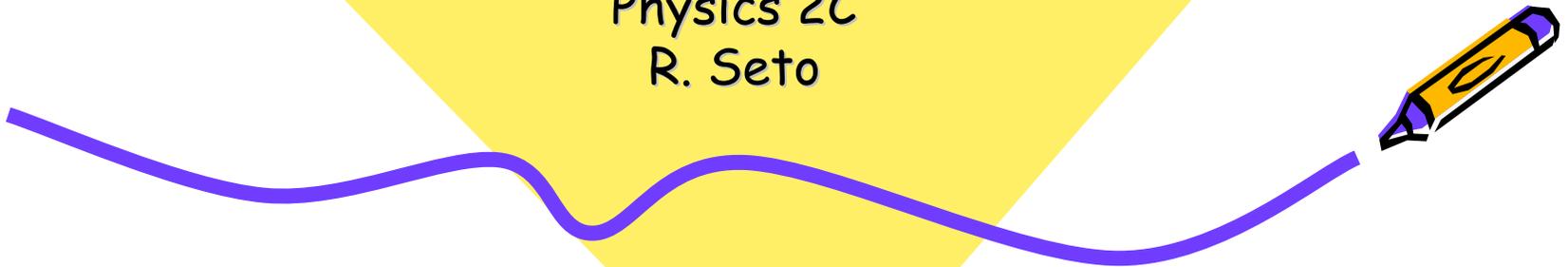


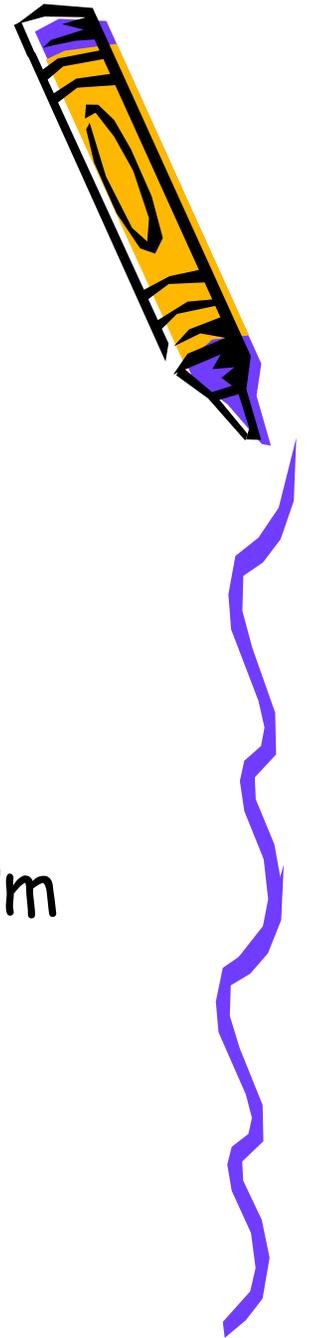
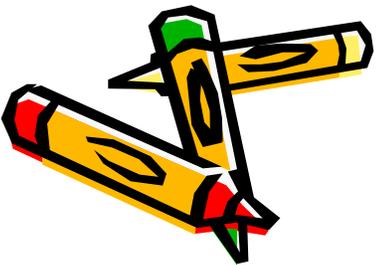
The end of classical physics a history

Chapter 37
Physics 2C
R. Seto

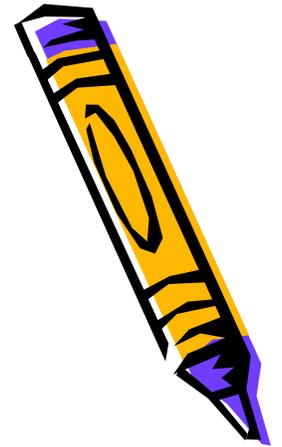


What is the world made of?

- Greeks - Air, water, earth, fire
- Later Democritus - Atoms
 - $pV=nRT$ (kinetic theory)
 - Chemistry - Dalton, Avagadro
 - from deviations to $pV=nRT$ size $\sim 10^{-10}\text{m}$

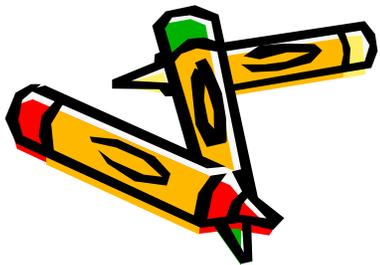


What's light?

