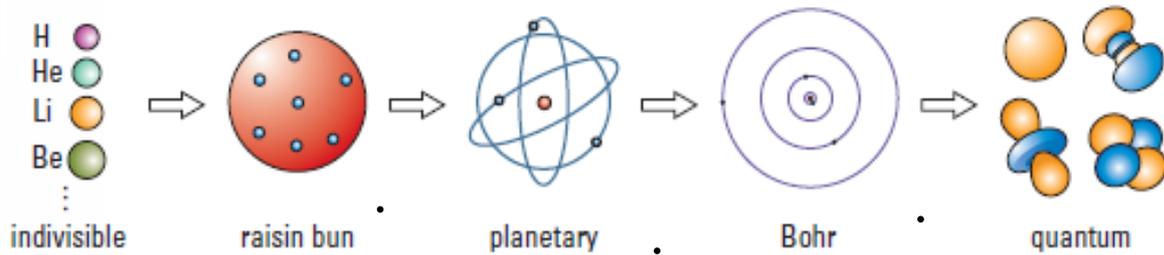


L01 - The Electron



Dalton J.S. Thomson Rutherford Bohr

Crash Course - The History of Atomic Chemistry

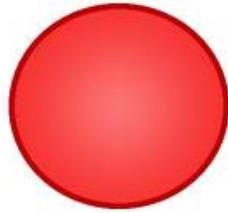
<https://www.youtube.com/watch?v=thnDxFdkzZs>



Science 10 - History of the Atomic Model

Dalton Model

- All matter is made of small, indivisible particles called atoms.
- All atoms of an element are identical in size and mass.
- Atoms of different elements have different properties.

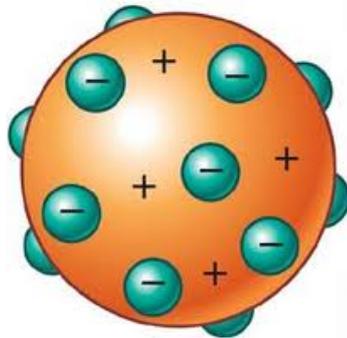


Evidence:

- J.J. Thomson discovered that all elements can produce a beam of negatively charged particles, suggesting that all atoms contained smaller particles that were identical.

J.J. Thomson Model

- Sphere has a positive charge.
- Embedded in the sphere are negative charges (electrons).

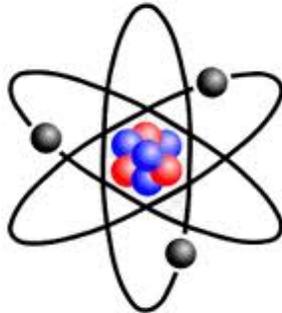


Evidence:

- Rutherford used radioactive substances and aimed the emitted particles at gold foil.
- Most passed through the foil, but 1 in 10,000 were deflected.

Rutherford Model

- Small positively charged nucleus (1/10,000 the size on the entire atom).
- Most of the atom is empty space.
- Nucleus orbited by electrons (like a planetary model).

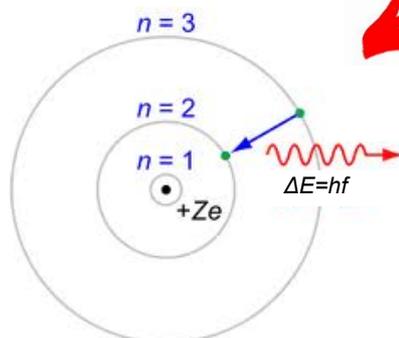


Evidence:

- Neils Bohr discovered that hydrogen atoms made to glow in a tube emitted very distinct colors of light.

Bohr Model:

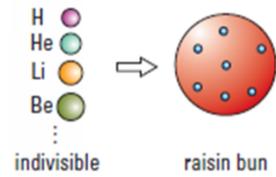
- Nucleus consists of protons and neutrons.
- Electrons exist in certain energy levels.
- When an electron passed to a lower energy level, they emit the energy as light (where different colors of light correspond to different energies).



