$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \; ; \; \Delta H = -906 \text{ kJ}$$

What is the enthalpy change when 150. L of nitrogen monoxide are formed by this reaction at 25.0 C and 1.50 atm pressure?

1 - Convert 150.L of NO gas to moles using ideal gas equation
2 - Convert moles NO gas to enthalpy change using thermochemical equation

$PV = nRT$

$n = \frac{PV}{RT}$

$P = 1.50 \text{ atm}$

$V = 150. \text{ L}$

$T = 25.0°C = 298.2 \text{ K}$

$R = 0.08206 \frac{L \cdot atm}{mol \cdot K}$

$n = ? \text{ mol NO}$

① $$n_{NO} = \frac{(1.50 \text{ atm})(150. \text{ L})}{\left(0.08206 \frac{L \cdot atm}{mol \cdot K}\right)(298.2 \text{ K})} = 9.194822048 \text{ mol NO}$$

② $4 \text{ mol NO} = -906 \text{ kJ}$

$$9.194822048 \text{ mol NO} \times \frac{-906 \text{ kJ}}{4 \text{ mol NO}} = \boxed{-2080 \text{ kJ} = \Delta H}$$

Heat of formation / enthalpy of formation!

34.086 g/mol

$$\begin{array}{cccc} -20.50 & 0 & -285.8 & -296.8 \end{array} \quad \Big] \; \Delta H_f^\circ, \text{ kJ/mol}$$

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$$

What is the enthalpy change at standard conditions when 25.0 grams of hydrogen sulfide gas is reacted?

1 - Find the enthaply of the reaction as written. Use Hess's Law and enthalpies of formation.
2 - Convert 25.0 g of hydrogen sulfide to moles using formula weight.
3 - Convert moles hydrogen sulfide to enthalpy change using the thermochemical equation.

---

(1) $\Delta H = \sum \Delta H^\circ_{f,\text{ products}} - \sum \Delta H^\circ_{f,\text{ reactants}}$ | See Appendix C, p A-8

$$= [2(-285.8) + 2(-296.8)] - [2(-20.50) + 3(0)] = -1124.2 \text{ kJ}$$

... for the reaction as written above!

Thermochemical equation:

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g); \Delta H = -1124.2 \text{ kJ}$$

34.086 g H_2S = mol H_2S | 2 mol H_2S = −1124.2 kJ

$$25.0 \text{ g } H_2S \times \frac{\text{mol } H_2S}{34.086 \text{ g } H_2S} \times \frac{-1124.2 \text{ kJ}}{2 \text{ mol } H_2S} = \boxed{-412 \text{ kJ}}$$

propane ↓

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g) \; ; \Delta H = -2043 \text{ kJ}$$

Calculate the volume of propane gas at 25.0 C and 1.08 atm required to provide 565 kJ of heat using the reaction above.

1 - Convert the 565 kJ energy requirement to moles propane using the thermochemical equation

2 - Convert moles propane to volume using ideal gas equation

---

① $\text{mol } C_3H_8 = -2043 \text{ kJ}$

* the sign of the energy requirement is negative, since the propane being reacted will LOSE this amount of energy (exothermic process)

$$\overset{*}{-}565 \text{ kJ} \times \frac{\text{mol } C_3H_8}{-2043 \text{ kJ}} = 0.2765540871 \text{ mol } C_3H_8$$

$PV = nRT$

$V = \dfrac{nRT}{P}$

$n = 0.2765540871 \text{ mol } C_3H_8$ $\quad R = 0.08206 \dfrac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$