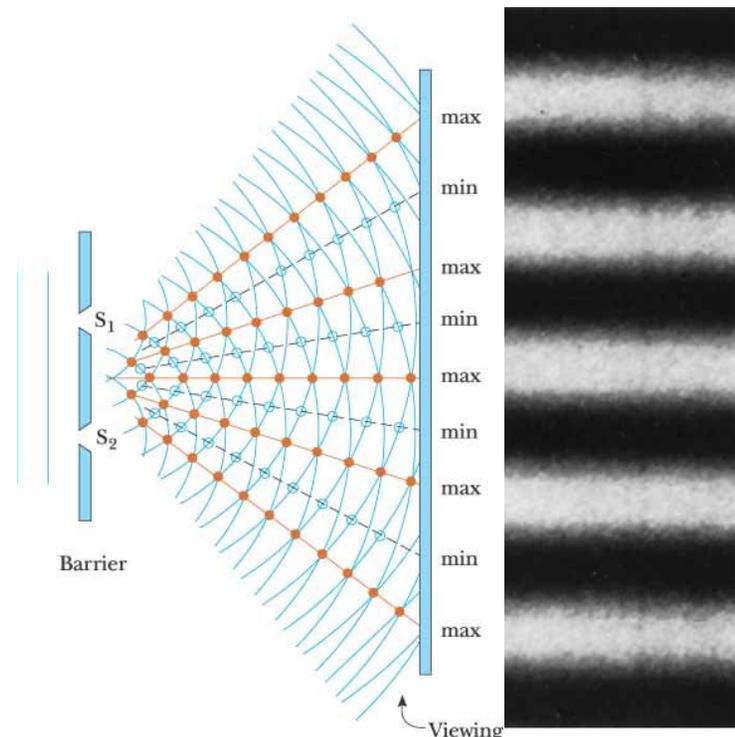


- Newton
- Little bullets

- Young
- waves

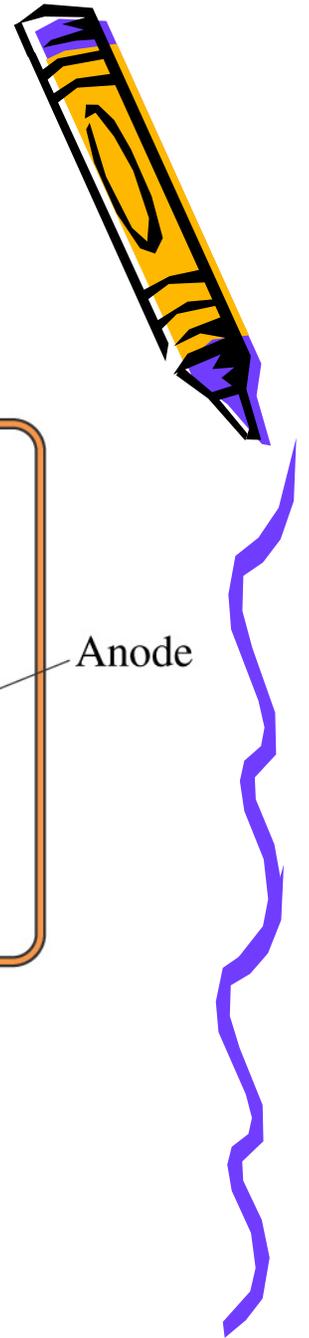
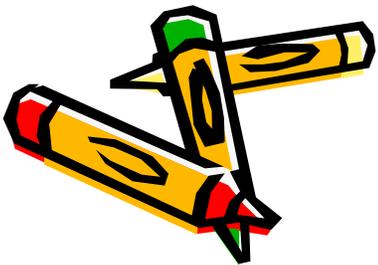
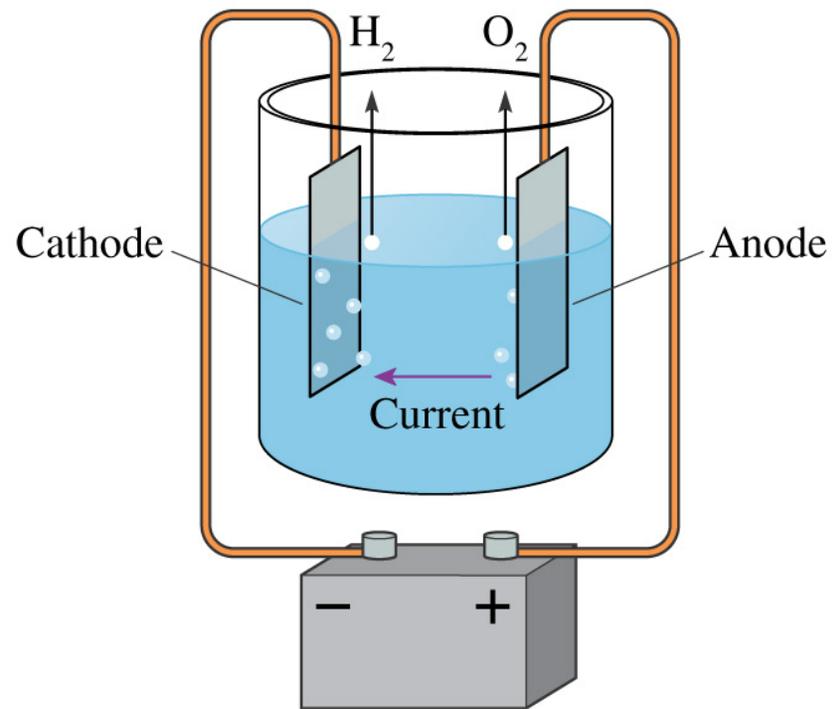


So who is right ?????



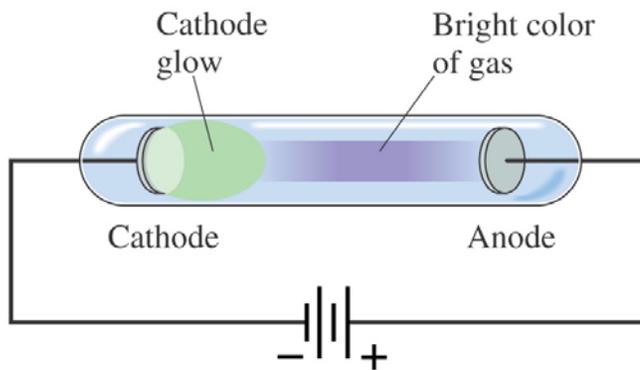
What's electricity?

- Can you take water "apart"
- Hmm
- So what is water?

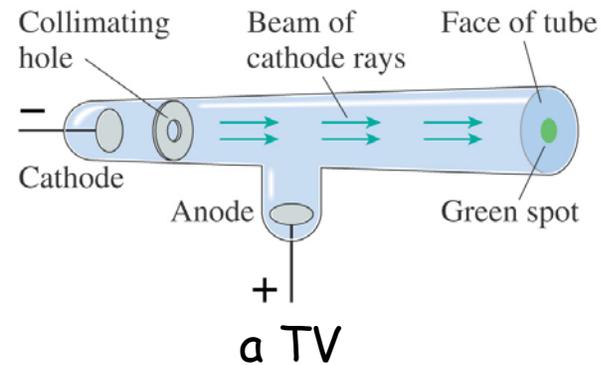


A tube and mr faraday

- Cathode Rays
 - Cathode glows and Gas glows pretty colors
 - pump the gas out and the glass glows

