Example problems:

FORMULA WEIGHTS in g/mol in purple

$$\underset{2.016}{2H_2(g)} + \underset{32.00}{O_2(g)} \longrightarrow \underset{18.02}{2H_2O(g)} \; ; \; \Delta H = -484 \text{ kJ}$$

Calculate the enthalpy change for the combustion of 1.00 kg of hydrogen gas.

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1 - Convert 1.00 kg hydrogen gas to moles. Use FORMULA WEIGHT.

2 - Convert moles hydrogen gas to enthalpy change. Use THERMOCHEMICAL EQUATION

(1) $2.016 \text{ g } H_2 = \text{mol } H_2$, $\text{kg} = 10^3 \text{ g}$

(2) $2 \text{ mol } H_2 = -484 \text{ kJ}$

$$1.00 \text{ kg } H_2 \times \underbrace{\frac{10^3 \text{ g}}{\text{kg}} \times \frac{\text{mol } H_2}{2.016 \text{ g } H_2}}_{(1)} \times \underbrace{\frac{-484 \text{ kJ}}{2 \text{ mol } H_2}}_{(2)} = \boxed{-12\bar{0}000 \text{ kJ per kg } H_2}$$

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

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 volume of NO to moles. Use IDEAL GAS EQUATION.
2 - Convert moles NO to enthalpy change. Use THERMOCHEMICAL EQUATION

① $PV = nRT$ $n = \frac{PV}{RT}$

$P = 1.50\ atm$ $V = 150.\ L$

$R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$ $T = 25.0°C = 298.2\ K$

① $$n_{NO} = \frac{(1.50\ atm)(150.\ L)}{\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(298.2\ K)} = 9.19482849\ mol\ NO$$

② $4\ mol\ NO = -906\ kJ$

$$9.19482849\ mol\ NO \times \frac{-906\ kJ}{4\ mol\ NO} = \boxed{-2080\ kJ}$$

Heat of formation / enthalpy of formation!

34.086g/mol

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

ΔH_f°, kJ/mol (Appendix C): $H_2S(g)$ −20.50; $O_2(g)$ 0; $H_2O(l)$ −285.8; $SO_2(g)$ −296.8

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

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1 - Find the enthalpy change for the reaction as written using Hess' Law.
2 - Convert 25.0 grams hydrogen sulfide to moles. Use FORMULA WEIGHT.
3 - Convert moles hydrogen sulfide to enthalpy change. Use THERMOCHEMICAL EQUATION.

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① $\Delta H = \sum \Delta H_{f,\text{products}} - \sum \Delta H_{f,\text{reactants}}$

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

Add the enthalpy term to the chemical equation to get the THERMOCHEMICAL equation:

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

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② $34.086\text{ g } H_2S = \text{mol } H_2S$ ③ $2\text{ mol } H_2S = -1124.2 \text{ kJ}$

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

② ③

propane

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$; $\Delta H = -2043$ 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 energy requirement to moles PROPANE. Use THERMOCHEMICAL EQUATION.
2 - Convert moles propane to volume. Use IDEAL GAS EQUATION.

(1) $mol\ C_3H_8 = -2043\ kJ$

Since the reaction is the SYSTEM here, the energy requirement has a NEGATIVE sign (as the reaction will LOSE energy to provide the heat!)

