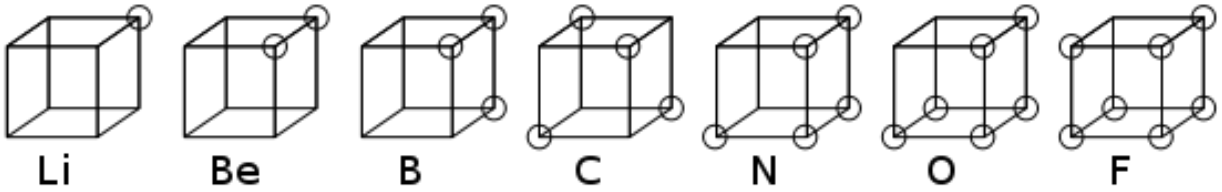
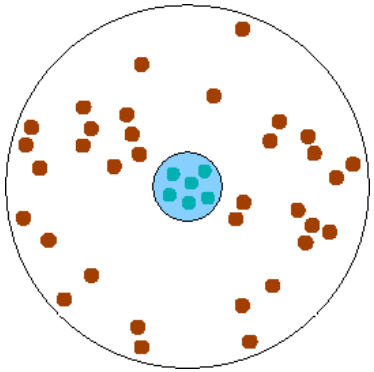
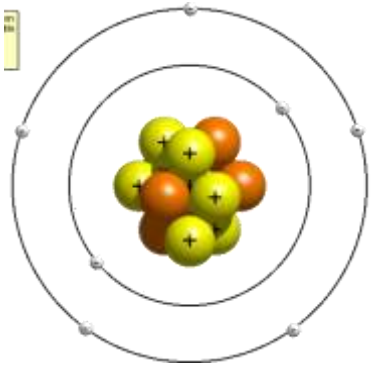
Pre-AP Chemistry

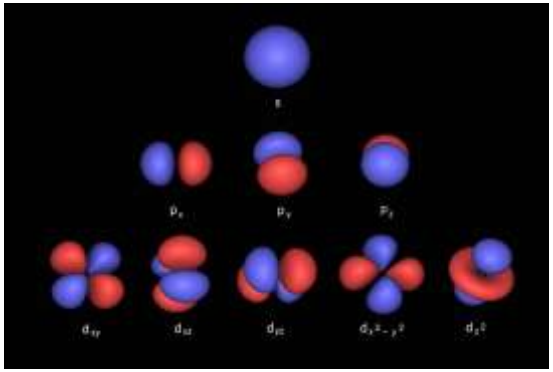
September 4, 2011

5. Discovery of the Atom



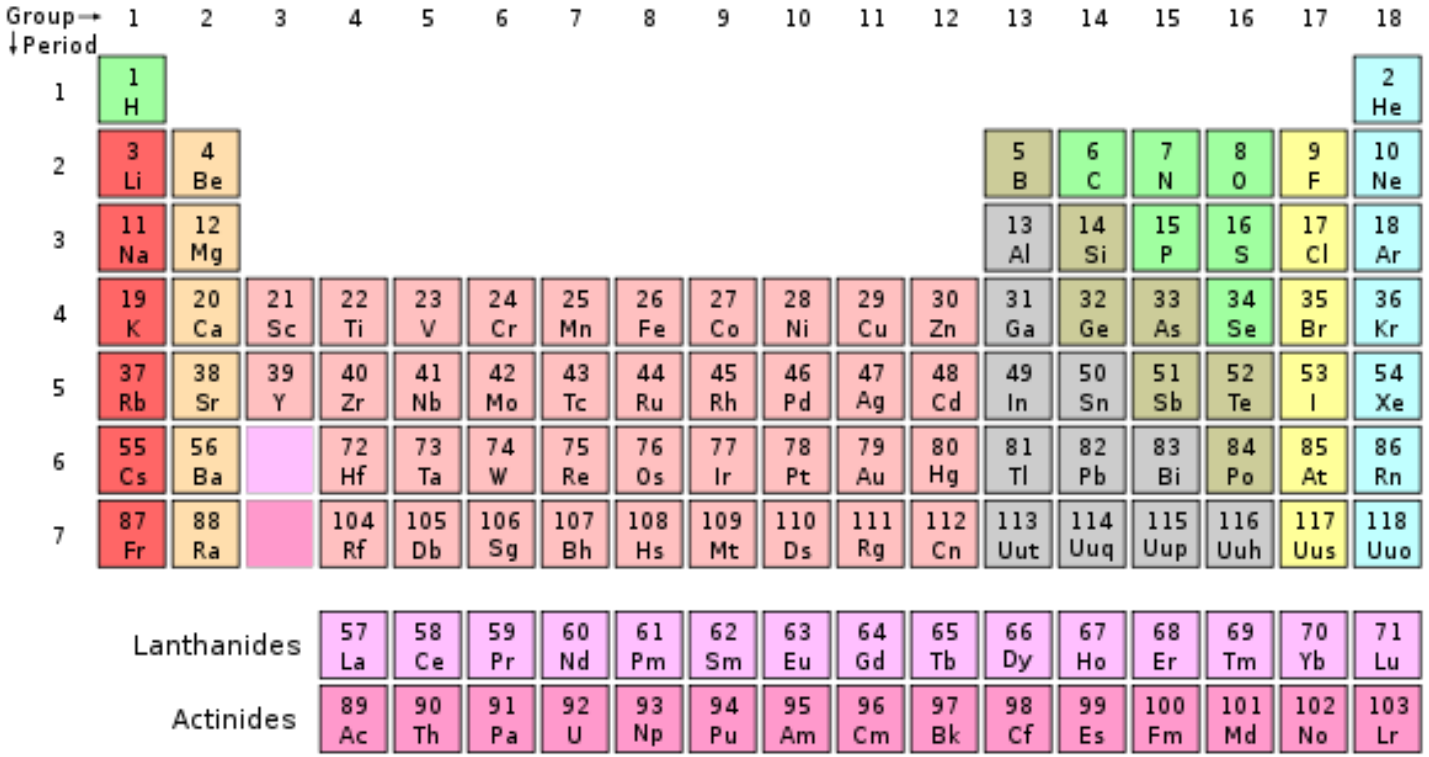






Review

- ‘Atom’ comes from the Greek ‘uncuttable’
- All matter is made of atoms
- There are only 118 known types of atoms



Outline

- Early Discoveries
- Electrons
- Nucleons

- Early Discoveries
  - Conservation of Mass
  - Constant Composition
  - Dalton's Theory
- Electrons
  - Faraday's Cathode Ray Experiments
  - Millikan's Oil Drop Experiments
- Nucleons
  - Protons
  - Neutrons
- How Small is 'Small'?