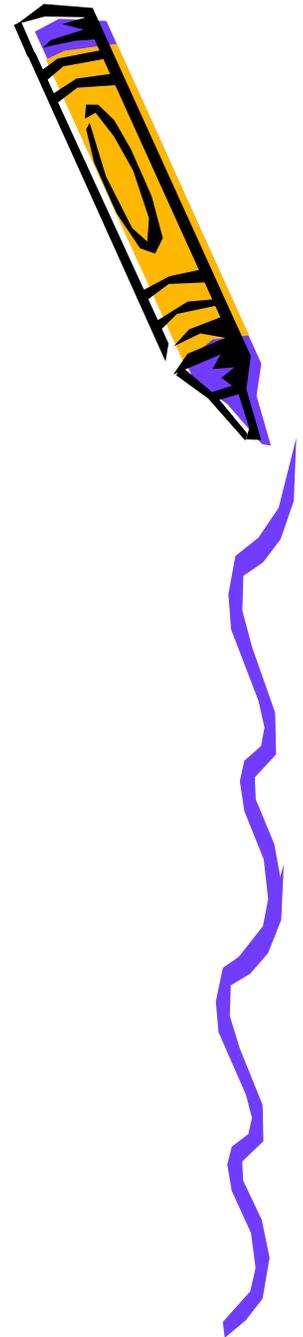


a flourecent light

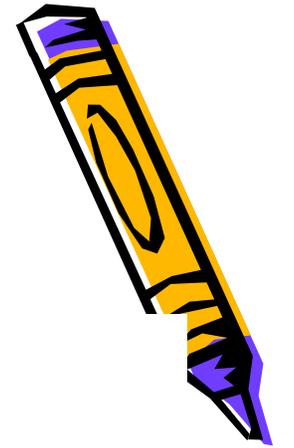


a TV

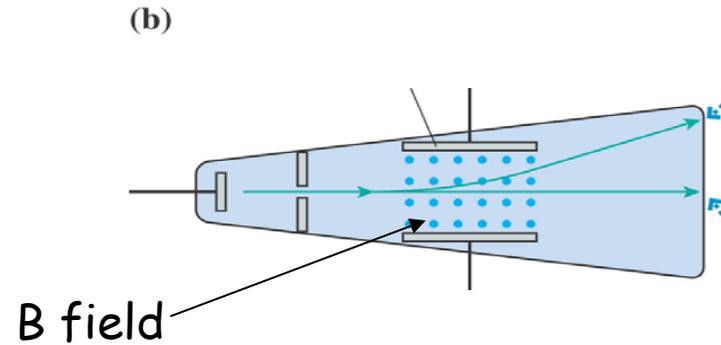
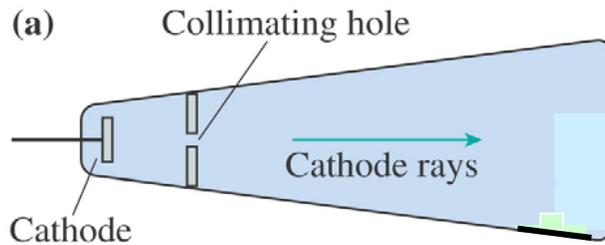
So just what is electricity????



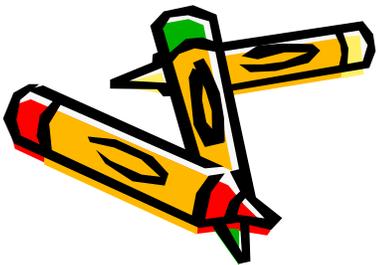
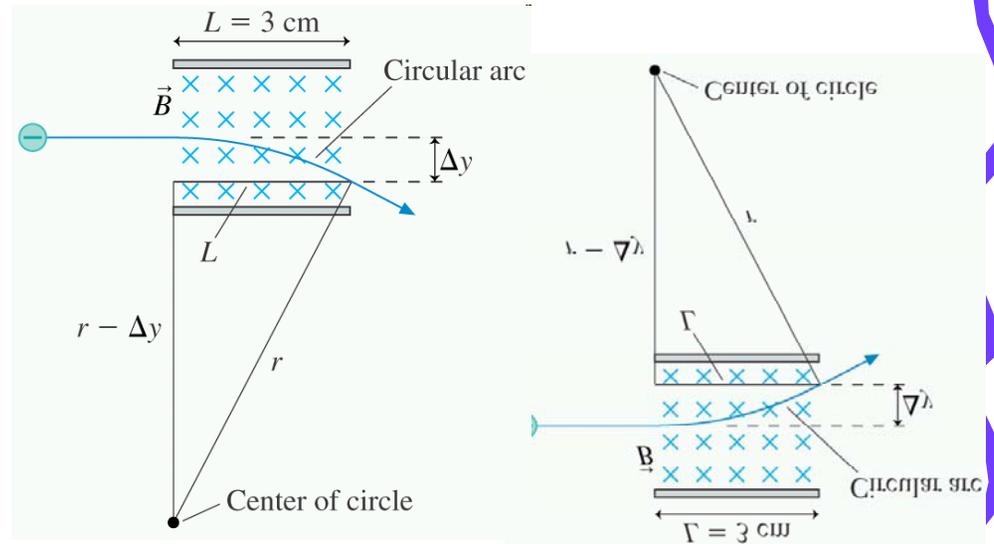
J.J. Thompson a clever and systematic guy



- Step 1

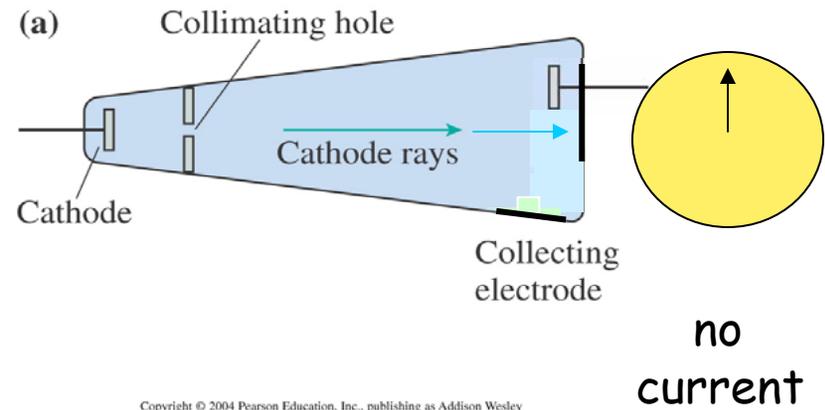
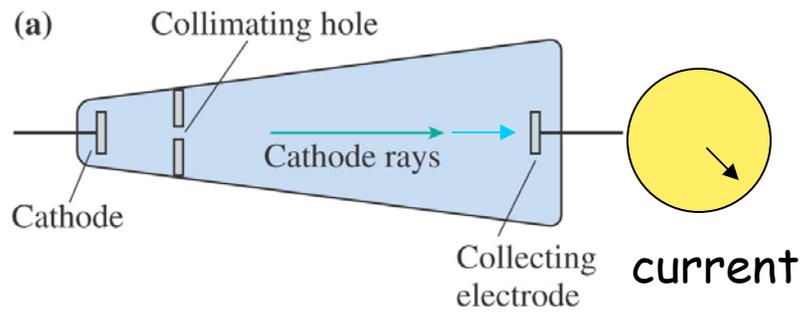