$T = 25.0°C = 298.2 \text{ K}$ $\quad P = 1.08 \text{ atm}$

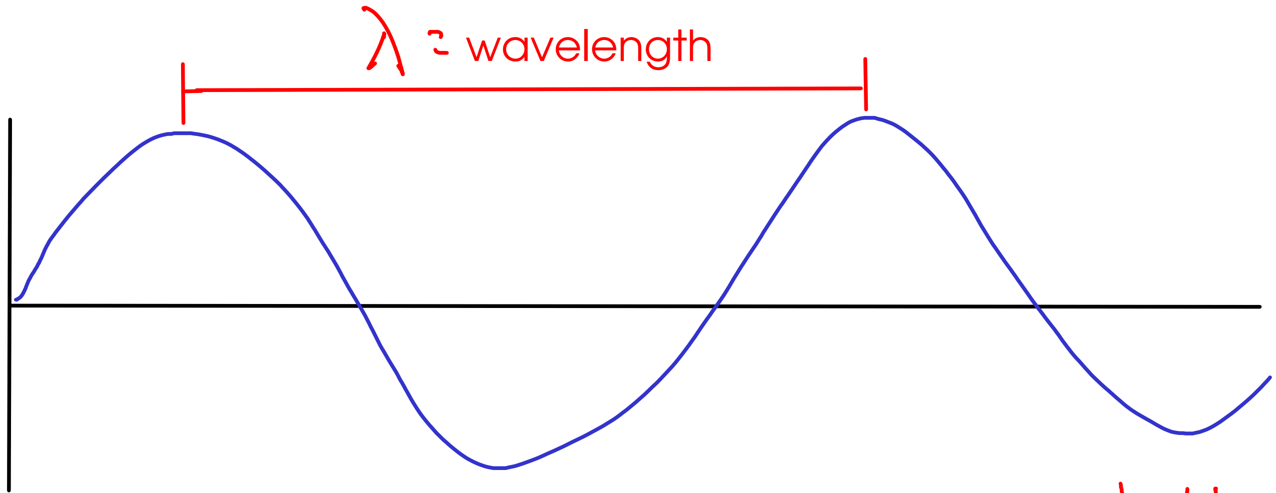
$V = ? \text{ L}$

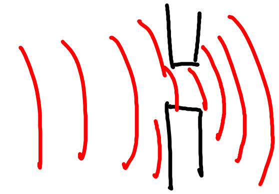
$$V = \frac{(0.2765540871 \text{ mol } C_3H_8)\left(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}\right)(298.2 \text{ K})}{(1.08 \text{ atm})}$$

$= \boxed{6.27 \text{ L } C_3H_8 \text{ needed}}$ @ 25.0°C, 1.08 atm

END OF CHAPTER 6

LIGHT





Diffraction

frequency = wavelengths / time = ν s^{-1} : Hertz, Hz

- Light has properties of WAVES such as DIFFRACTION (it bends around small obstructions).

- Einstein noted that viewing light as a particle that carried an energy proportional to the FREQUENCY could explain the PHOTOELECTRIC EFFECT!

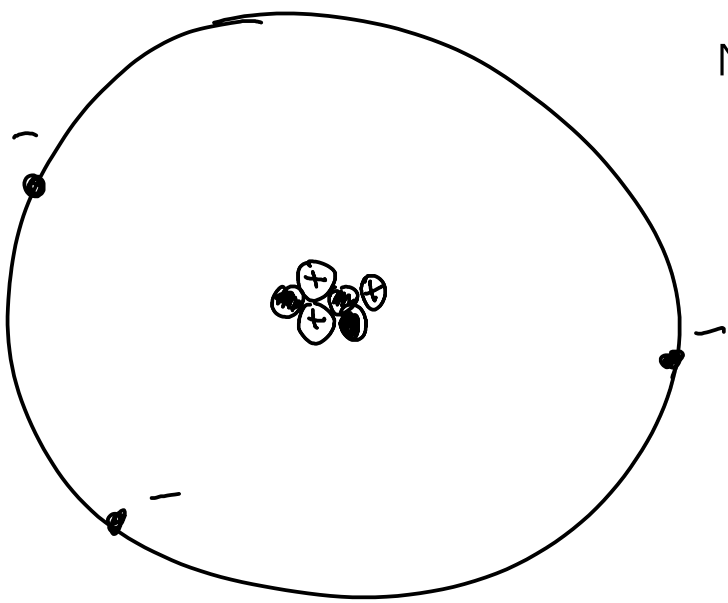
$$E_{photon} = h\nu$$

h: Planck's constant: 6.63×10^{-34} J·s

E_{photon}: photon = particle or packet of light

(The photoelectric effect is the emission of electrons from a metal caused by exposure to light. Einstein discovered that if the light were not of the correct FREQUENCY, increasing the INTENSITY of the light would not cause electron emission. He concluded that individual photons must have enough energy to excite an electron - i.e. they must have the appropriate frequency.)