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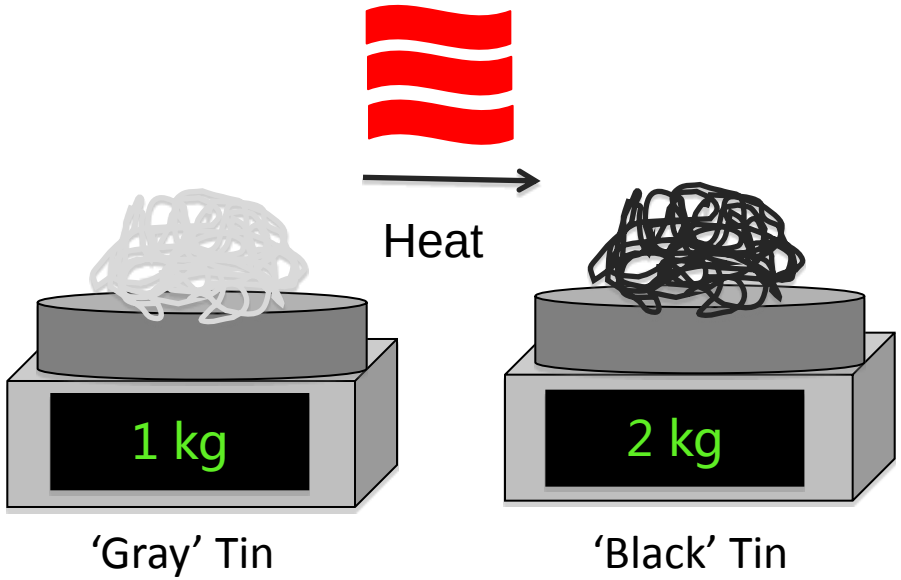
Conservation of Mass

- The total mass of of substances before and after a chemical reaction is the same
- Demonstrated by Lavoisier in 1774



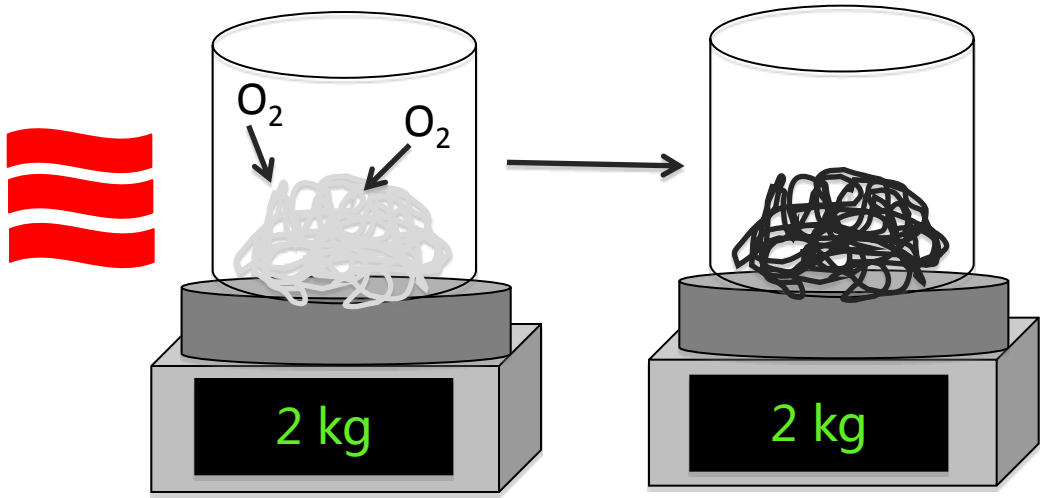
Heat is not matter and has no mass – where did extra mass come from?

1774

Conservation of Mass

Conservation of Mass

- The total mass of of substances before and after a chemical reaction is the same
- Demonstrated by Lavoisier in 1774



Tin
Glass
+ Air (with Oxygen)
Total Mass =

Tin Oxide
Glass
+ Air (no Oxygen)
Total Mass

1774
Conservation of Mass

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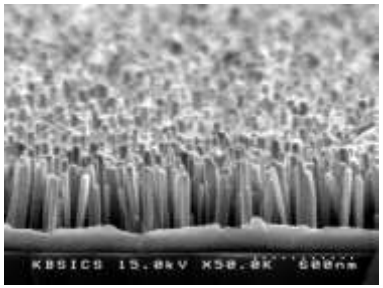
Constant Composition

- All samples of a compound have the same composition, the same proportions by mass of each component
- Demonstrated by Proust in 1799



TiO_2

1774 — Conservation of Mass

1799 — Constant Composition

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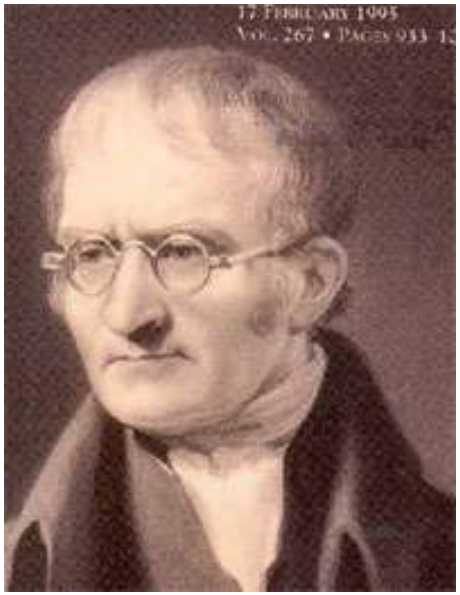
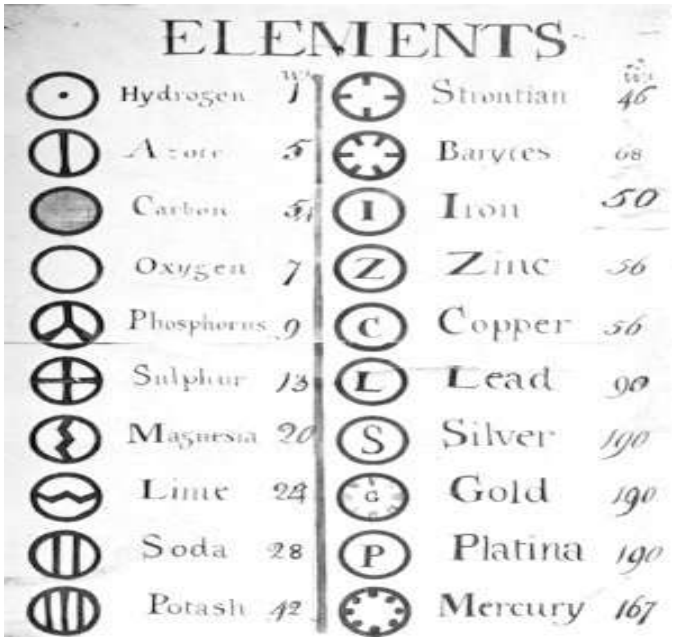
Dalton's Atomic Theory (1808)

