FW: 46.026   32.00   44.01   18.02

$$2HCHO_2(l) + O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l)$$

If 50.3 kJ of heat was released when 5.48 g of formic acid are burned at constant pressure, then what is the enthalpy change of this reaction per mole of formic acid?

$Q = -50.3\ kJ$; $\Delta H = \dfrac{Q_{\text{constant pressure}}}{mol\ HCHO_2}$

Find moles formic acid:

$$5.48\,g\ HCHO_2 \times \frac{mol\ HCHO_2}{46.026\,g\ HCHO_2} = 0.11906\ mol\ HCHO_2$$

$$\Delta H = \frac{-50.3\,kJ}{0.11906\ mol\ HCHO_2} = \boxed{-422\ kJ/mol\ HCHO_2}$$

Based on the calculation above, can we complete this thermochemical equation?

$$2HCHO_2(l) + O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l);\ \Delta H = \underline{-844}\ kJ$$

We calculated the enthalpy change PER MOLE of formic acid (as is common in calorimetry experiments). But, this equation is based on TWO MOLES of formic acid, so we need to double the enthalpy change.

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

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

$PV = nRT$ | $P = 1.50\ atm$ $\quad T = 25.0°C = 298.2\ K$

$n = \frac{PV}{RT}$ | $V = 150.\ L$

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

$$① \ n_{NO} = \frac{(1.50\ atm)(150.\ L)}{\left(0.08206 \frac{L \cdot atm}{mol \cdot K}\right)(298.2\ K)} = 9.194822849\ mol\ NO$$

$4\ mol\ NO = -906\ kJ$

$$② \ 9.194822849\ mol\ NO \times \frac{-906\ kJ}{4\ mol\ NO} = \boxed{-2080\ kJ}$$

34.086g/mol

Heat of formation / enthalpy of formation!

$$\begin{array}{ccccccc} -20.50 & & 0 & & -285.8 & & -296.8 \\ 2H_2S(g) & + & 3O_2(g) & \longrightarrow & 2H_2O(l) & + & 2SO_2(g) \end{array} \quad \Big] \Delta H_f^\circ, \text{ kJ/mol}$$

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

1 - Find the enthalpy change for the reaction as written using Hess's Law. See Appendix C for enthalpy of formation data

2 - Convert 25.0 grams of hydrogen sulfide to moles using formula weight.

3 - Convert moles hydrogen sulfide to enthalpy change using thermochemical equation.

---

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

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

Thermochemical equation:

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

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

$$25.0 \text{ g } H_2S \times \underbrace{\frac{\text{mol } H_2S}{34.086 \text{ g } H_2S}}_{2} \times \underbrace{\frac{-1124.2 \text{ kJ}}{2 \text{ mol } H_2S}}_{3} = \boxed{-412 \text{ kJ}}$$

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 the energy requirement to MOLES PROPANE using thermochemical equation
2 - Convert moles propane to volume using ideal gas equation

$$mol\ C_3H_8 = -2043\ kJ$$

(1) $$-565\ kJ \times \frac{mol\ C_3H_8}{-2043\ kJ} = 0.276554087\ mol\ C_3H_8$$

$$PV = nRT$$

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

$n = 0.276554087\ mol\ C_3H_8$ $\quad P = 1.08\ atm$

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

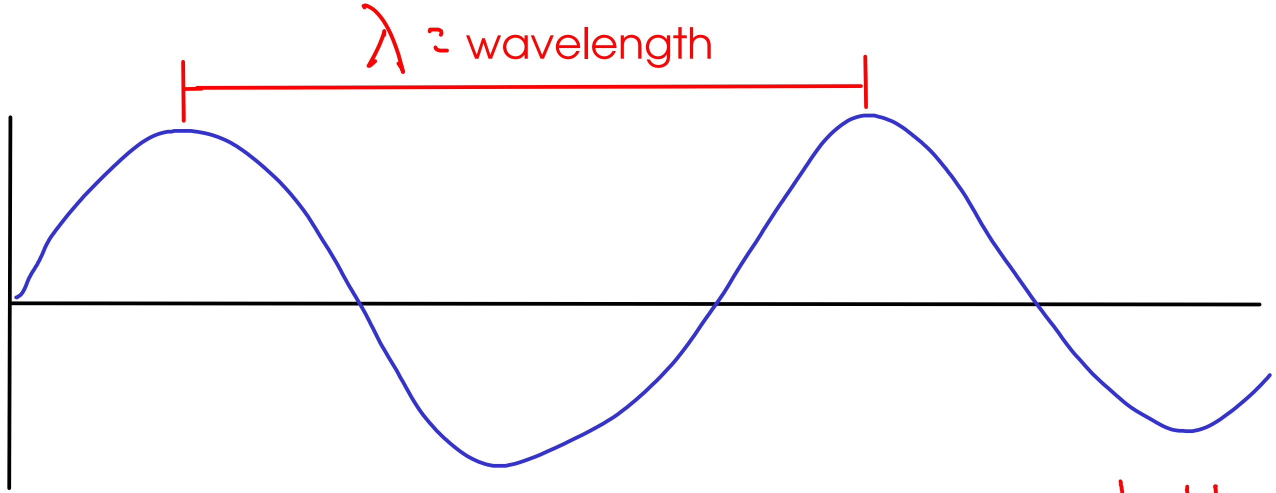
$T = 25.0°C = 298.2\ K$

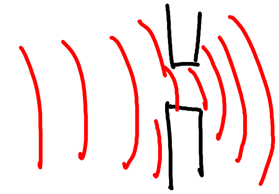
$$V = \frac{(0.276554087\ mol\ C_3H_8)(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298.2\ K)}{(1.08\ atm)} =$$

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

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!

