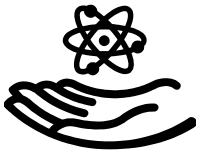
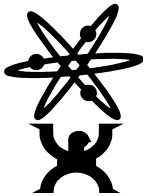
Atomic Structure-The BIG Picture

Discovery of the components of the atom and subsequent modeling of the atomic structure led to explosive advances in chemistry, medicine, and energy

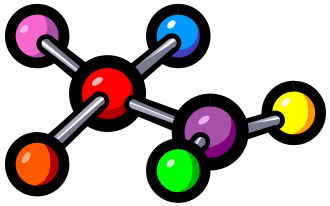


ATOMIC STRUCTURE



Chemistry

- The nature of the chemical bond
- New molecule synthesis
- Predictions about reactivity
- Information about how reactions work
- Electronics / computer development
- New analytical (measuring) methods
- Emergence of the field of Nuclear Chemistry

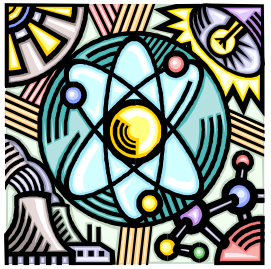


Medicine

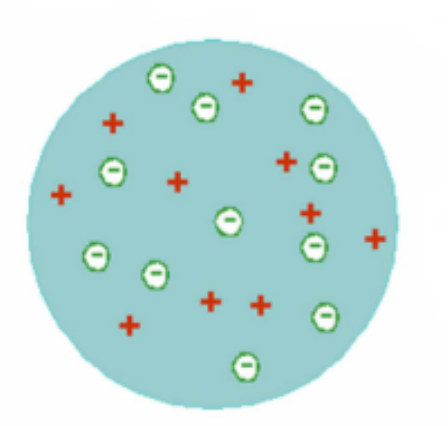
- Isotope tracers
- New drugs
- Cancer treatments
- New cell screening methods

Energy

- Nuclear fission
- Nuclear fusion
- Power plants
- Understanding of the nature of the sun, planets, stars, etc
- Weapons



Progression of the Atomic Model…Discovery of the electron



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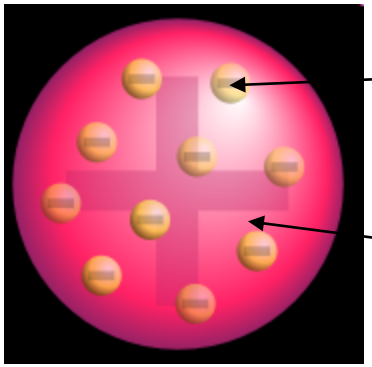


WIkipedia

"Plums"

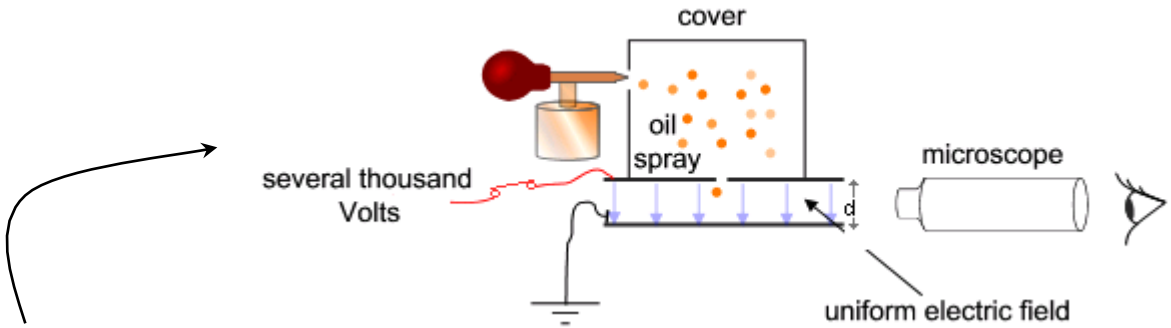
"pudding"

Thomson's "Plum Pudding" Model

- He discovered the electron (link) in 1897 before the nucleus was discovered
- Later discoveries invalidated this model

J.J. Thomson in Philosophical Magazine, 1904

"… the atoms of the elements consist of a number of negatively electrified corpuscles enclosed in a sphere of uniform positive electrification, … "



Millikan later determined the mass and charge of the electron:

Millikan animation

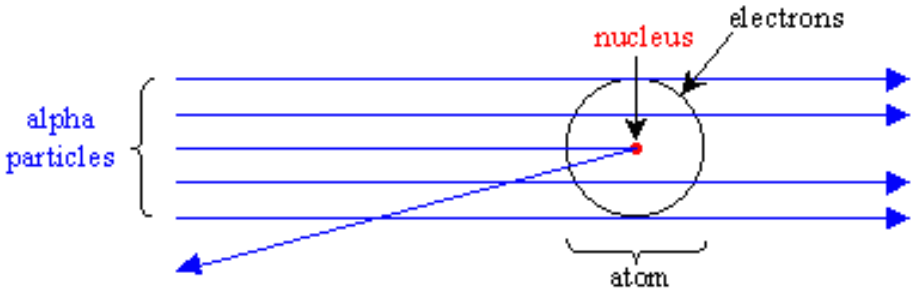
Charge: 1.602 176 53(14) x 10^{-19} coulomb