- All elements are composed of atoms that cannot be created or destroyed by a chemical change (Conservation of Matter)
- All atoms of one element are alike. Atoms of different elements are different
- In compounds, different elements combine in simple numerical ratios (Lavoisier)





1774 — Conservation of Mass

1799 — Constant Composition

1808 — Dalton's Theory

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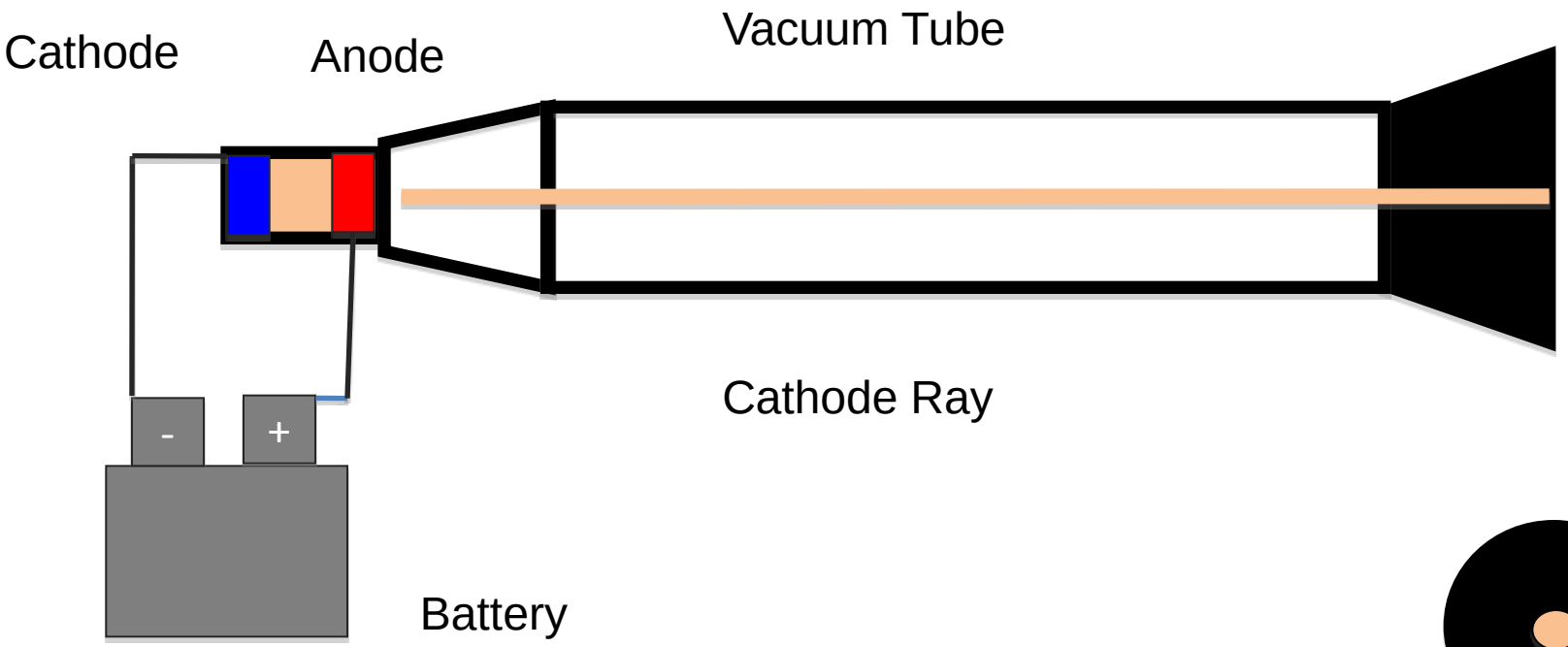
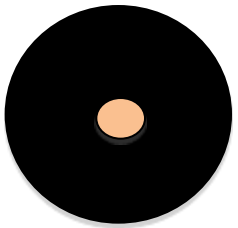
Cathode Ray Tube

- Invented by Michael Faraday in 1838
- Faraday showed that ray properties were independent of cathode material

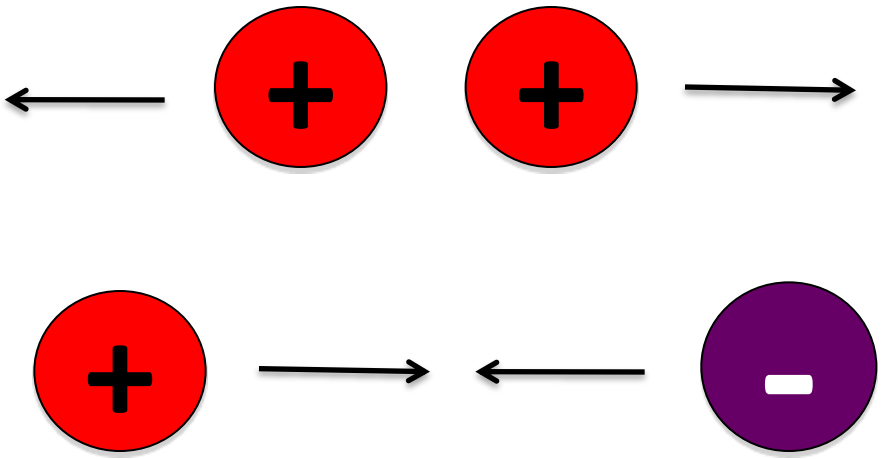




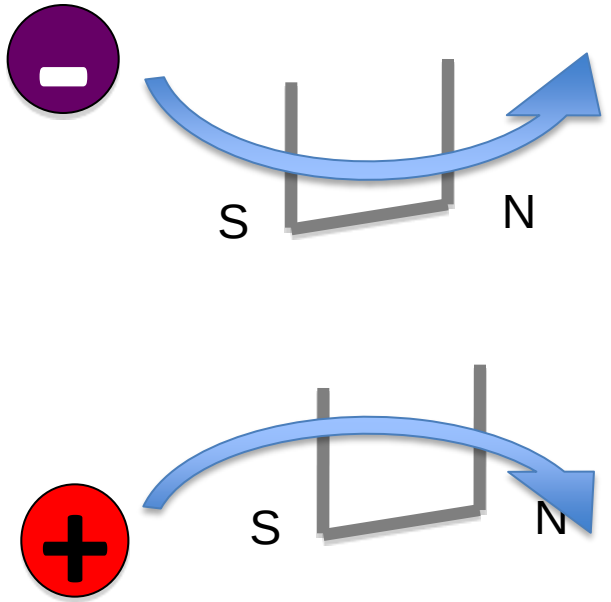
Cathode Ray Tube

- To understand the cathode ray tube, we need to review **electric charge**.
- **Charge** is a **property of matter**, just like mass, volume, and color
- Scientists represent charge as '**q**' with units in **Coulombs (C)**

