5.2 QUANTUM THEORY AND THE BOHR MODEL OF THE ATOM

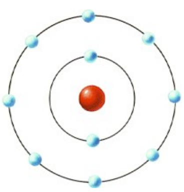
DEMO: FLAME TEST

What colour is produced when the various salts are brought into the flame?

NaCl	$CuCl_2$	$CuSO_4$	$CaCl_2$	KCl

Think: Why do these salts produce flames of different colours?

PROBLEMS WITH RUTHERFORD'S MODEL



Problem #1: e^- and p^+ have opposing charges

- ∴ e^- and p^+ are attracted together, causing them to collide into each other

Problem #2: orbiting e^- are **accelerating** charges

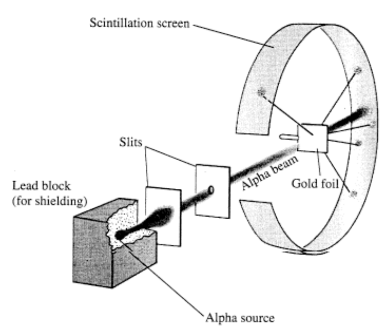
- ∴ e^- when accelerating will lose enr (energy) and collapse towards the nucleus

NIELS BOHR TO THE RESCUE

Niels Bohr believed in the nuclear model of the atom and utilized quantum theory to save it.

QUANTUM THEORY: enr, thought to act as a wave, can also be thought to behave like particles in enr packets **quanta**.

E=h*v* E=energy, ***v***=frequency, **h**=Planck's constant

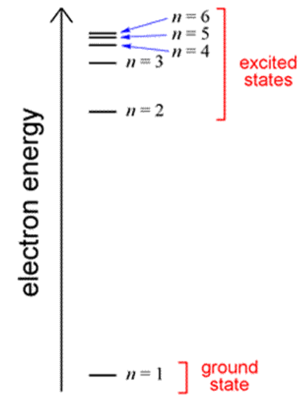


- Enr can only be absorbed or emitted in whole numbers of quanta (1 quantum E=h*v*, 2 quanta E=2h*v*)

WAVES: Disturbances that moved through space; can have any # within a range

PARTICLES: objects with definite boundaries hat bounced off each other during collisions; only whole #

BOHR'S EXPERIMENT



He observed light emitted from hydrogen gas irradiated (exposed to radiation) with enr. This pattern of bright light was called **bright-line spectrum**.

Using this spectrum and his knowledge of quantum theory, he postulated:

1. **1.** E^- in a hydrogen atom occupy specific energy states (**allowed energy levels/ stationary levels**). Each enr state was given a #, *n*: **quantum number**. The lowest enr state, *n*=1, is called the **ground state**. The higher enr states, *n*=1,2,3 etc, is called **excited states**.

Energy level: specific amount of energy which an electron in an atom can possess.

2. **2.** E^- are fixed within the allowed energy levels. ∴ e^- moving in an allowed orbit will not radiate or absorb enr

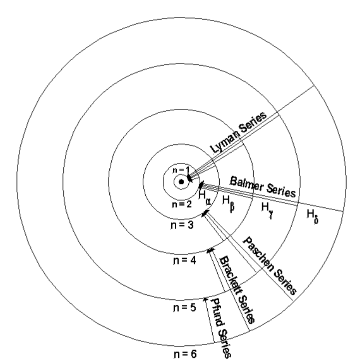
3. **3.** Only when moving from one allowed orbit to the next will the e^- radiate or absorb enr

Using Bohr's Postulations, Rutherford's model was saved.

BRIGHT LIGHT SPECTRUM EXPLAINED

The pattern of lines corresponds with the specific enr level pattern.

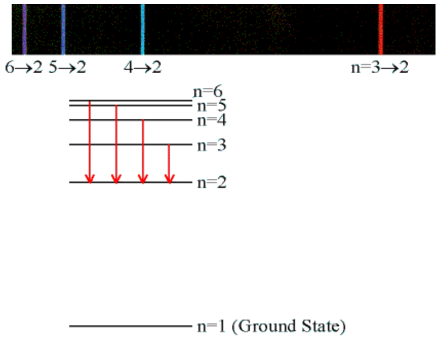
Light seen: e^- in a higher enr level gives off enr and drops to a lower level



In order to see the spectral lines that we saw, there are a series of steps that electrons must go through:

1. The electrons absorb energy (e.g. radiation, electricity).
2. The electrons are excited from the ground state to occupy a higher energy level (an excited state).
3. The electron at a higher energy level is not stable and eventually falls back down to a lower energy state. (*This could be back to ground state or to an excited state above ground state but below where it previously was.)*
4. On relaxing to a lower energy state, energy is released as electromagnetic radiation (Colour).

The electromagnetic radiation released may fall in the visible range (e.g. flame tests, gas discharge lamps) or it may fall outside of the visible range (e.g. ultraviolet radiation, infrared radiation).



PRACTICALITY OF SPECTRUM

In the demonstration, salts containing lithium, sodium, copper, calcium and zinc produced different colours due to that diff elements produce diff emission spectra. Therefore, bright-line emission spectra can be used as a means to identify different elements.

"Spectrum of the Stars" - Video

Another application of emission spectra involves staring off into galaxies far, far away. There are stars all over the universe, and with the help of powerful telescopes and emission spectra, we can learn a lot about those distant stars. As with the previous application, we can determine what the elemental composition of stars are. As stars move toward our galaxy, the lines on the emission spectra decreasing in wavelength. As stars move away from our galaxy, the lines on the emission spectra increasing in wavelength. Astronomers use this information, coupled with the distance from the Earth to that star, to determine the speed with which galaxies are moving in the universe!

BOHR MODEL FLAWS

The Bohr model of the atom predicts very nicely the behaviour of electrons in hydrogen. However, the Bohr model fails at accurately predicting the energy levels on elements with more electrons than hydrogen. Every other element has more e^- than hydrogen, and those e^- begin with different individual enr levels. Thus, the spectrum of other elements have many more spectral emissions, all at different energies.