron was known, determination of either the charge or the mass of an electron would yield the other.



Ernest Rutherford (1911)

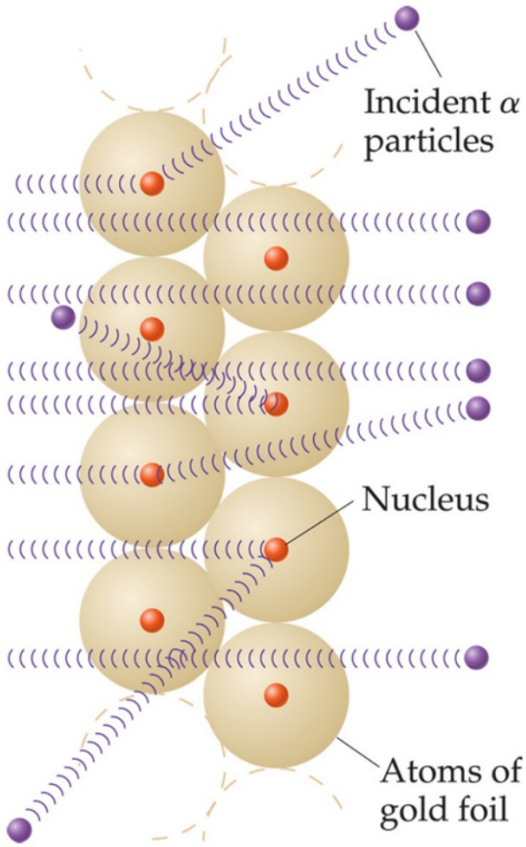
Gold Foil Experiment

New Zealand

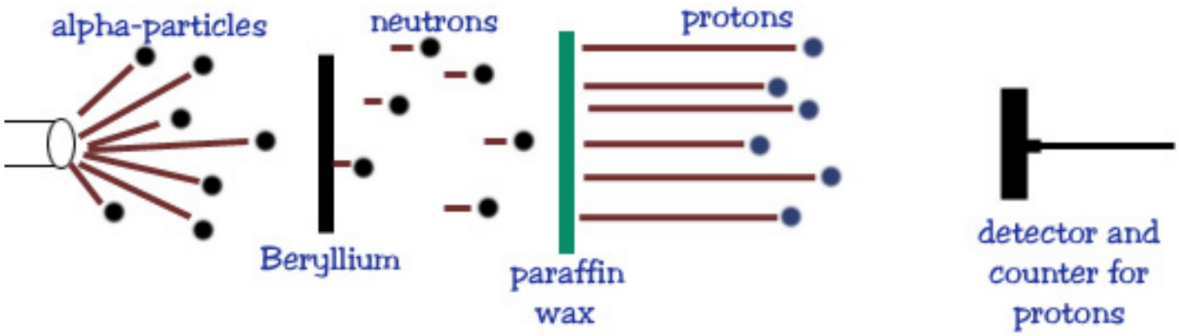


Analysis of Rutherford's Experiment

An atom is largely free space occupied by widely separated electrons, with the mass of the atom concentrated in a tiny, centrally located, positively-charged nucleus



James Chadwick
England, 1932



Discovered the neutron -- a neutral, nuclear particle with a mass approx. equal to a proton

Niels Bohr
Denmark (1936)

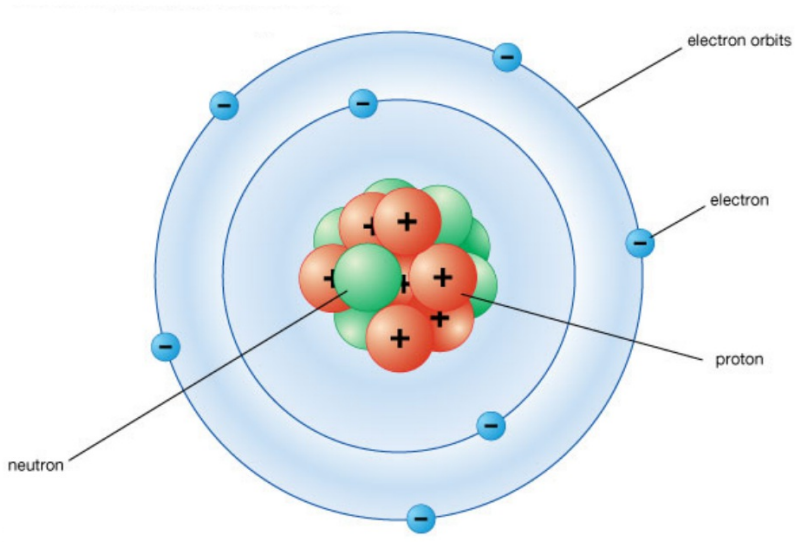


Diagram only worked for hydrogen, most ideas did not check out but is an acceptable "snapshot" for location of subatomic particles

Enrico Fermi (1938)

Italian Nobel Prize winner who created the first nuclear reactor.