- $F_B = qvB = mv^2/r$
- $q/m = v/rB$

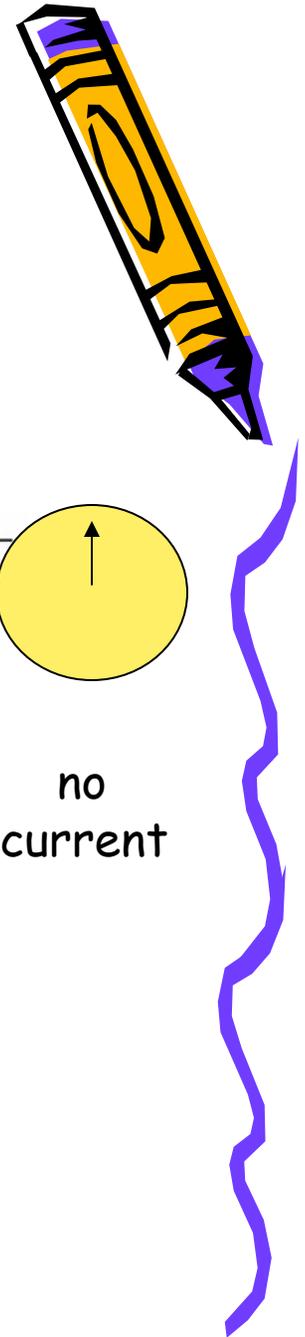
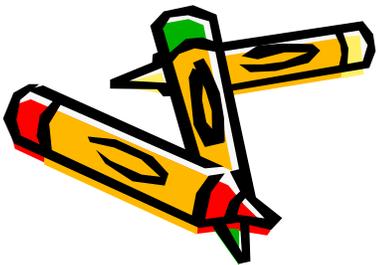
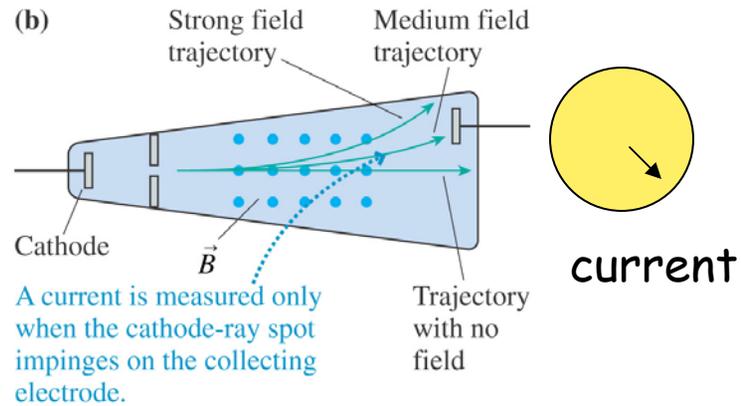


JJ Step 2

- $F_B = qvB$

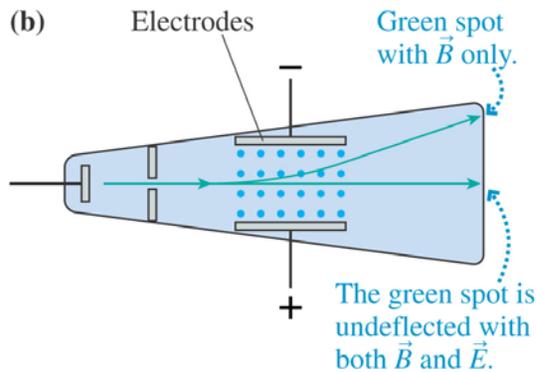


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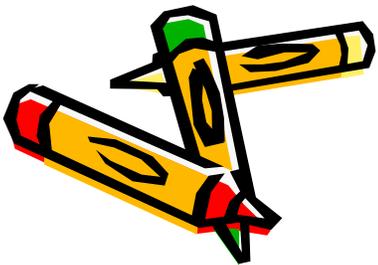
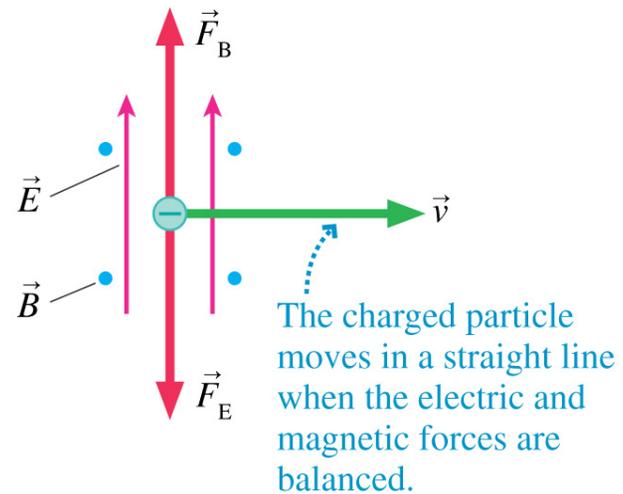
JJ Step 3

- $F_E = qE$
- $F_B = F_E$
- $qvB = qE$



- $v = E/B$
- $q/m = v/rB$ (from before)
- $q/m = E/rB^2$

(c)

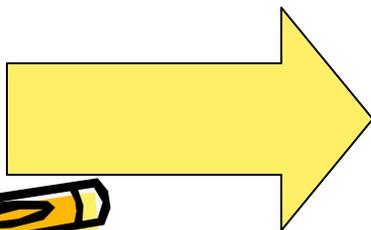
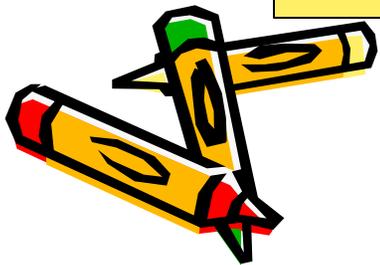


$$q/m = 1.76 \times 10^{11} \text{ C/kg}$$

JJ

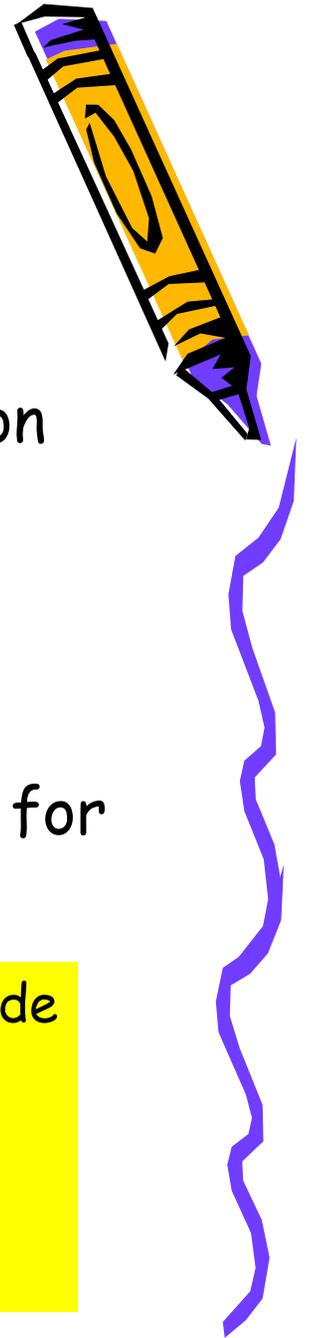
So - what does it mean?