- Particles with the **same charge repel** each other, and particles with **opposite charges attract** each other

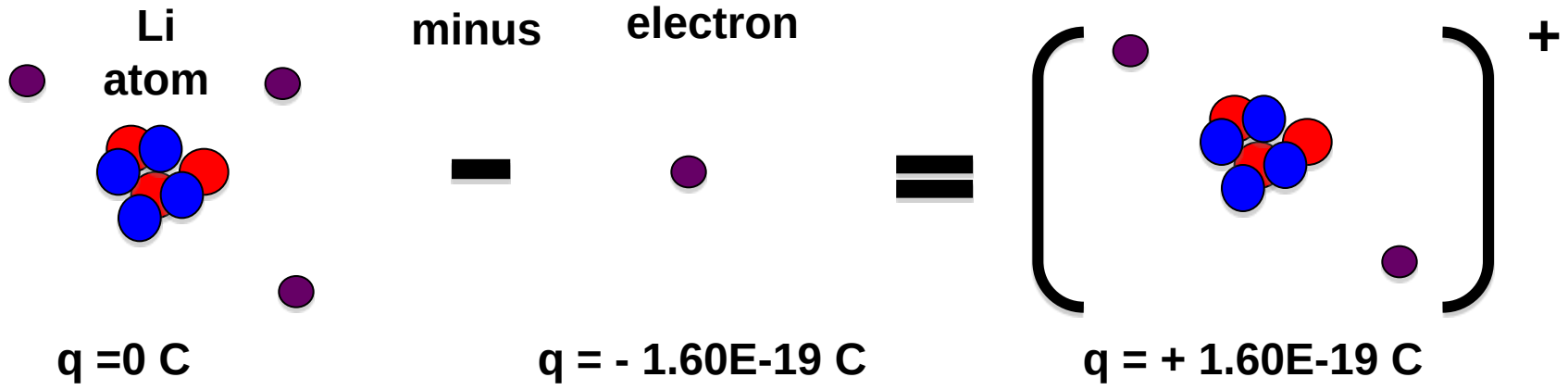


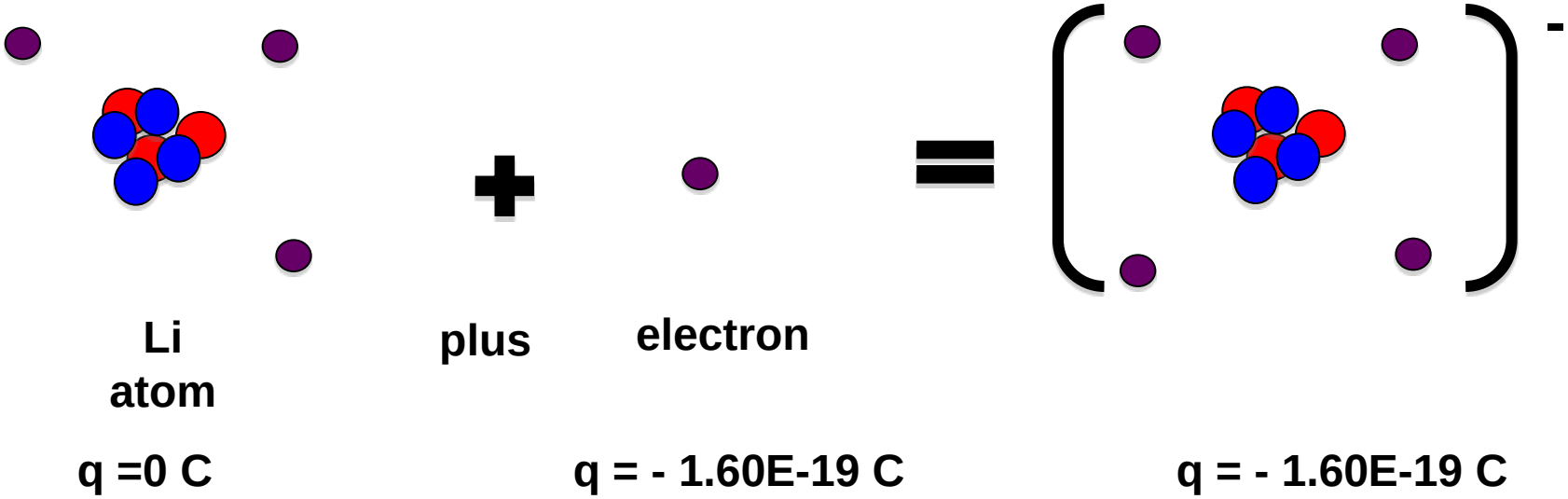
- **Magnetic fields** also exert forces on charged particles



Cathode Ray Tube

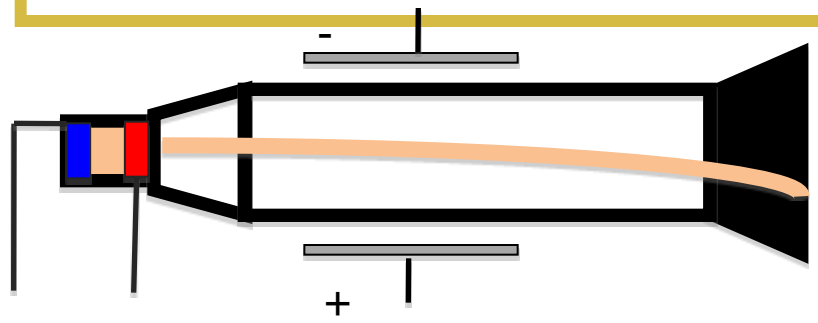
- Charged particles are formed by gaining or losing electrons