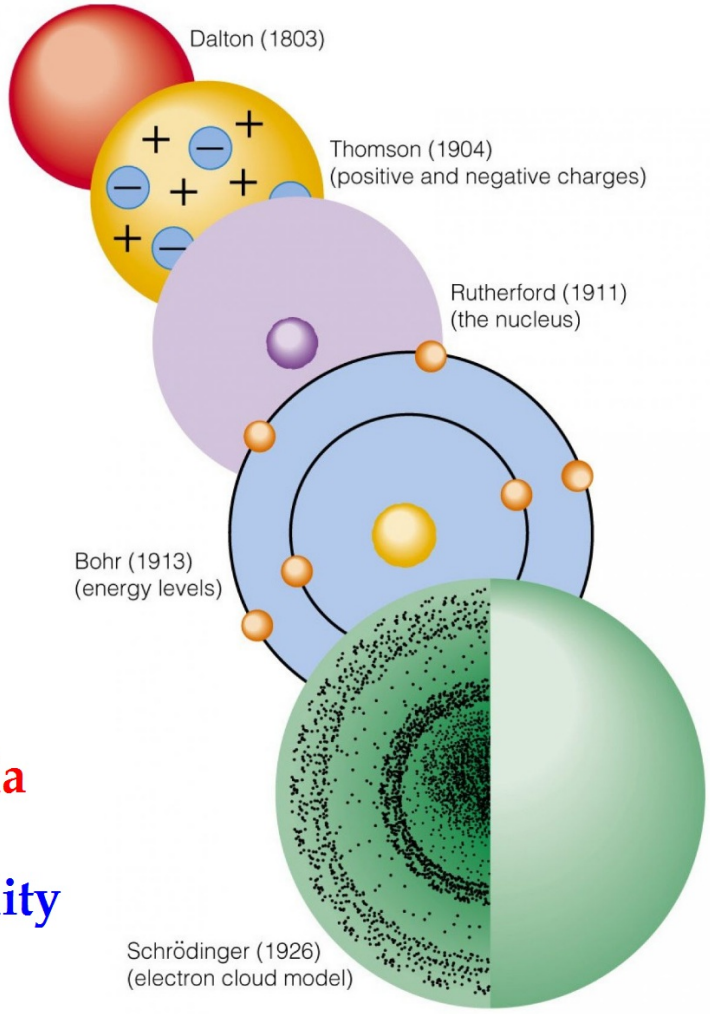
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

This led him to prepare more than 40 radioactive elements by neutron bombardment and to discover some of the transuranic elements*.

*Transuranic = any element with atomic number greater than 92

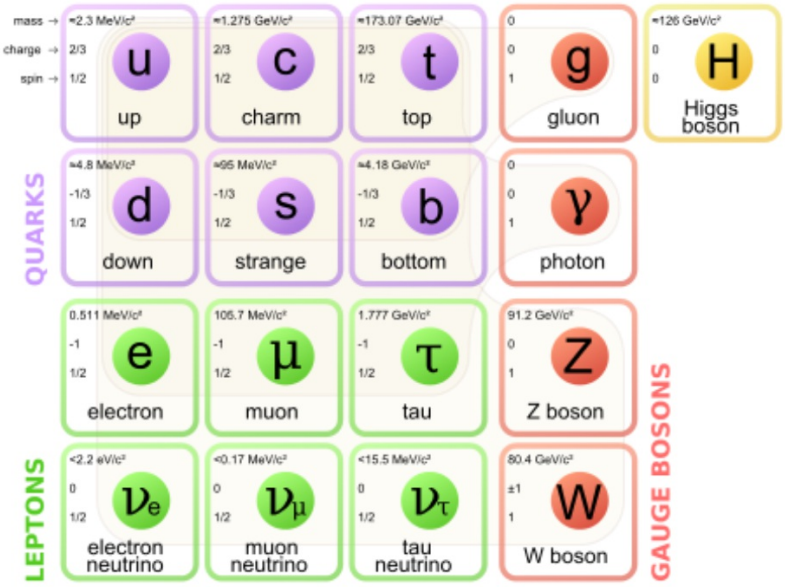
Atomic Theory and Models

Schrödinger (1926) -- Austria
Improved on Bohr's model stating a statistical probability of electron position



Gell-Mann and G. Zweig (1964)

Independently propose the quark model, making protons and neutrons elementary particles no longer.