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

(2) $PV = nRT$

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

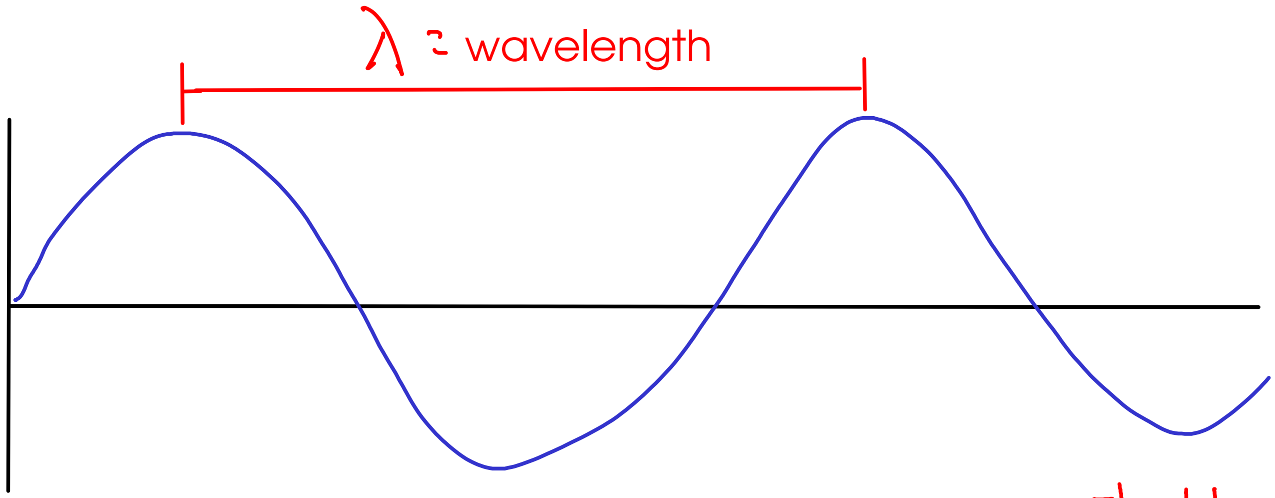
$P = 1.08$ atm; $n = 0.2765540871\ mol\ C_3H_8$

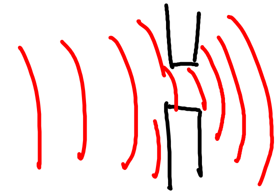
$R = 0.08206\ \frac{L\text{-}atm}{mol\text{-}K}$; $T = 25.0°C = 298.2\ K$

$$V = \frac{(0.2765540871\ mol\ C_3H_8)(0.08206\ \frac{L\text{-}atm}{mol\text{-}K})(298.2\ K)}{(1.08\ atm)} = 6.27\ L\ C_3H_8$$

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!

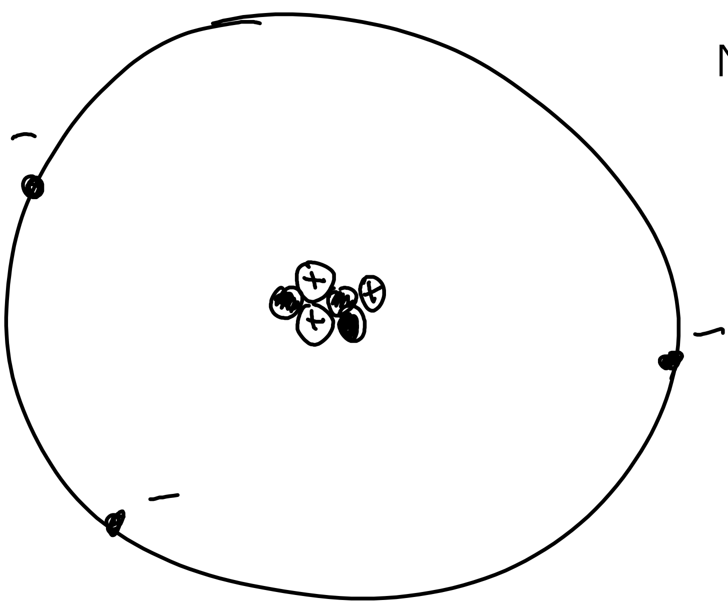
$$E_{photon} = h\nu$$

Planck's constant: 6.63×10^{-34} J·s

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:

