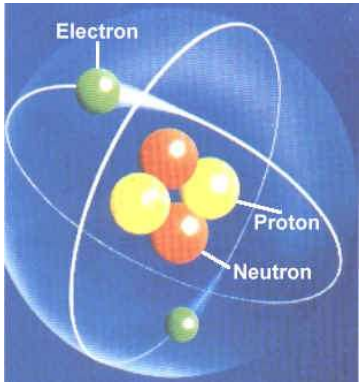
John Dalton

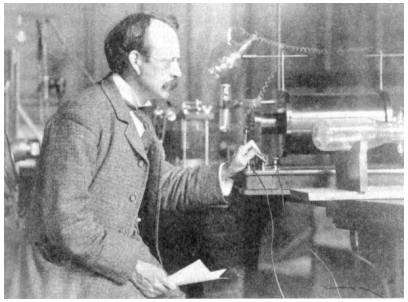
Aristotle

Ernest Rutherford

# Chapter 2

## *Atomic Theory: Introduction*



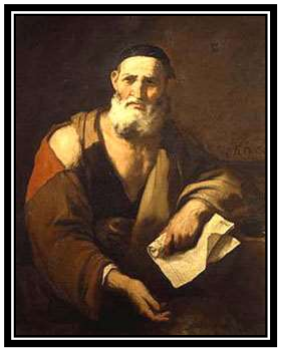
J.J. Thomson

Democritus

# ...A Short History

5th Century B.C.

Matter consists of small particles: atomos



Lucippus

Democritus

Aristotle

Aristotle dismissed the idea as nonsense.

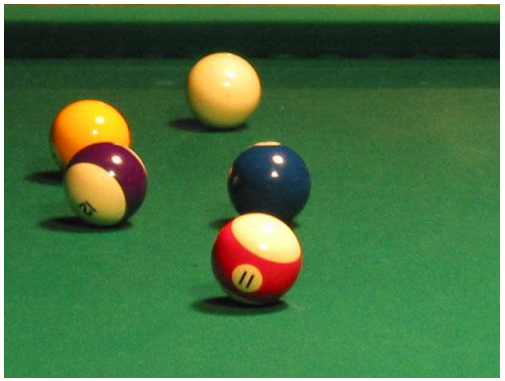
# ...A Short History

**John Dalton (1766 – 1844)**

John Dalton

1. Matter is made up of small particles.

2. Particles (atoms) are <u>indivisible.</u>

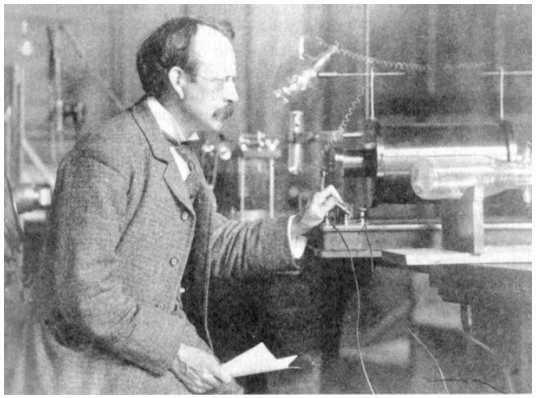


3. Atoms of one element are identical and unique to that element.

4. Combinations of atoms in different whole number ratios are compounds.

# ...A Short History

J.J. Thomson (1856 – 1940)



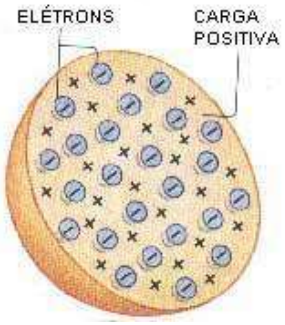
J.J. Thomson

Cathode rays come from atoms.