The photoelectric effect and Einstein's ideas about the energy content of light led us to discover a new model for the atom! How? Let's start with the nuclear model:



Nuclear model:

- Protons and neutrons in a dense NUCLEUS at center of atom
- Electrons in a diffuse (mostly empty) ELECTRON CLOUD surrounding NUCLEUS.

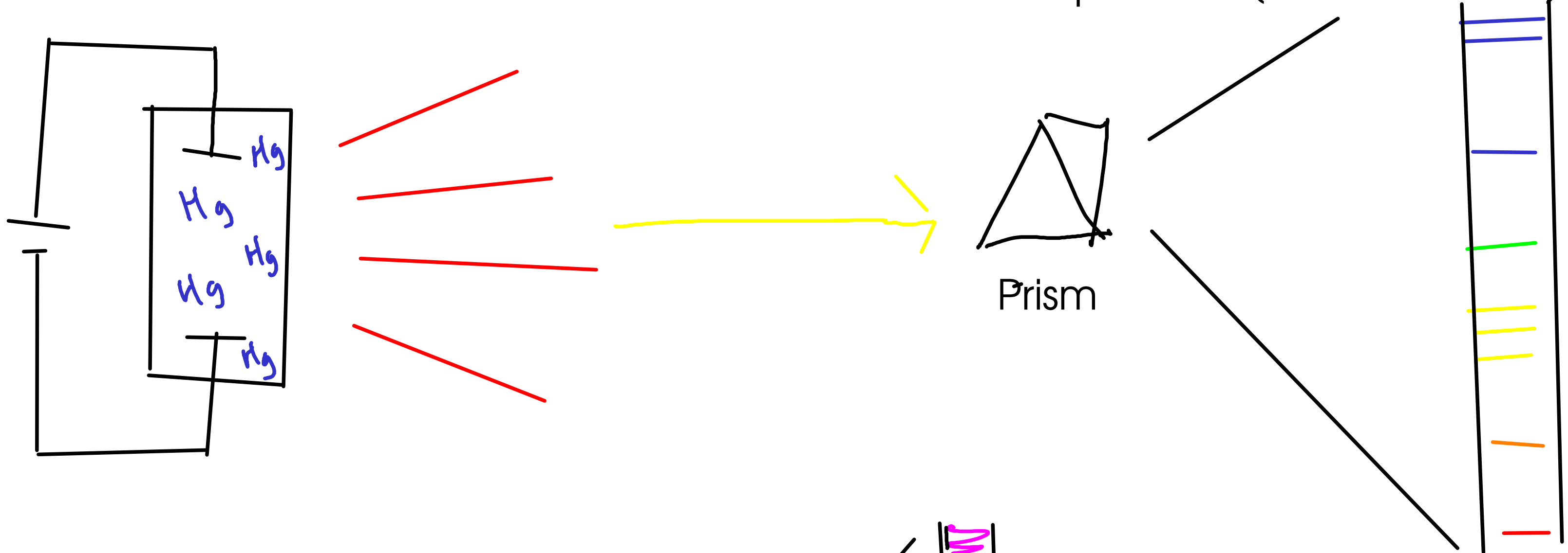
... so what's wrong with the nuclear model? Among other things, it doesn't explain ...

ATOMIC LINE SPECTRA

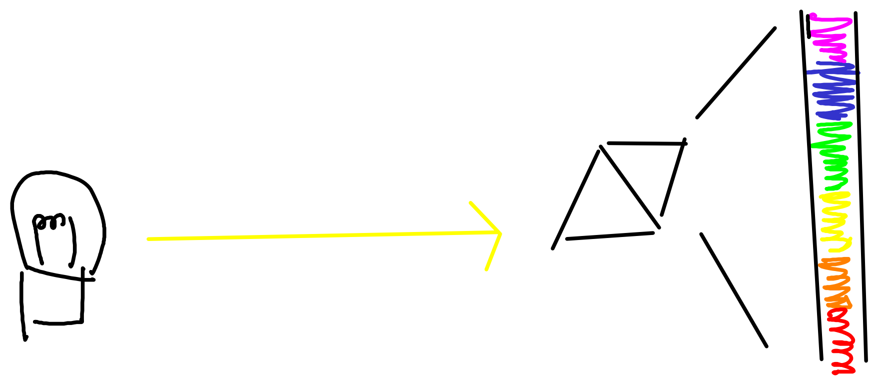
- if you take element and ATOMIZE it, if excited by energy it will emit light at unique frequencies. The set of emitted frequencies is called an ATOMIC LINE SPECTRUM.