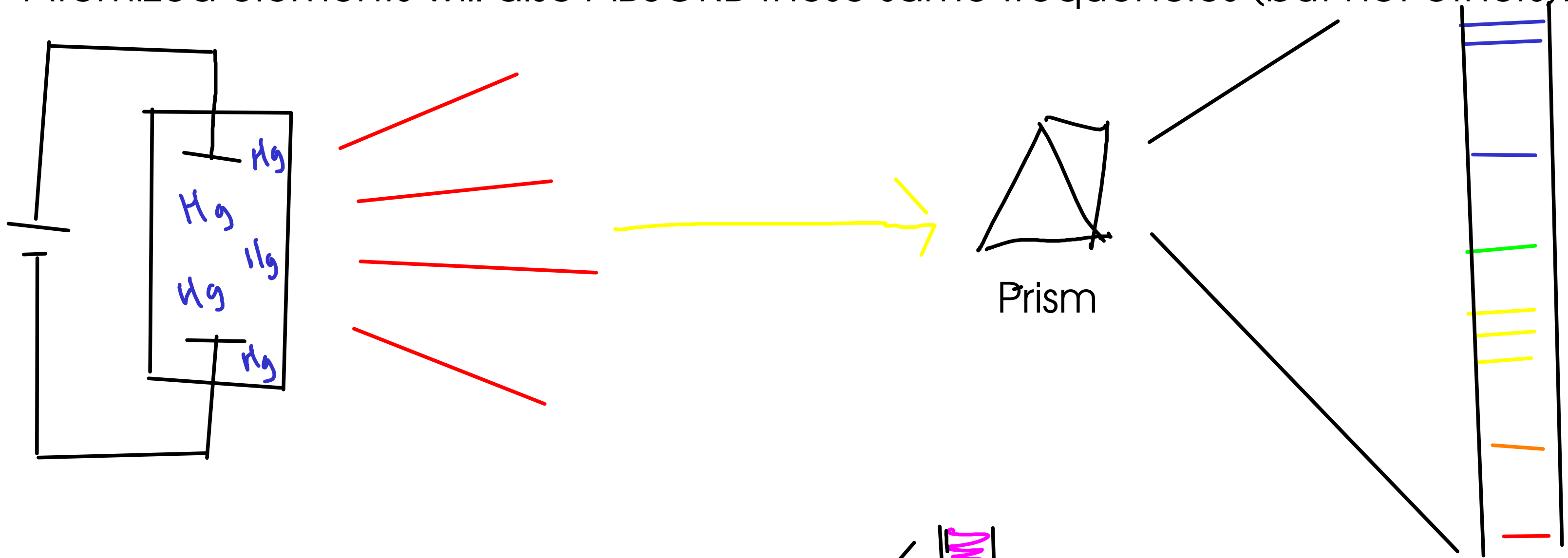
- Protons and neutrons in a dense NUCLEUS at center of atom
- Electrons in a diffuse (mostly empty) ELECTRON CLOUD surrounding NUCLEUS.

... 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.

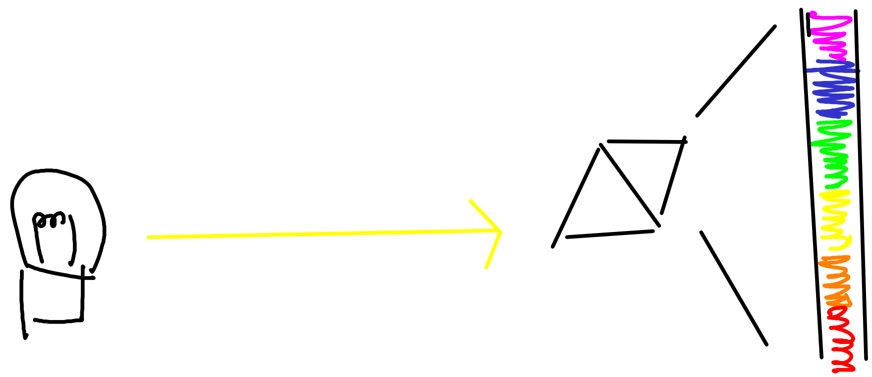
- Atomized elements will also ABSORB these same frequencies (but not others)!



p265 (9th)

p269 (10th)

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?