Today: From Dalton to J.J. Thomson

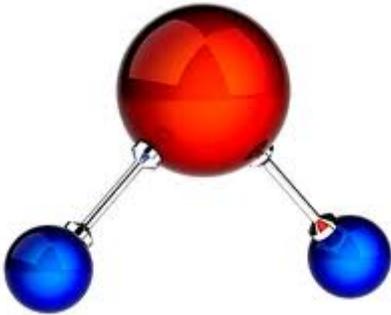
The Discovery of the Electron, and the **Charge to Mass Ratio**

3/9



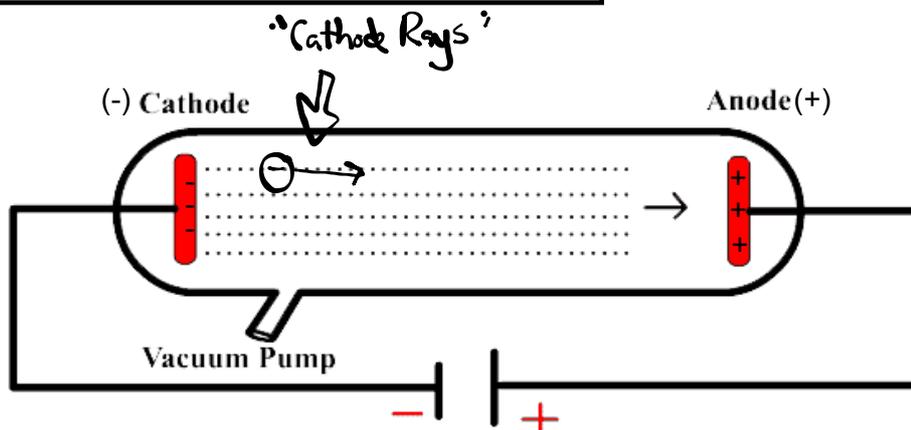
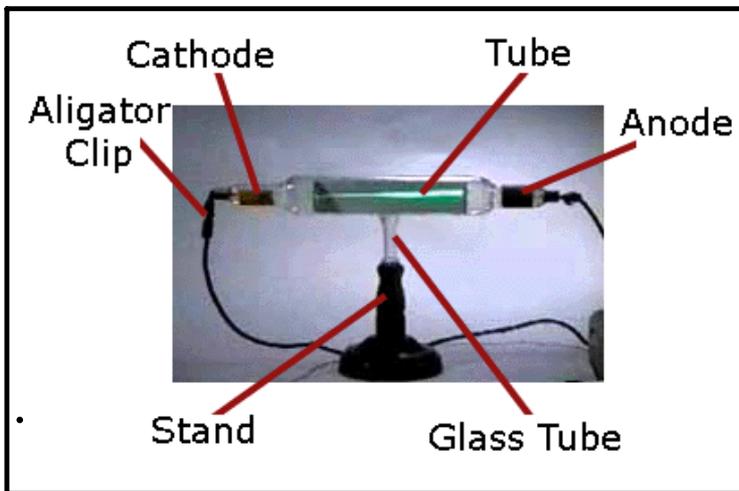
John Dalton - Billiard Ball Model

Atoms were seen as **solid, spherical objects** that could join to other atoms in certain ratios to create molecules



J.J. Thomson and Cathode Rays

Cathode Rays: Mysterious flow from the cathode (negative) to the anode (positive) when a vacuum tube was connected to a high voltage



Properties of "Cathode Rays"