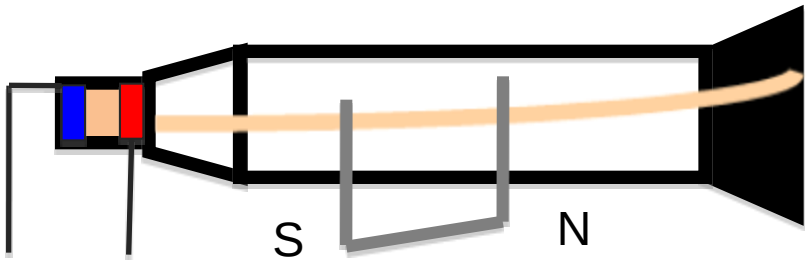


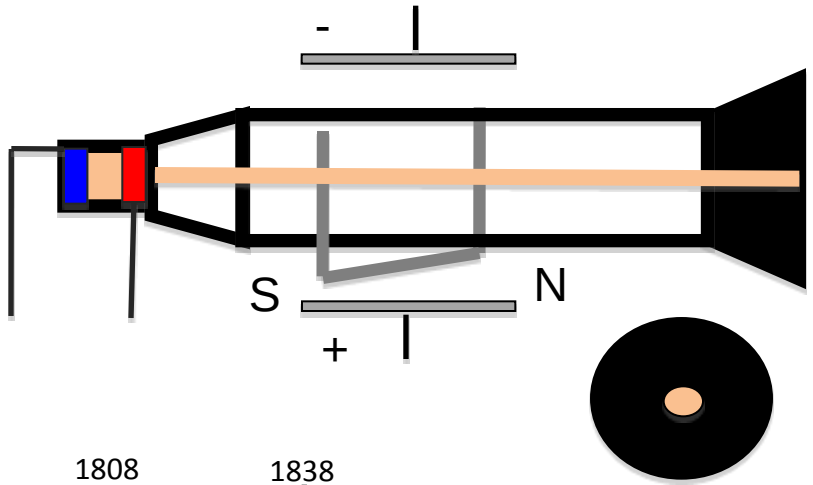


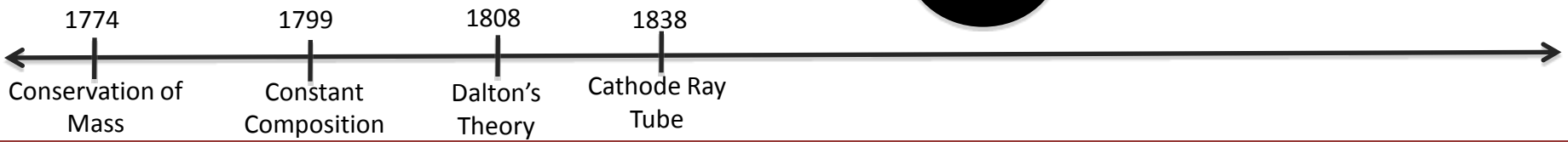
Cathode Ray Tube

- Thomson also showed that **cathode rays** acted as if **negatively charged**
- In 1897, Thomson discovered the **mass-to-charge ratio** of the electron









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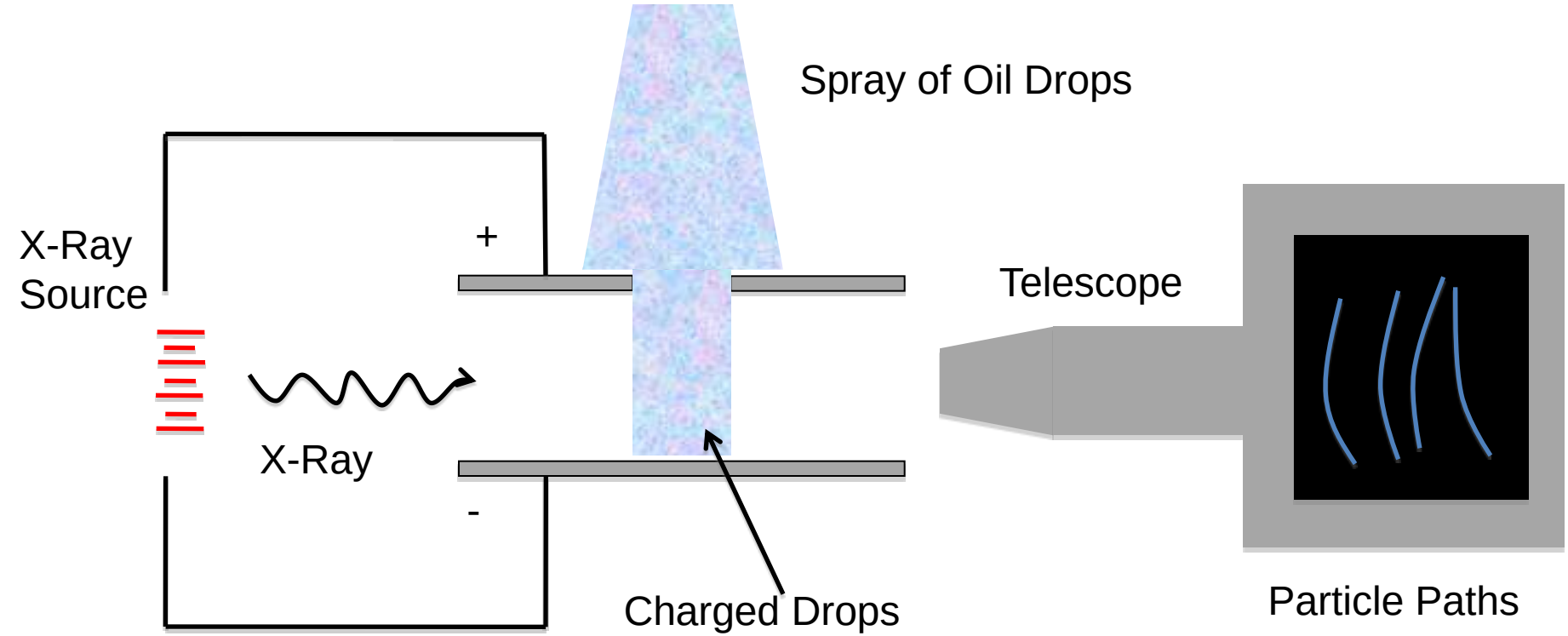
Oil Drop Experiment

- Millikan recorded the paths of charged oil droplets falling in an electric field
- He found that the charge (q) on every droplet was an integral multiple of a **fundamental charge** (e): q = ne, n = 0,1,2,3 …



Mini Quiz

- If Thomson found that the **mass-to-charge ratio** of an electron was 5.59E-12 kg/Coulomb, and Millikan found that the **charge** one electron was 1.60E-19 Coulombs, then what can you conclude is the mass of one electron?

$$\frac{m_{electron}}{q_{electron}} = 5.59 \times 10^{-12} \frac{kg}{Coulomb}$$

$$q_{electron} = 1.60 \times 10^{-19} Coulomb$$

$$m_{electron} = ?$$

Mini Quiz

- If Faraday found that the **mass-to-charge ratio** of an electron was 5.59E-12 kg/Coulomb, and Millikan found that the **charge** one electron was 1.60E-19 Coulombs, then what can you conclude is the mass of one electron?