- measure the q/M of other stuff - Hydrogen ion
- Different by a factor of 1000
- So
 - charge for H ion smaller?
 - Mass of Cathode rays smaller?
- Electrolysis - charge came in basic units same for H or Cathode rays

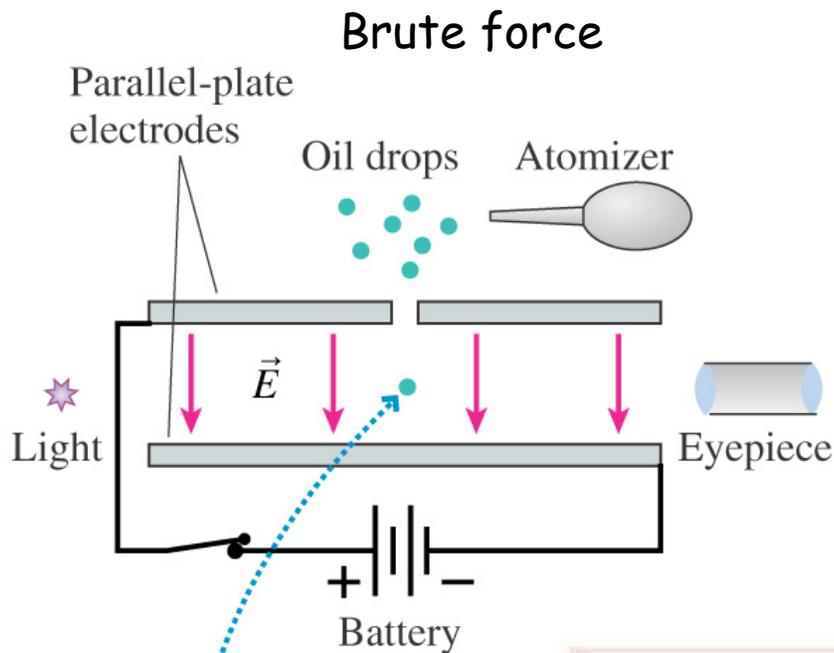
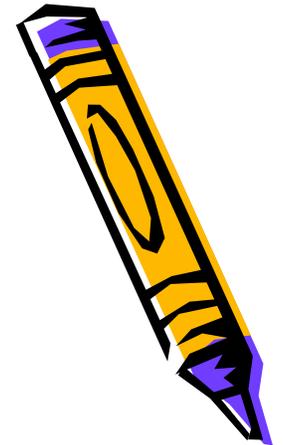


Mr Thompson (1897) said that Cathode rays had a negative charge, and weighed $1/1000$ that of atoms

it's the ELECTRON



Mr. Millikan founder of Caltech Clever - but not so elegant



mass of oil droplet
from terminal velocity

The upward electric force on a negatively charged droplet balances the downward gravitational force.

Millikan's oil-drop experiment measured the fundamental unit of charge:

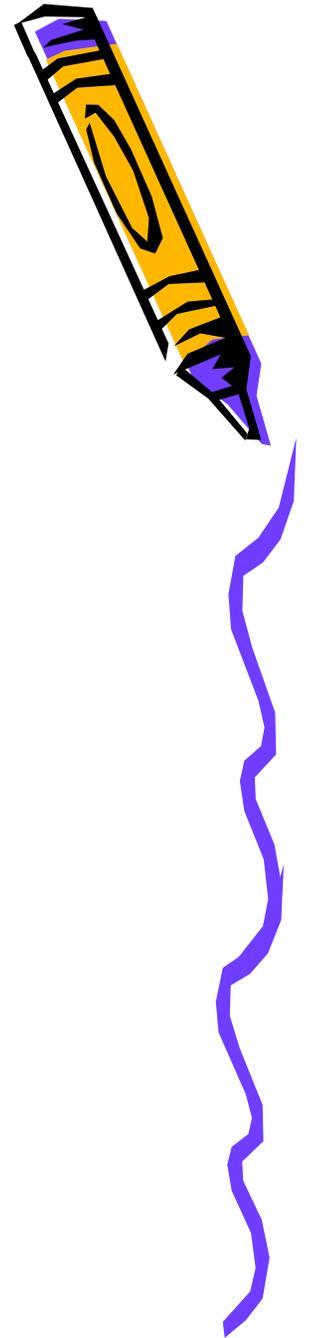
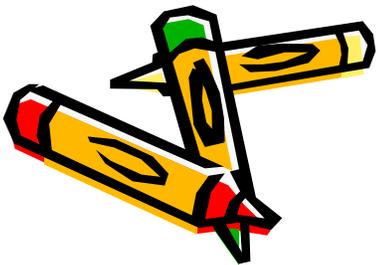
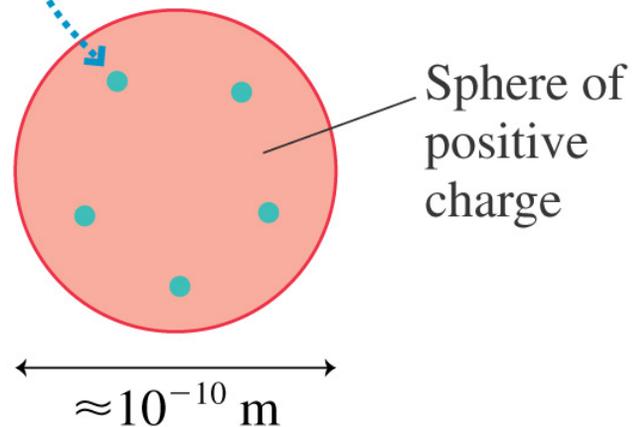
$$e = 1.60 \times 10^{-19} \text{ C}$$



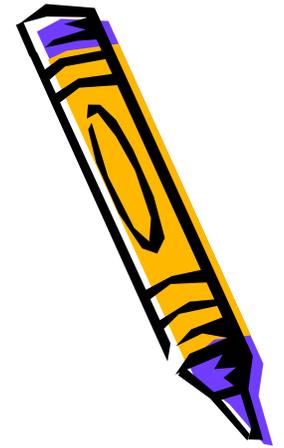
So what's an atom?