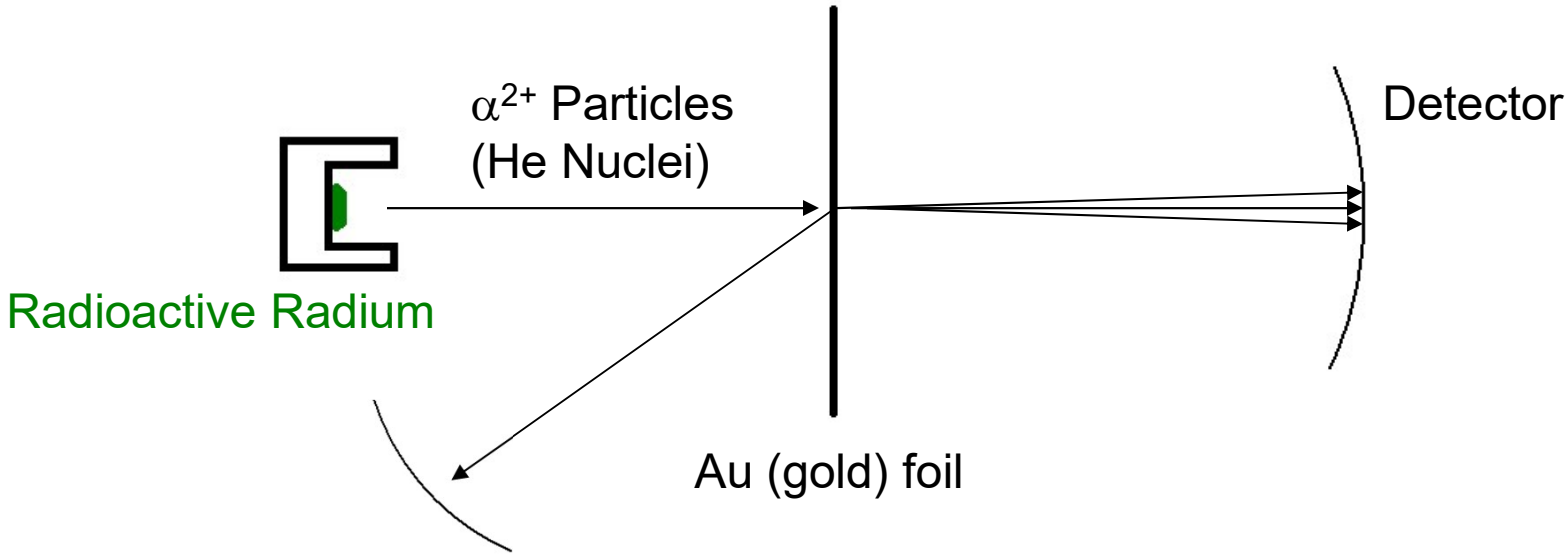
Electrons (cathode rays) are found within atoms.

Atoms are divisible into smaller pieces.

Plumb pudding atomic model.