$$m_{electron} = 1.60 \times 10^{-19} Coulombs \times 5.59 \times 10^{-12} \frac{kg}{Coulomb}$$

$$m_{electron} = 8.94 \times 10^{-31} kg$$

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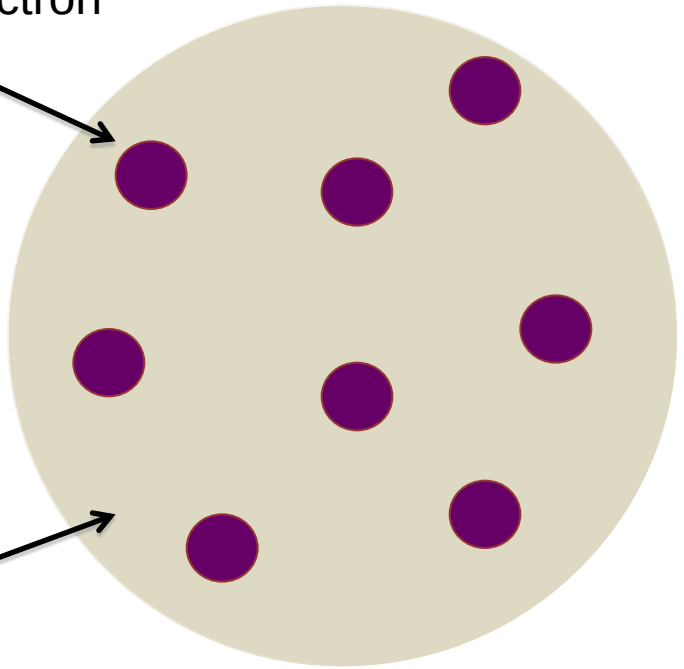
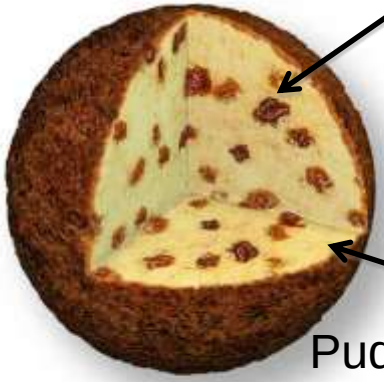
Thomson's Atomic Model

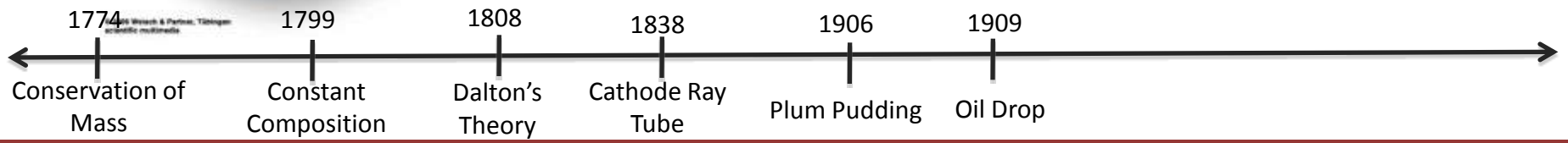
- Atoms are mostly positively charged clouds
- Only electrons have mass in atoms, and they are distributed uniformly like 'fruits in plum pudding'