<https://www.youtube.com/watch?v=pXOMDTxJtcE>



COLLECTED EVIDENCE

1. The Cathode Rays travel in straight line
2. The Cathode Rays are made up of material particles
3. The Cathode Rays produce heating effect
4. The Cathode Rays carry negative charge
 - a. Electric field deflection
 - b. Magnetic field deflection
5. The Cathode Rays produce green fluorescence on the glass walls of the discharge tube.
6. The Cathode Rays penetrate through thin sheets of metals
7. The Cathode Rays affect the photographic plates
8. The Cathode Rays produce X-rays when they strike against hard metals

CONCLUSIONS

1. Cathode Rays are made up of material particles
2. Cathode Rays carry negative charge

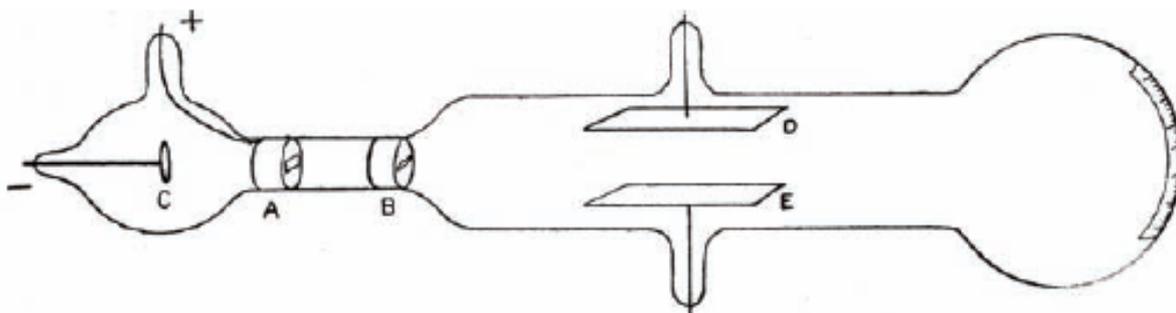
The negatively charged material particles constituting the Cathode Rays are called "electrons".

Thomson's Experiment – IMPORTANT!!!

Big Idea: **Charge to Mass Ratio!**

Thomson's Experiment

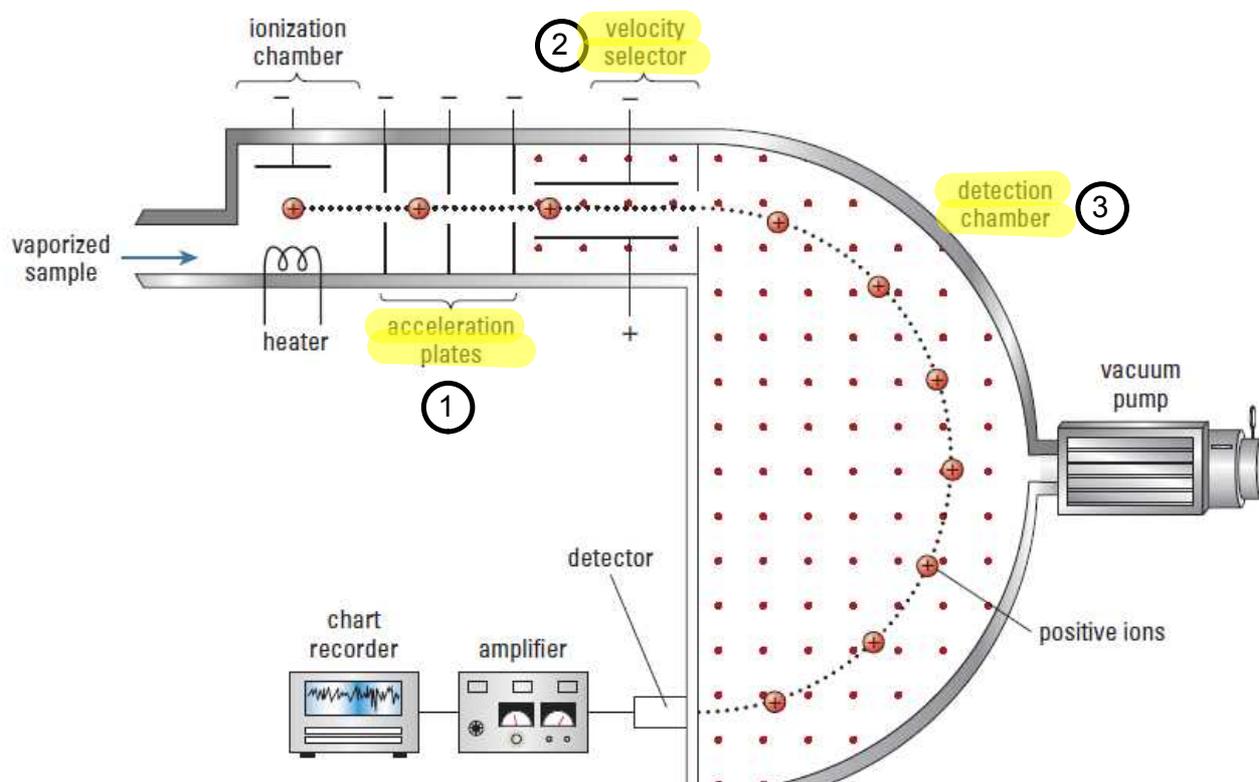
- Are they a particle or is it EMR?
- Put it through an electric field!
- It was bent so it must be a charged particle.
- Determined that it was a negatively charged particle (electron).