Mass: 9.10938188 × 10^{-31} kilograms , about 1/1840 of a proton

Refining the atomic model

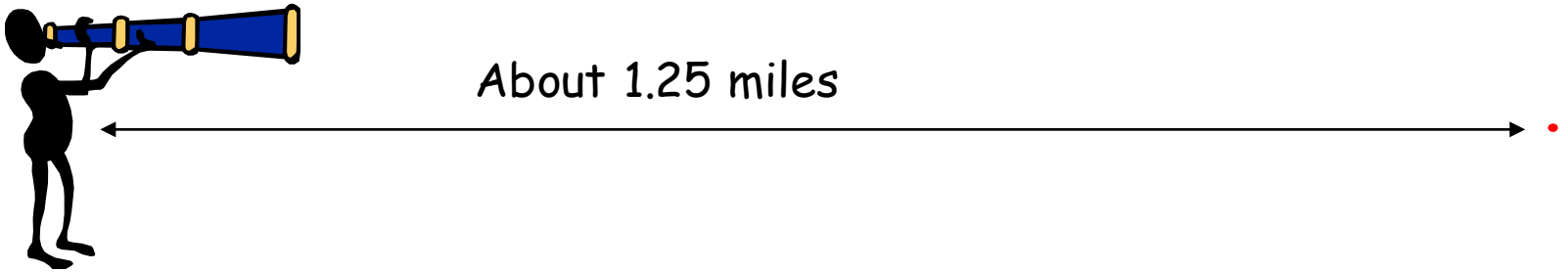
Rutherford's famous gold foil experiment:

- showed that the positive charge of the atom MUST be concentrated in a *tiny, yet heavy* volume he called the nucleus
- almost *ALL* of the mass of the atom is in the nucleus
- very lignt electrons surround this nucleus
- the volume that an atom occupies is mostly **empty space**



Gold foil animation

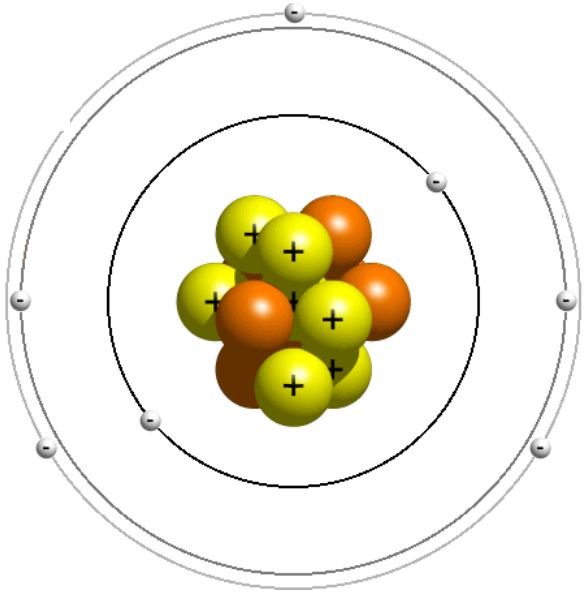
If a nucleus were as big as you are wide, the edge of its atom (outermost electron orbital) would be over a mile away!



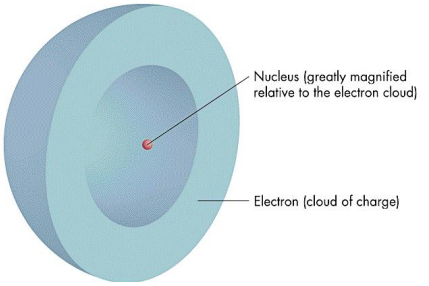
Further refinement of the model

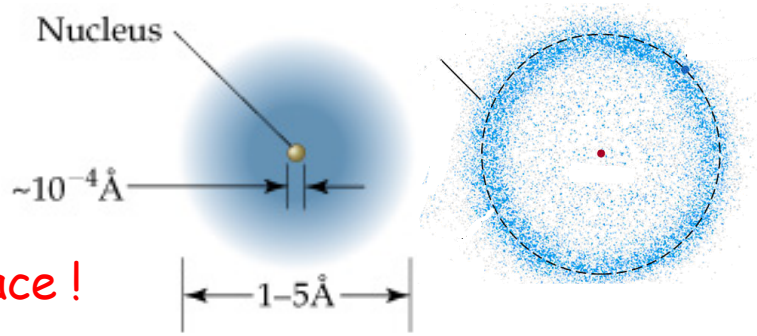
- What's in an atomic nucleus?
  - Protons-discovered by Rutherford
    - Positively charged $1.60217653 \times 10^{-19}$ Coulomb
    - A diameter of about 1.65×10^{-15} m
    - Mass of 1.6726×10^{-27} kg
    - About 1840 times the mass of an electron
  - Neutrons-discovered by Chadwick in 1932
    - Not charged
    - A diameter of about 1.65×10^{-15} m
    - Mass of 1.6749×10^{-27} kg

Current model of the atom



Led to the current model





Bohr Model

Lots of empty space !