- We got "electrons"
- We got atoms which get positively charged

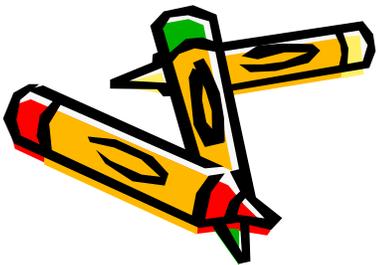
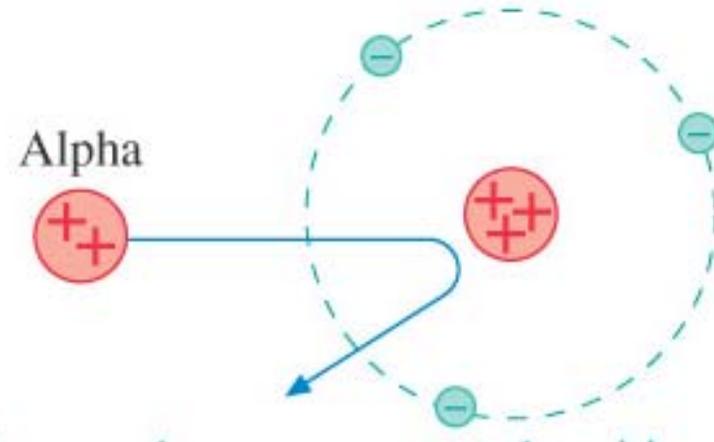
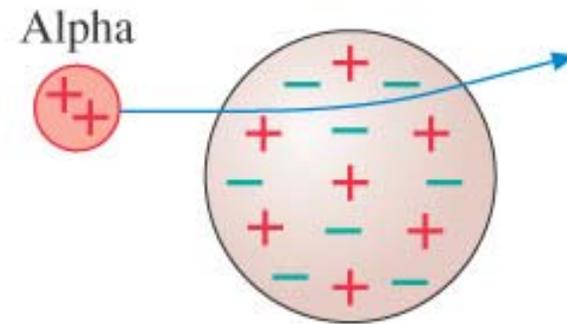
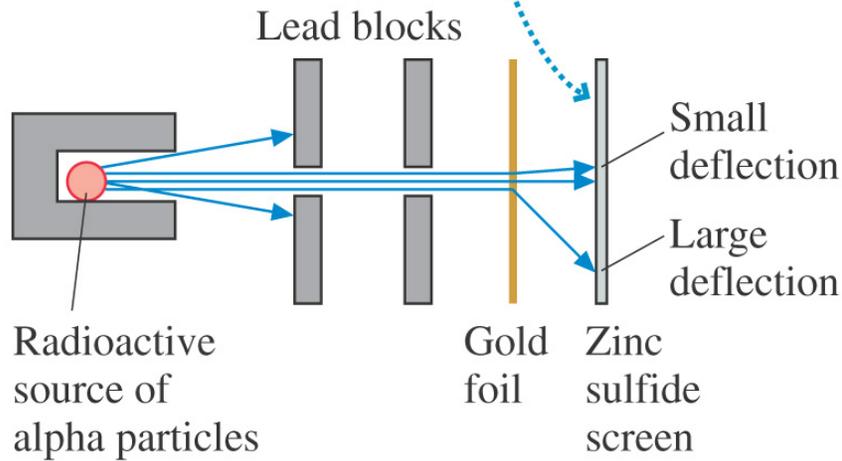
Thomson proposed that small, negative electrons are embedded in a sphere of positive charge.



Enter Rutherford

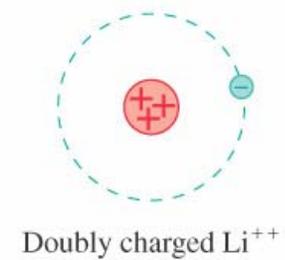
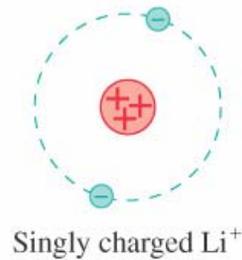
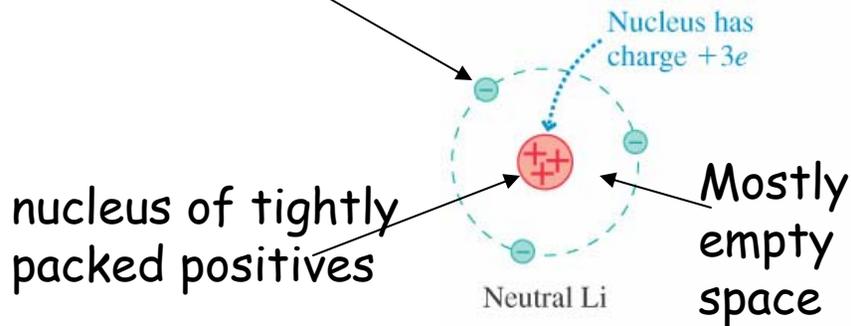


The alpha particles make little flashes of light where they hit the screen.



So what does this explain?

electrons orbiting

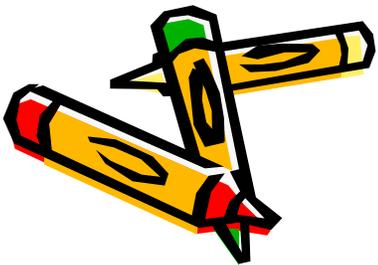
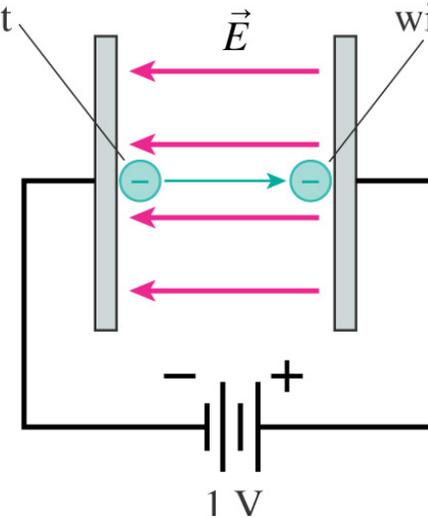


One **electron volt** (1 eV) is the energy an electron or proton (charge $\pm e$) gains by accelerating through a potential difference of 1 V.