Plum / Electron



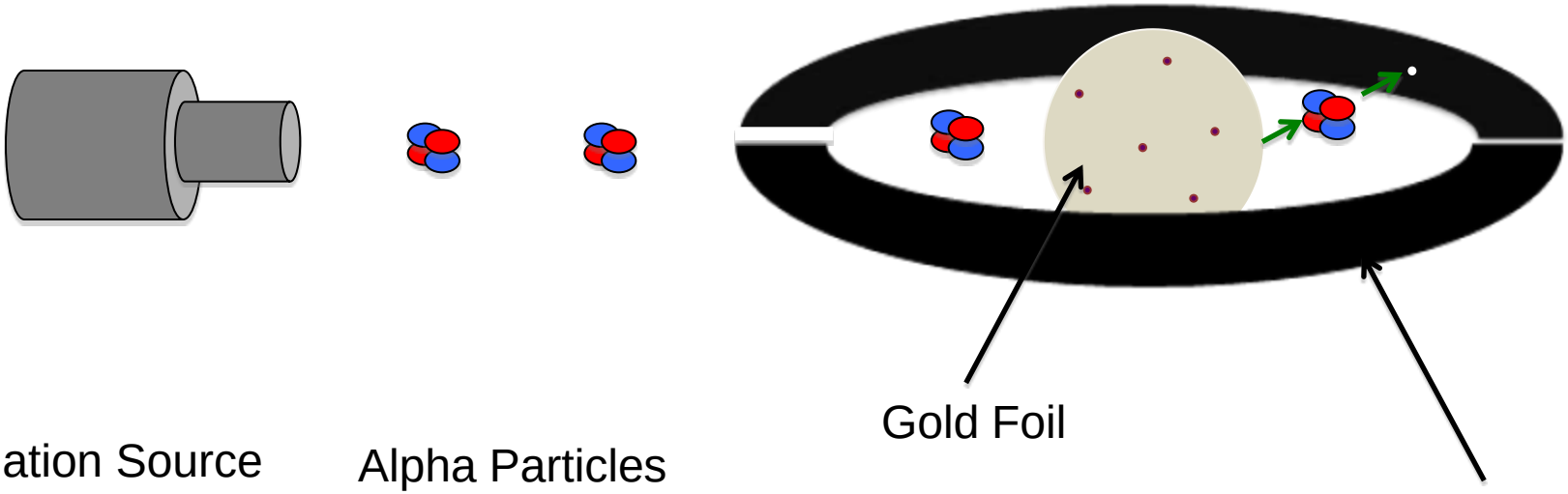


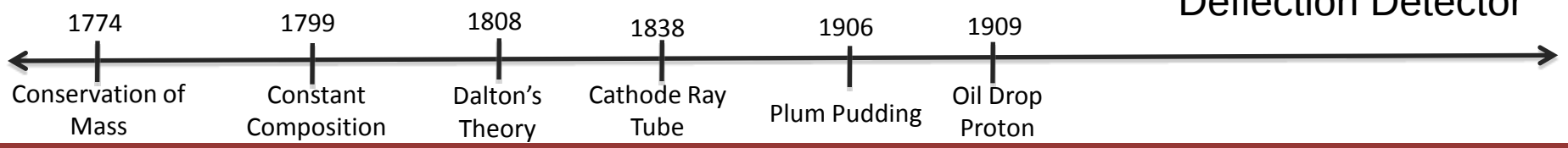
Pudding / Positively Charged Cloud



Discovery of the Proton

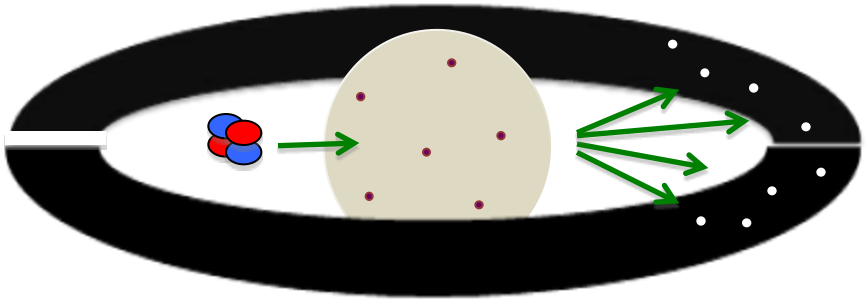
- Rutherford fired alpha particles at a thin gold foil
- Hoped to learn about distribution of electrons in space by analyzing how alpha particles were deflected

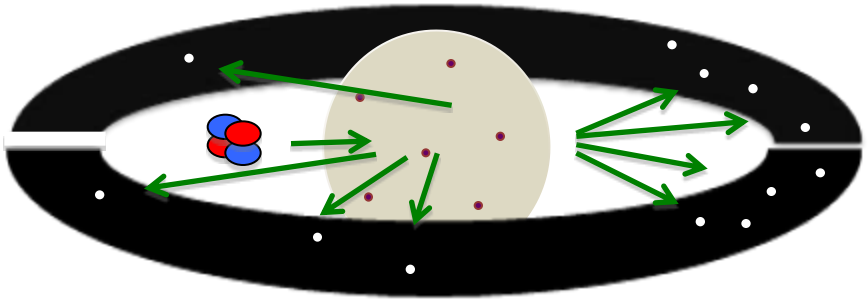


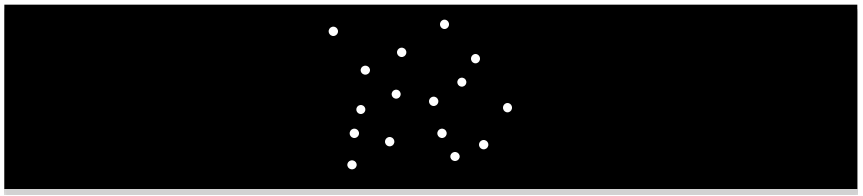


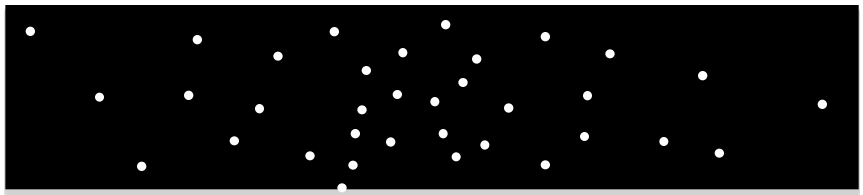
Discovery of the Proton

- Electrons expected to only slightly deflect alpha particles
- Experimentally, 1 / 20,000 alpha particles found to be significantly deflected – some completely reversed direction!







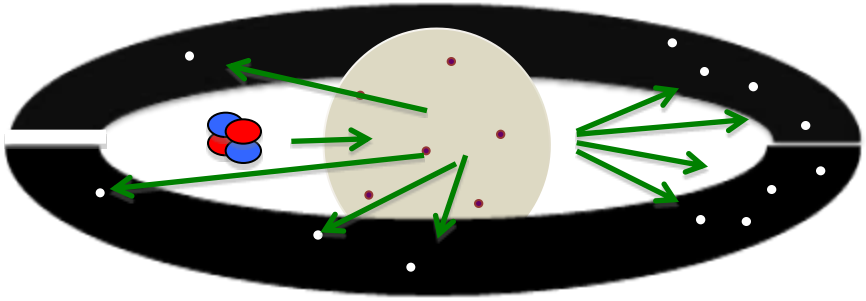


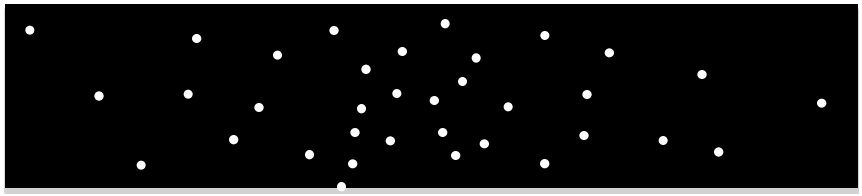
Expected Result

Actual Result

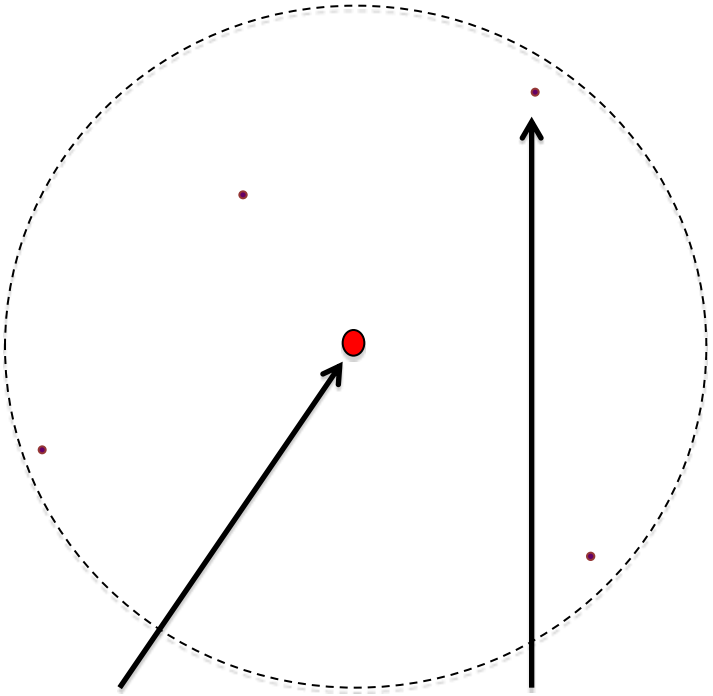
Rutherford Atomic Model

- Large-angle deflection required massive particle occupying very small fraction of space in an atom
- Positively charged particles called protons