- Atomized elements will also ABSORB these same frequencies (but not others)!

p265



Atomic line spectrum Unique to each element.

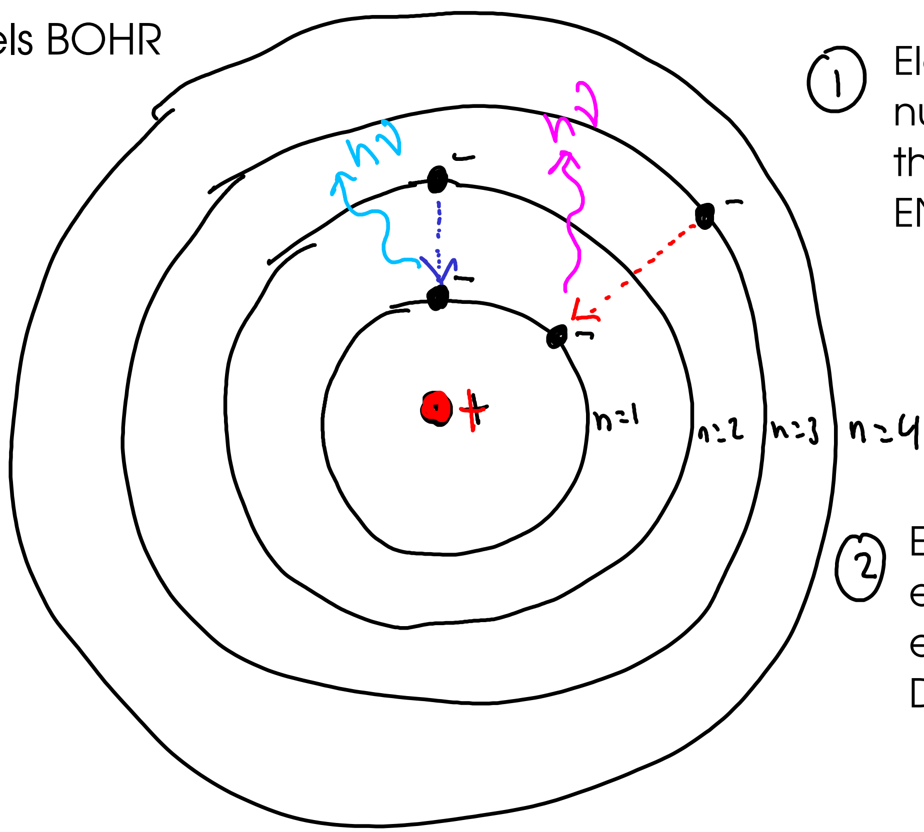


Continuous spectrum (from white light)

... so, why don't atoms by themselves emit continuous spectra like a flashlight would?

- The regular patterns of emission and absorption of light by atoms suggest that the electron cloud has some sort of regular structure. The specific frequencies of light emitted and abosrbed relate to specific values of ENERGY in the electron cloud.

Niels BOHR



1. Electrons can't be just ANYWHERE around a nucleus. They can exist only at certain distances from the nucleus. These distances correpsond to certain ENERGIES and are called ENERGY LEVELS!

2. Electrons CAN move (transition) between different energy levels by gaining or losing exactly enough energy to get into the new energy level. This was a DIRECT transition .

Bohr's model was the first proposal that predicted the existence of atomic line spectra, and it exactly predicted the spectra of hydrogen and "hydrogen-like" (i.e. one-electron) species.

The spectra were "off" for multi-electron atoms.