The rays from the cathode C pass through a slit in the anode A, which is a metal plug fitting tightly into the tube and connected with the earth; after passing through a second slit in another earth-connected metal plug B, they travel between two parallel aluminium plates about 5 cm long by 2 broad and at a distance of 1.5 cm apart; they then fall on the end of the tube and produce a narrow well-defined phosphorescent patch. A scale pasted on the outside of the tube serves to measure the deflexion of this patch.

Mass Spectrometer – Finding Charge to Mass Ratio!

Three important sections, (1) Acceleration Plates, (2) Velocity Selector, (3) Detection Chamber



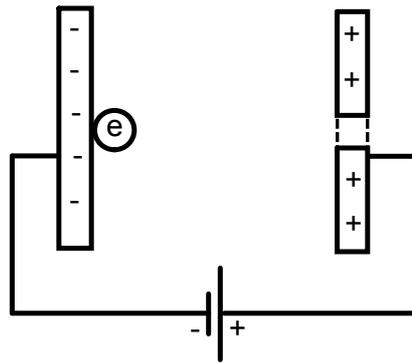
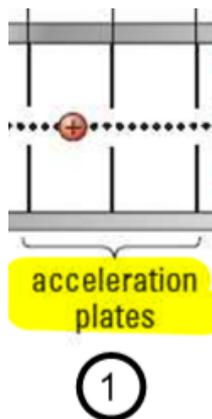
Part 1 - Acceleration Plates

How to solve? Conservation of Energy!