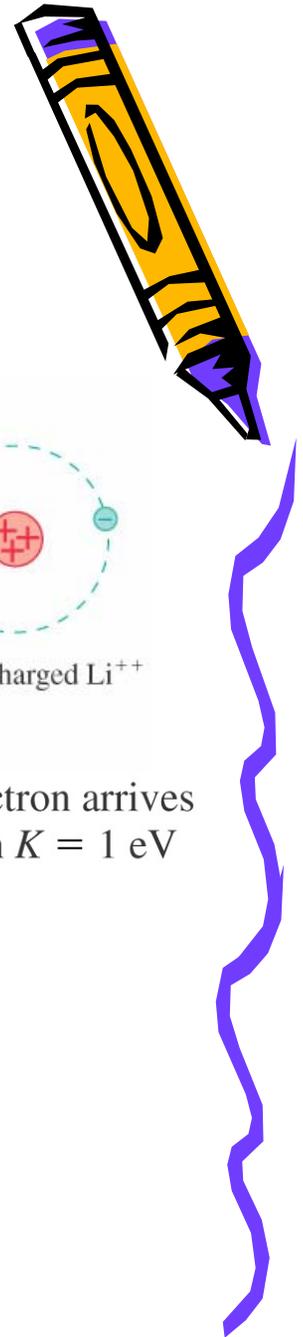
$$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$$

Electron starts from rest

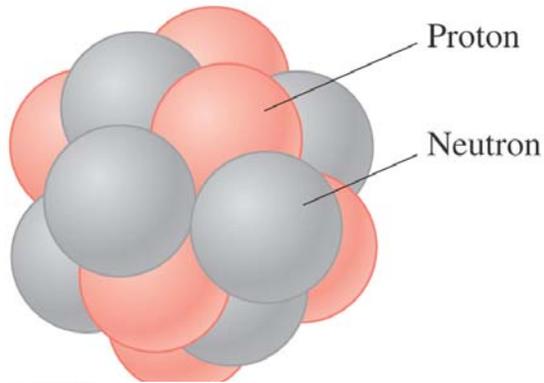
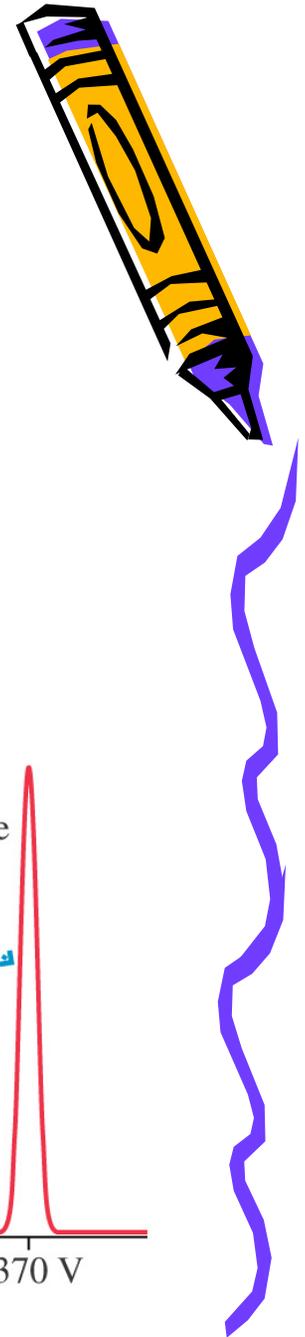
Electron arrives with $K = 1 \text{ eV}$



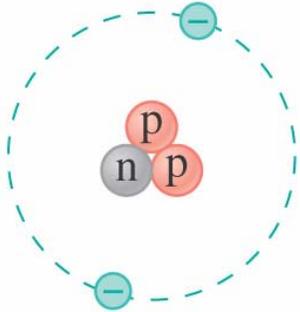
a convenient unit for later



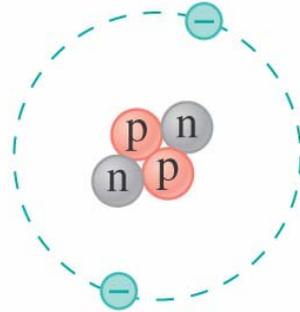
Into the nucleus



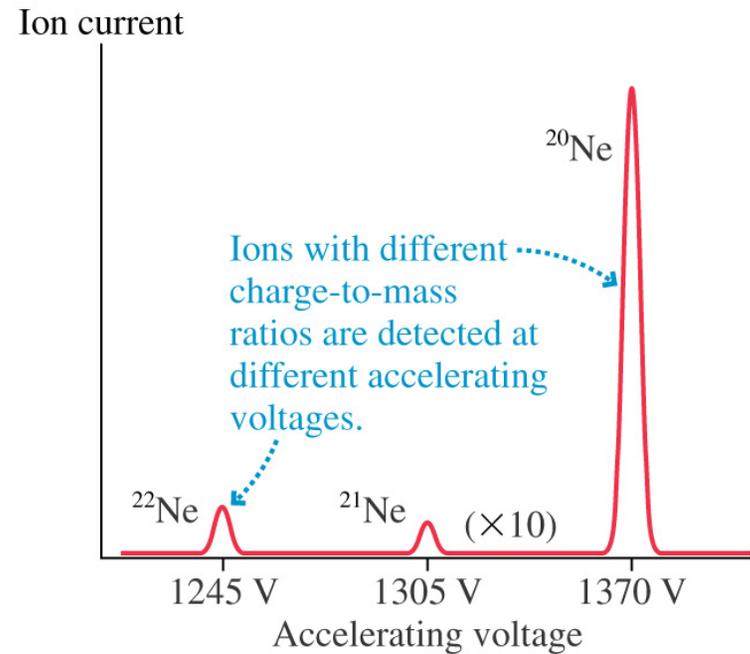
Mass spectrometer
measure q/m for ions
e.g. Neon



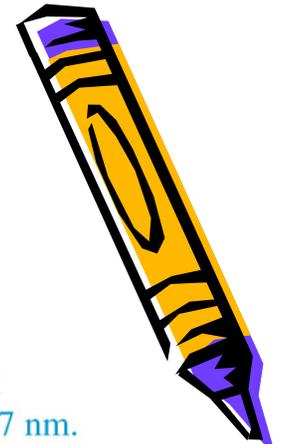
${}^3\text{He}$
 $Z = 2$ $N = 1$
 $A = 3$
0.0001% abundance