Actual Result



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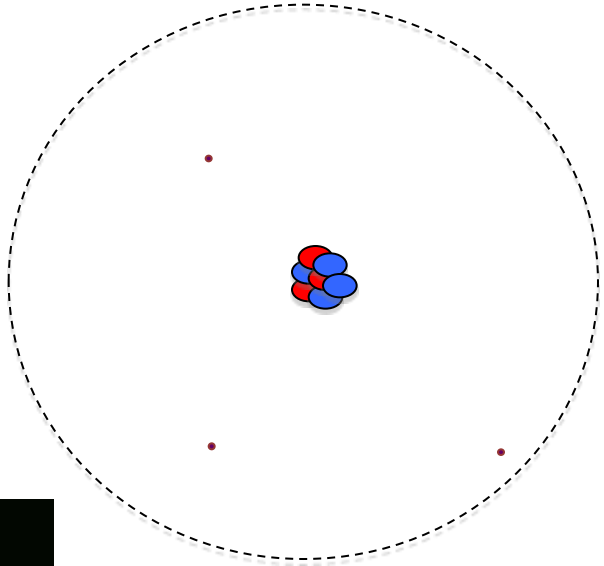
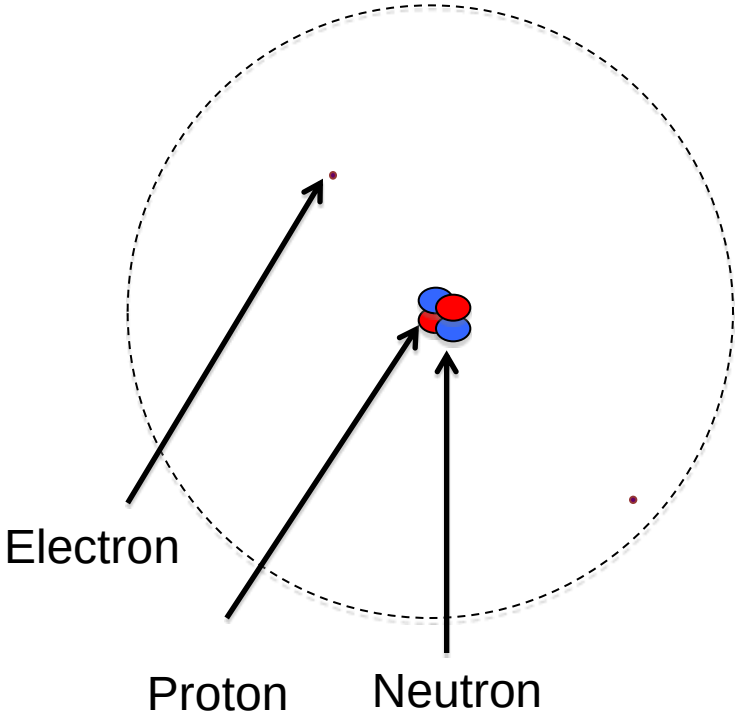
Discovery of the Neutron

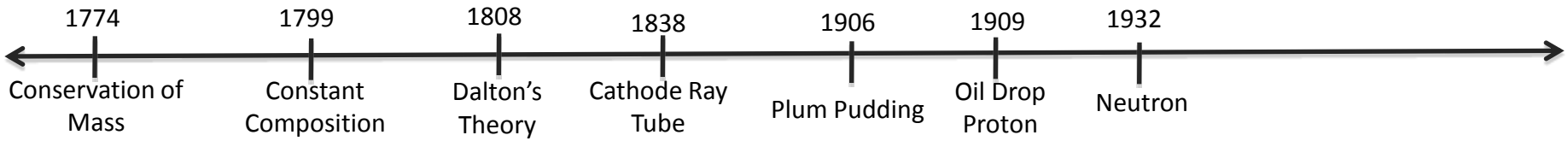
- Massive neutral particle predicted on the basis of inconsistency between experimental data and quantum mechanical predictions
- Discovered by Chadwick in 1932

He

Li

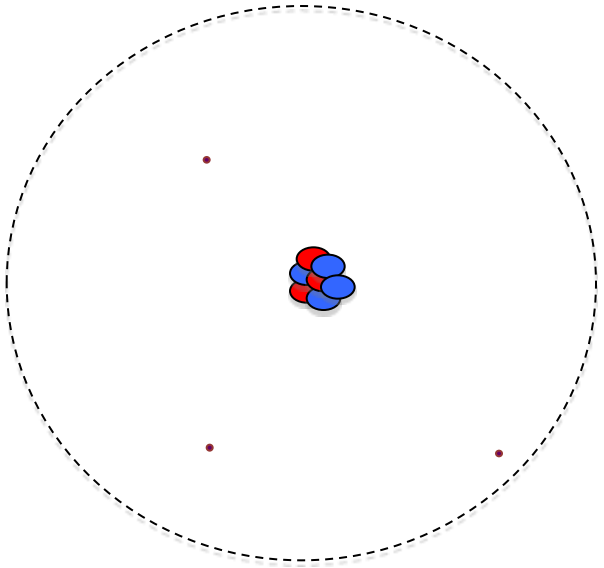






Summary of Sub-Atomic Particles

Particle	In Nucleus	Relative Charge	Relative Mass
Electron	No	-1	1/1800
Proton	Yes	+1	1
Neutron	Yes	0	1



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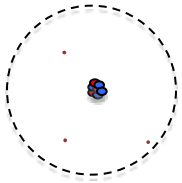
How Small is ‘Small’?

- An atom is mostly empty space

The nucleus is to the atom as a ping pong ball is to the Forbidden City.

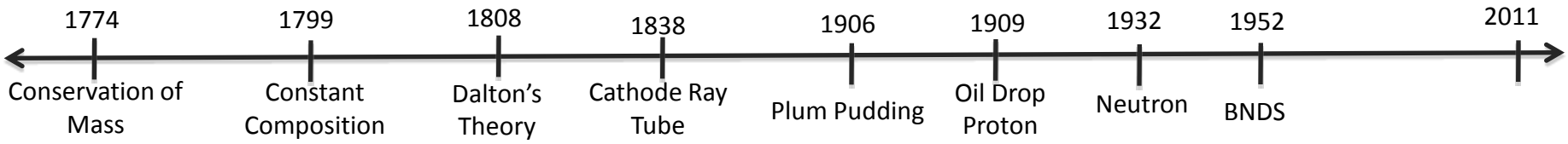
An atom is extremely small



An atom is to a ping pong ball as a ping pong ball is to the Earth.

Summary

- Atoms of a each element are unique
- An atom consists of a nucleus of protons and neutrons surrounded by electrons
- Atoms are extremely small and mostly empty space



Homework

- Read Ch. 4 (pp. 75 – 85)
- Problems: Worksheet on the discovery of the atom
- HW due tomorrow