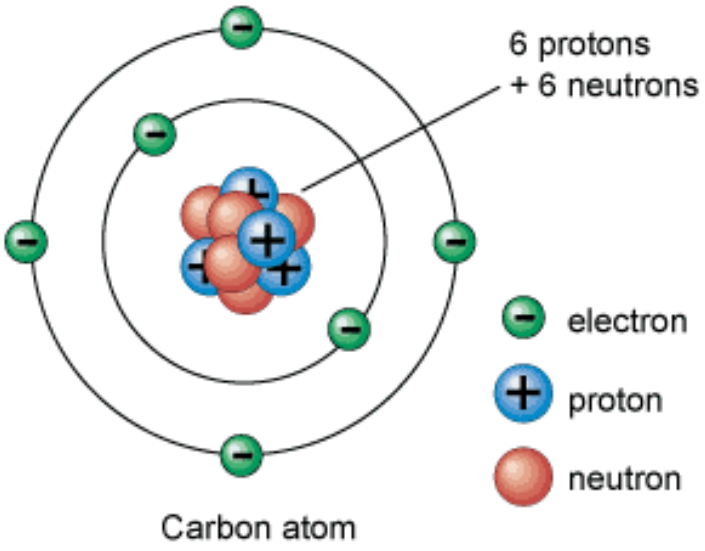
- electrons in well defined "planetary" orbits or paths around the nucleus
- still good for visualizing the energy transitions of electrons

- overall spherical shape
- electrons occupy certain orbital volumes or clouds
- the type of cloud it occupies depends upon its energy or distance from the nucleus

http://education.jlab.org/qa/atom_model_04.gif

http://www.mhhe.com/physsci/astronomy/fix/student/images/16f07.jpg

Atomic number and Mass number



# of protons + # neutrons = mass number

A carbon atom with 6 protons and 6 neutrons has a mass number = 12

# of protons = atomic number

The atomic number of carbon is 6.

Number of electrons will equal the number of protons for an atom with **NO NET CHARGE**

Isotopes and Atomic Mass

What's the difference between MASS NUMBER and ATOMIC MASS?

It turns out that atoms OF THE SAME ELEMENT may exist as ISOTOPES.

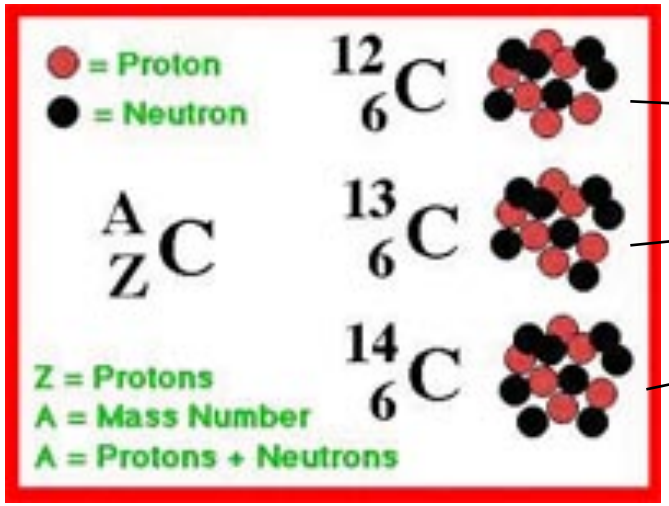
ISOTOPE
- an atom with the same atomic number (same number of protons) but a *different* number of neutrons
- isotopes of the same atom have approximately the same chemical properties

Symbolizing isotopes: C-12 or $^{12}_{6}C$

Mass number

Chemical symbol

protons



The ATOMIC MASS is a weighted average of the mass for each isotope

http://earthguide.ucsd.edu/virtualmuseum/images/ThreeCarbonIsotopes.jpg

Atomic Mass

- The amu (atomic mass unit) is the unit used to express the mass of an atom.

1 amu = 1/12 of the mass of the C-12 isotope of carbon

$1 \text{ amu} = 1.66053886 \times 10^{-24} \text{ grams}$

The mass of 1 proton or 1 neutron is approximately 1 amu.

Carbon-12 makes up 98.89% of naturally-occurring carbon. Carbon-13 makes up 1.11% of naturally occurring carbon. Use this information to determine the average atomic mass of carbon.

$(12\text{amu})(.9889) + (13 \text{ amu})(.0111) = 12.0111 \text{ amu}$

Atomic Charge and IONS

- Atoms in elements are not charged because the number of protons = the number of electrons
- When an atom GAINS one or more electrons, it becomes NEGATIVELY charged because it now holds more electrons than protons
- When an atom LOSES one or more electrons, it becomes POSITIVELY charged because it now holds fewer electrons than protons
- IONS are charged atoms. A CATION is positively charged. An ANION is negatively charged.