# Rutherford's Experiment



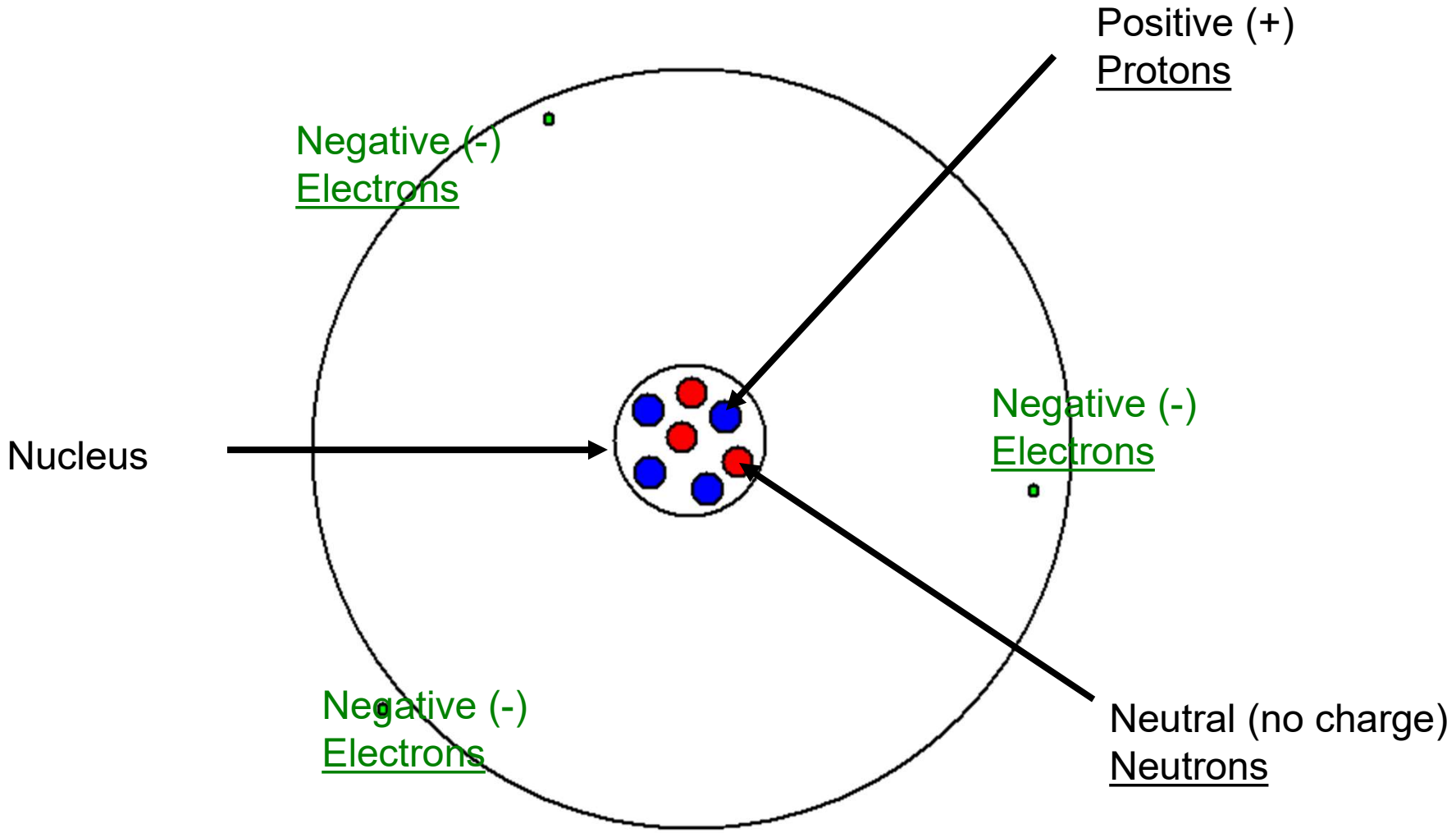

Some $\alpha^{2+}$ particles observed to recoil backwards

Conclusion: Atoms have a small, massive, positively charged core: NUCLEUS

Most $\alpha^{2+}$ particles pass straight through the target

Conclusion: Matter and therefore atoms are mostly EMPTY SPACE

# The Atom


Positive (+)
Protons
Negative (-)
Electrons
Nucleus
Negative (-)
Electrons
Negative (-)
Electrons
Neutral (no charge)
Neutrons

# Particle Inventory

- Proton
  - Abbreviation: $p^+$
  - 1+ positively charged
  - Mass = $1.67262 \times 10^{-24}$ g (1.00727 amu … ~ 1 amu = 1 Dalton)
- Neutron
  - Abbreviation: $n^0$
  - Neutral … no charge
  - Mass = $1.67493 \times 10^{-24}$ g (1.00866 amu … ~ 1 amu = 1 Dalton)
- Electron
  - Abbreviation: $e^-$
  - 1- negatively charged
  - Mass = $9.10939 \times 10^{-28}$ g (0.00054858 amu … ~ 0 amu ~ 0 Da)

# Particle Bookkeeping
## *Nuclide Symbols*

Example: Consider a neutral carbon atom…

**Mass Number**
The number of protons
& neutrons in the nucleus

$^{12}_{6}C$

Carbon's symbol

**Atomic Number**
Number of protons
in the nucleus

SUBTRACT for $n^0$

| | |
|---|---|
| **12** | **$p^+$ & $n^0$** |
| **– 6** | **$p^+$** |
| 6 | **$n^0$** |

Electrons? For a neutral atom p+ = e-

Electrons = **6**

# Atomic Mass Units…Defined

- Need a small unit of mass suitable for atoms and atomic particles
- "grams" is too big to be reasonable (electron's mass = $9.10939 \times \mathbf{10^{-28}}$ **g)**
- **Define**

  **one carbon-12 atom = 12.00000…amu = 12 Da**
- **All other atomic weights are relative to carbon-12 atom**

# More Nuclide Symbols
# Isotopes: Same $p^+$…Different $n^0$

| $^{50}_{24}Cr$ | $^{52}_{24}Cr$ | $^{53}_{24}Cr$ | $^{54}_{24}Cr$ |
|---|---|---|---|
| 24 $p^+$ | 24 $p^+$ | 24 $p^+$ | 24 $p^+$ |
| 50 – 24 = 26 $n^0$ | 52 – 24 = 28 $n^0$ | 53 – 24 = 29 $n^0$ | 54 – 24 = 30 $n^0$ |
| 24 $e^-$ | 24 $e^-$ | 24 $e^-$ | 24 $e^-$ |
| **Mass = 49.9461 amu** | **Mass = 51.9405 amu** | **Mass = 52.9407 amu** | **Mass = 53.9389amu** |
| **Abundance 4.35%** | **Abundance 83.79%** | **Abundance 9.50%** | **Abundance 2.36%** |