$$\Delta V = \frac{\Delta E}{q} \Rightarrow E_k = \frac{1}{2}mv^2$$

$$E_p \rightarrow E_k$$

$$q\Delta V \rightarrow \frac{1}{2}mv^2$$

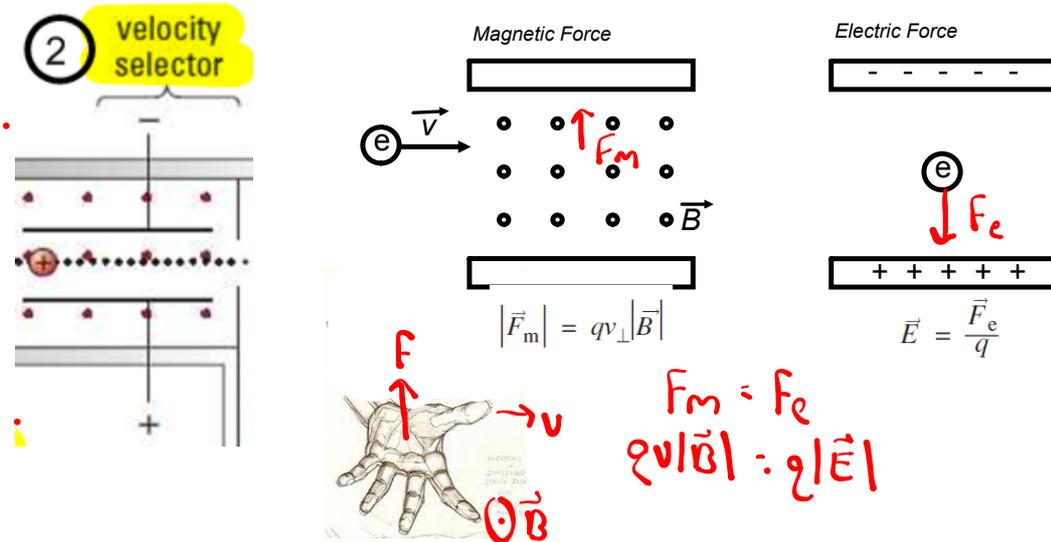


Q1: If an electron is placed between parallel plates, what voltage would be needed to accelerate it to 2.00×10^7 m/s?

- $E_p \rightarrow E_k$
- $q\Delta V \rightarrow \frac{1}{2}mv^2$
- $(1.60 \times 10^{-19}) \Delta V = \frac{1}{2} (9.11 \times 10^{-31}) (2.00 \times 10^7)^2$
- $\Delta V = 1138.75 \text{ V}$
- $= a.b \times 10^d$
- | | | | |
|---|---|---|---|
| 1 | 1 | 4 | 3 |
|---|---|---|---|

Part 2 - Velocity Selector

Only a particular speed will cause the magnetic force balances out the electric force



Q2: A beam of electrons pass undeflected through a 0.50 T magnetic field combined with a 50kN/C electric field. How fast are the electrons travelling that pass through undeflected?

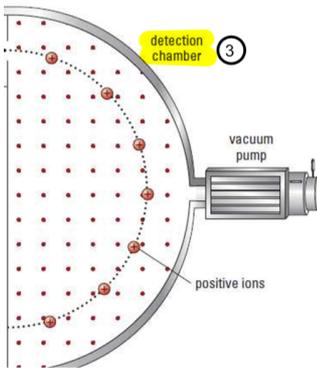
$$qv|\vec{B}| = q|\vec{E}|$$

$$v = \frac{|\vec{E}|}{|\vec{B}|} = \frac{50 \times 10^3}{0.5}$$

$$v = 1.00 \times 10^5 \text{ m/s}$$

Part 3 - Detection Chamber

Only a magnetic force is applied to the particle which causes it to travel in circular motion. Detectors are present to determine the radius of curvature.



$$|\vec{F}_m| = qv_{\perp}|\vec{B}| \quad |\vec{a}_c| = \frac{v^2}{r}$$

$$F_m = F_c$$

$$qv|\vec{B}| = \frac{mv^2}{r}$$

Q3: When a beam of electrons, accelerated to a speed of 5.93×10^5 m/s, is directed to a uniform $100 \mu\text{T}$ magnetic field, they travel in a circular path with a radius of 3.37 cm. Determine the charge to mass ratio for an electron.

$$qv|\vec{B}| = \frac{mv^2}{r}$$

$$q = \frac{mv}{Br}$$

$$\frac{q}{m} = \frac{v}{Br} = \frac{(5.93 \times 10^5)}{(100 \times 10^{-6})(3.37 \times 10^{-2})} = 1.76 \times 10^{11} \text{ C/kg}$$

Charge to mass ratio.

Confirm?

$$\frac{q}{m} = \frac{(1.60 \times 10^{-19})}{(9.11 \times 10^{-31})} = 1.76 \times 10^{11} \text{ C/kg}$$