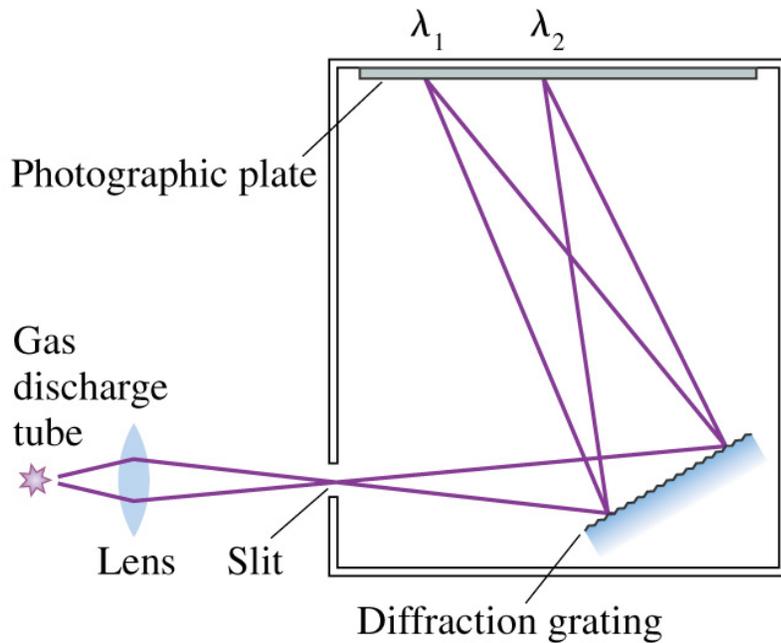
${}^4\text{He}$
 $Z = 2$ $N = 2$
 $A = 4$
99.9999% abundance



Trouble ahead



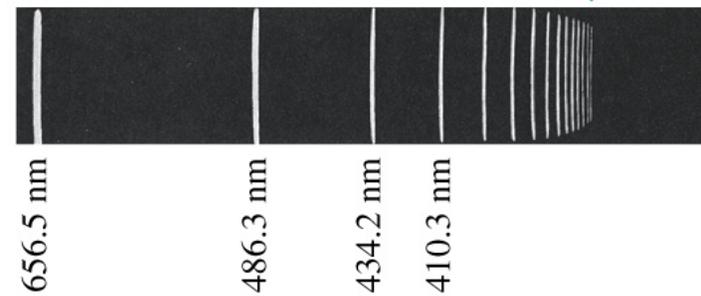
(a) Measuring an emission spectrum



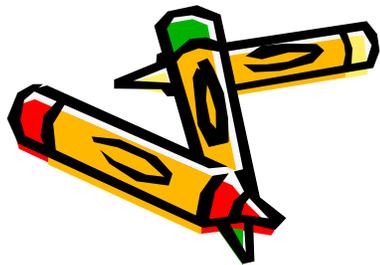
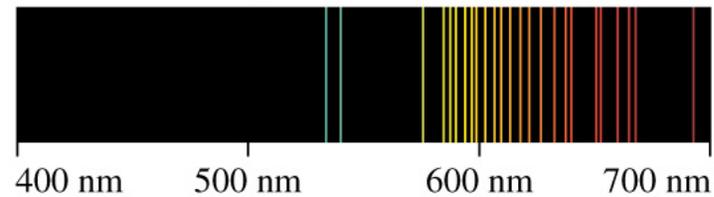
(b)

The spectral lines extend to the series limit at 364.7 nm.

Hydrogen emission spectrum



Neon emission spectrum



Balmer Gussed
m,n integers

$$\lambda \sim \frac{1}{\frac{1}{m^2} - \frac{1}{n^2}}$$

BUT WHY???

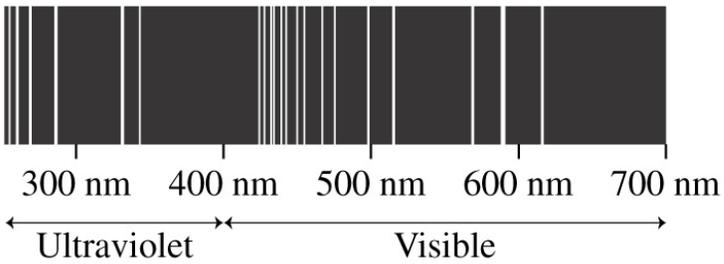


(b) Absorption and emission spectra of sodium

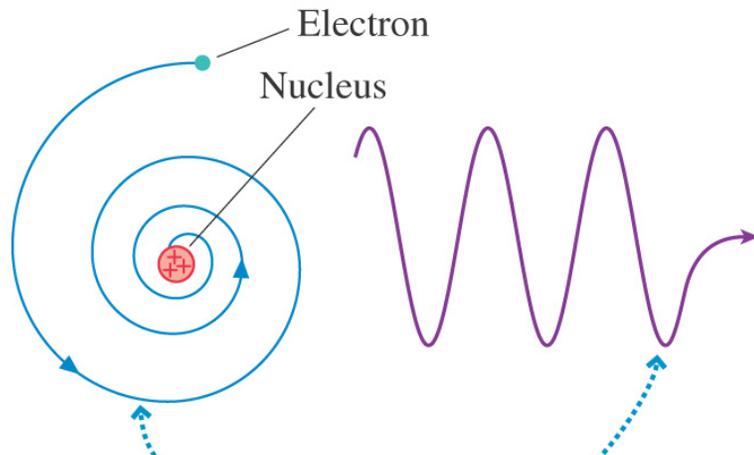
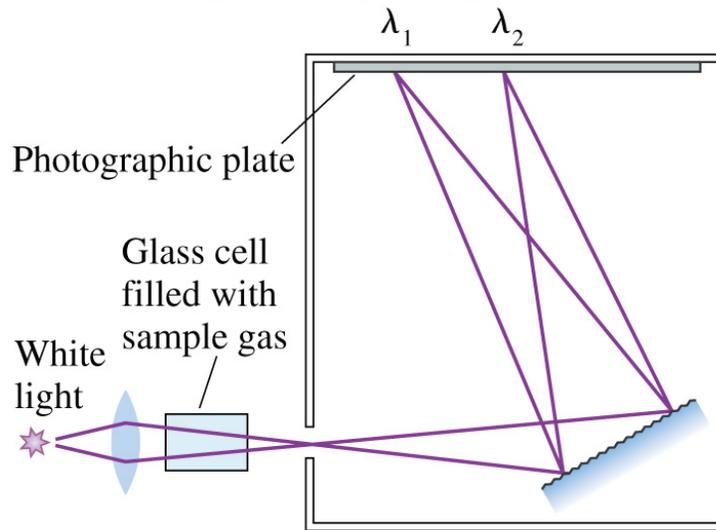
Absorption



Emission



(a) Measuring an absorption spectrum



According to classical physics, an electron would spiral into the nucleus while radiating energy as an electromagnetic wave.

quantum mechanics