Weighted Average Mass

**= (49.9461 × 0.0435) + (51.9405 × 0.8379) + (52.9407 × 0.0950) + (53.9389 × 0.0236)**

Weighted Average Mass **= 51.9961 amu**

# Weighted Averages
# Periodic Table

24

Cr

51.9961

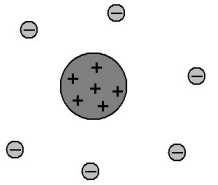
Atomic Number

Number of $p^+$

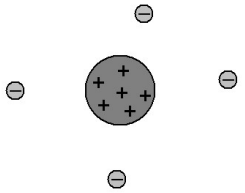
Average Atomic Mass

# Electrons & Protons

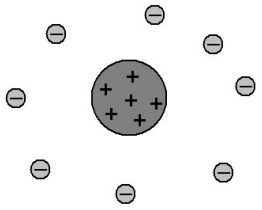
- **# e- = # p+**
  - Electrically neutral
  - Neutral atom
- **# e- < # p+**
  - Electrically net Positive
  - Positively charged atom
  - “Cation”
- **# e- > # p+**
  - Electrically net Negative
  - Negatively charged atom
  - “Anion”



C atom



$C^{2+}$ cation



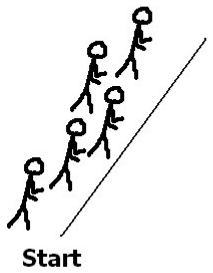
$C^{2-}$ anion

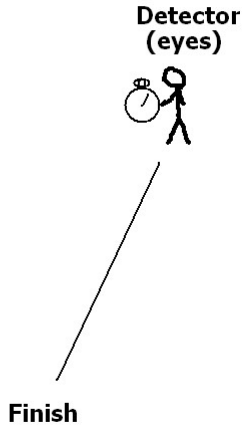
# Mass Spectrometry:

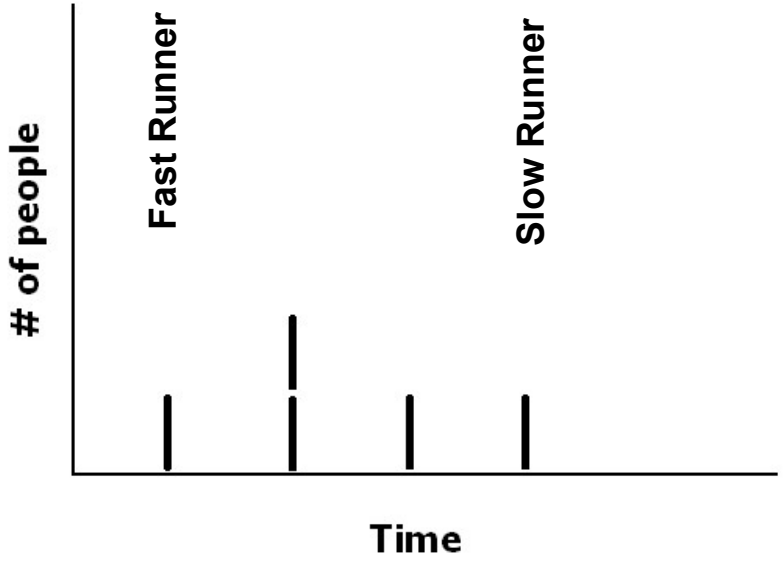
## Experimentally determining the masses of ions

## Read and understand pg. 52 in textbook

TIME OF FLIGHT MASS SPECTROMETRY …the great race!



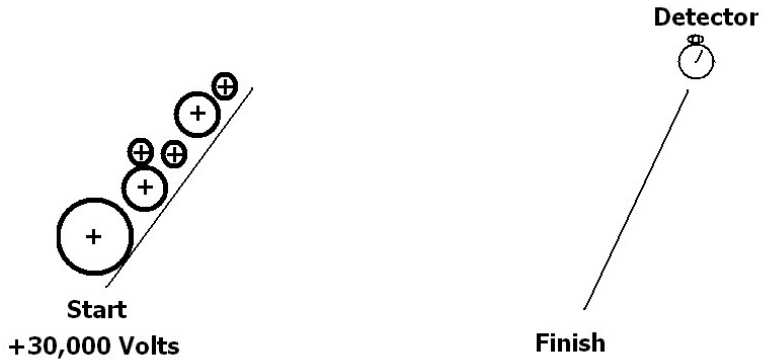



# Mass Spectrometry:

## Experimentally determining the masses of ions

## Read and understand pg. 52 in textbook

IONS: 3 different masses




Time of Flight Mass Spectrometer

Which graph is correct????