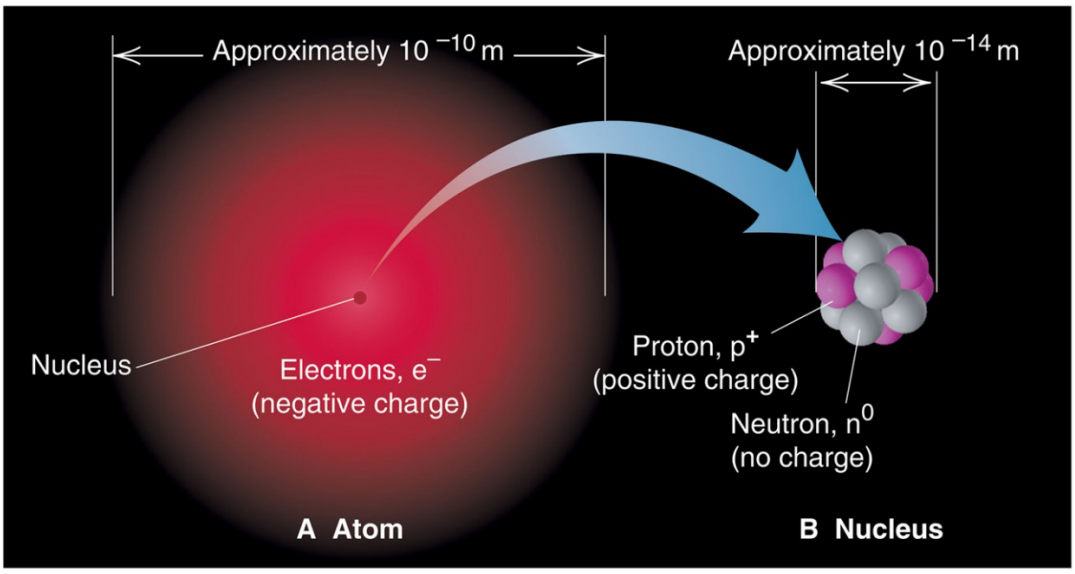


Gell-Mann is the only one to have been awarded the Nobel Prize.

General Features of the Modern Atom

The atom is an electrically neutral, spherical entity composed of a positively charged nucleus surrounded by one or more negatively charged electrons.

The atomic nucleus is composed of protons and neutrons collectively called nucleons.



Objective Check

The student will be able to (1) identify the key scientists/events which lead to the development of the modern atomic theory, (2) discuss the structure of the atom in terms of fundamental particles, (3) calculate the average atomic mass of an atom.

[1] How are we meeting our objective?
[2] Which scientist do you think had the greatest impact on the modern atomic theory and why?
[3] Which country lead the development?

General Characteristics of the Fundamental Subatomic Particles

Name(Symbol)	Charge Relative	Mass Relative(amu)	Location in the Atom
Proton (p^+)	1+	1.00727	Nucleus
Neutron (n^0)	0	1.00866	Nucleus
Electron (e^-)	1-	0.00054858	Outside Nucleus

Atomic Symbols, Isotopes, Numbers

$^{A}_{Z}X$ The Symbol of the Atom or Isotope

X = Atomic symbol of the element

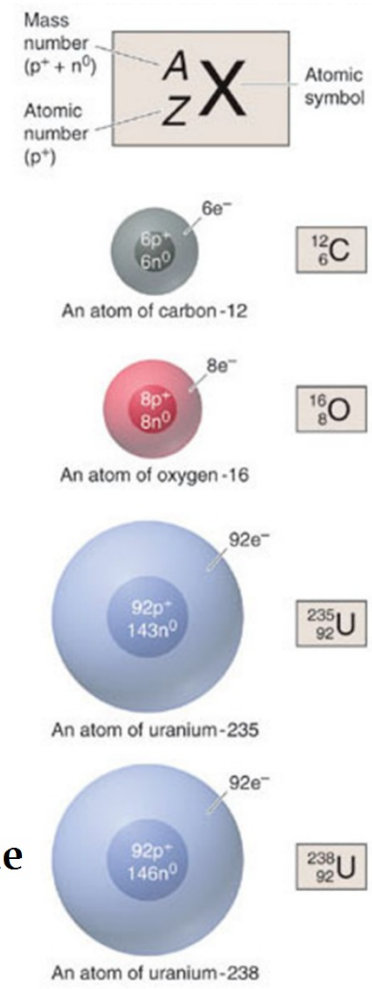
A = mass number; A = Z + N

Z = atomic number
(the number of protons in the nucleus)

N = number of neutrons in the nucleus

Isotope = atoms of an element with the same number of protons, but a different number of neutrons

The mass number is allowed to change. The one on the periodic table is the most common isotope of that element.



Atomic Structure
Example Set #1

Find the number of protons, neutrons, and electrons for aluminum-27.

Atomic Structure
Example Set #2

Find the number of protons, neutrons, and electrons for magnesium -- 24 (cation, 2+) and antimony --125 (anion, 3-).

Particles You Should Know

mention shorthand

$^{4}_{2}He$ $^{0}_{-1}\beta$ $^{0}_{0}\gamma$

$^{0}_{+1}\beta$ $^{0}_{-1}e$

$^{1}_{1}p$	$^{1}_{0}n$	$^{0}_{-1}e$

Isotopes of Hydrogen