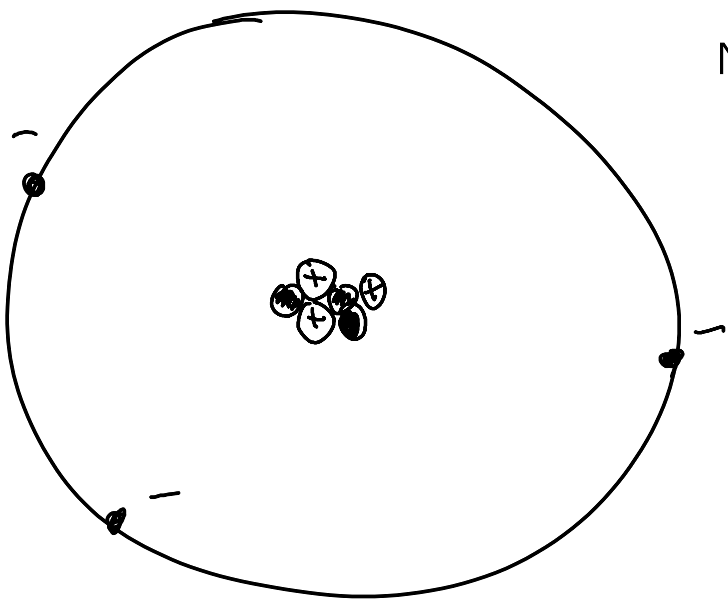
$$E_{photon} = h\nu$$

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)!

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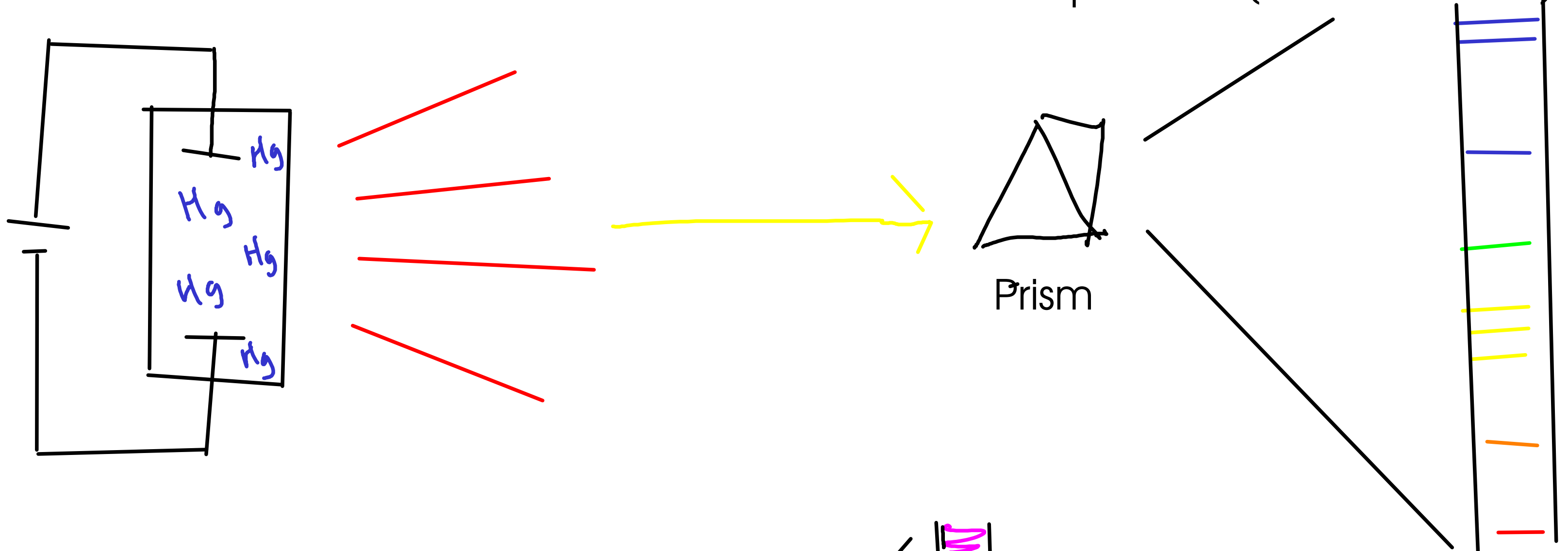
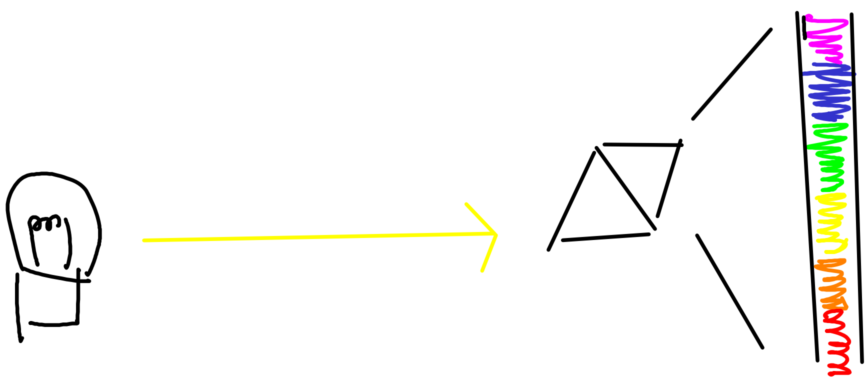


Atomic line spectrum
Unique to each element.



Continuous spectrum (from white light)

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