Chem 111

Lecture 17

Announcements

- Exam 1 grades are up.
- Exam 2 in two weeks.

Homework

- Start Reading Chapter 6
- OWL online homework

Recap

- Enthalpy
- Enthalpy of reactions
- Hess's Law

Let's Practice

Calculate ΔH for the reaction

C(graphite) → C (diamonds)

Using:

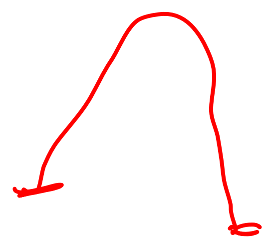
C(graphite) + $O_2(g)$ → $CO_2(g)$ ΔH =-393.5kJ

C(diamond) + $O_2(g)$ → $CO_2(g)$ ΔH =-395.4kJ

C(graphite) + $\cancel{O_2(g)}$ → $\cancel{CO_2(g)}$ ΔH = -393.5kJ

$\cancel{CO_2(g)}$ → C(diamond) + $\cancel{O_2(g)}$ ΔH = 395.4kJ

C(graphite) → C(diamond) ΔH = 1.9kJ



Enthalpies of Formation

Great number of enthalpies of reactions of been tabulated.

Enthalpy of Formation: sometime called the heat of formation, ΔH_f, is the enthalpy it takes to form a substances from its elements.

Standard Enthalpy ΔH^o: enthalpy change when all reactants and products are in their standard state (pure form at 1 atm and 298 K)

$$2C(\text{graphite}) + 3H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow C_2H_5OH(l) \qquad \Delta H^o_f = -277.7\text{kJ}$$

0 $\quad O_2(g) \rightarrow O_2(g) \qquad \Delta H^o = 0$ kJ

Enthalpies of Formation

$\Delta H_{rxn}^{o} = \Sigma \Delta H_f^{o}(\text{products}) - \Sigma \Delta H_f^{o}(\text{reactants})$

	ΔH^{o}_{f} kJ / mol
$C_3H_8(g)$	-103.85
$CO_2(g)$	-393.5
$H_2O(l)$	-285.5

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$

3C + 4H₂ → C₃H₈

$C_3H_8(g) \rightarrow 3C(s) + 4H_2(g)$ $\quad - \Delta H^{o}_{f}[C_3H_8(g)]$

$3C(s) + 3O_2(g) \rightarrow 3CO_2(g)$ $\quad 3\,\Delta H^{o}_{f}[CO_2(g)]$

$4H_2(g) + 2O_2(g) \rightarrow 4H_2O(l)$ $\quad 4\,\Delta H^{o}_{f}[H_2O(l)]$

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$

$\Delta H_{rxn}^{o} = 3\,\Delta H^{o}_{f}[CO_2(g)] + 4\,\Delta H^{o}_{f}[H_2O(l)] - \Delta H^{o}_{f}[C_3H_8(g)]$

$\Delta H_{rxn}^{o} = -2220\text{ kJ}$

A + B → C 100

C → A + B −100

Let's Practice

$\Delta H_{rxn}^o = \Sigma\Delta H_f^o(\text{products}) - \Sigma\Delta H_f^o(\text{reactants})$

Calculate the standard enthalpy change for the combustion of 1 mol of benzene, $C_6H_6(l)$

	ΔH^o_f kJ / mol
$C_3H_8(g)$	-103.85
$CO_2(g)$	-393.5
$H_2O(l)$	-285.5
$C_6H_6(l)$	49.04

$$\underset{2}{C_6H_6(l)} + \underset{15}{\tfrac{15}{2}O_2(g)} \rightarrow \underset{12}{6CO_2(g)} + \underset{6}{3H_2O(l)}$$

-103

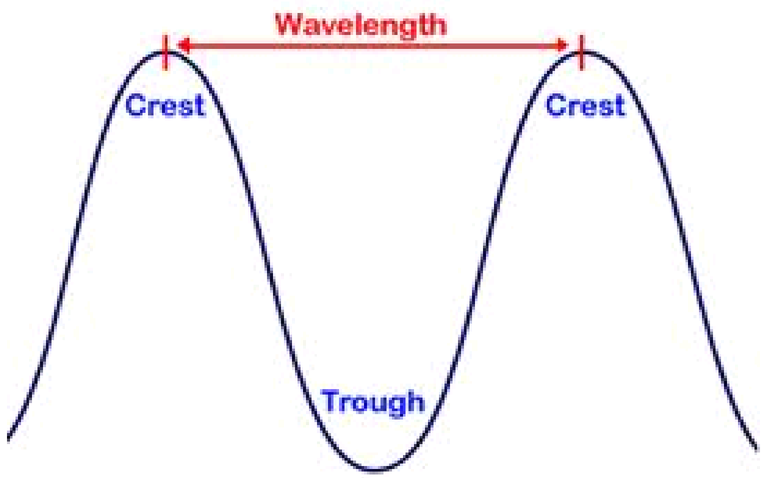
$$\Delta H_{rxn}^o = \left(\underset{12}{6}(-393.5\text{ kJ}) + \underset{=6}{3}(-285.5\text{ kJ})\right) - \left(\underset{2}{(49.04)} + 0\right)$$

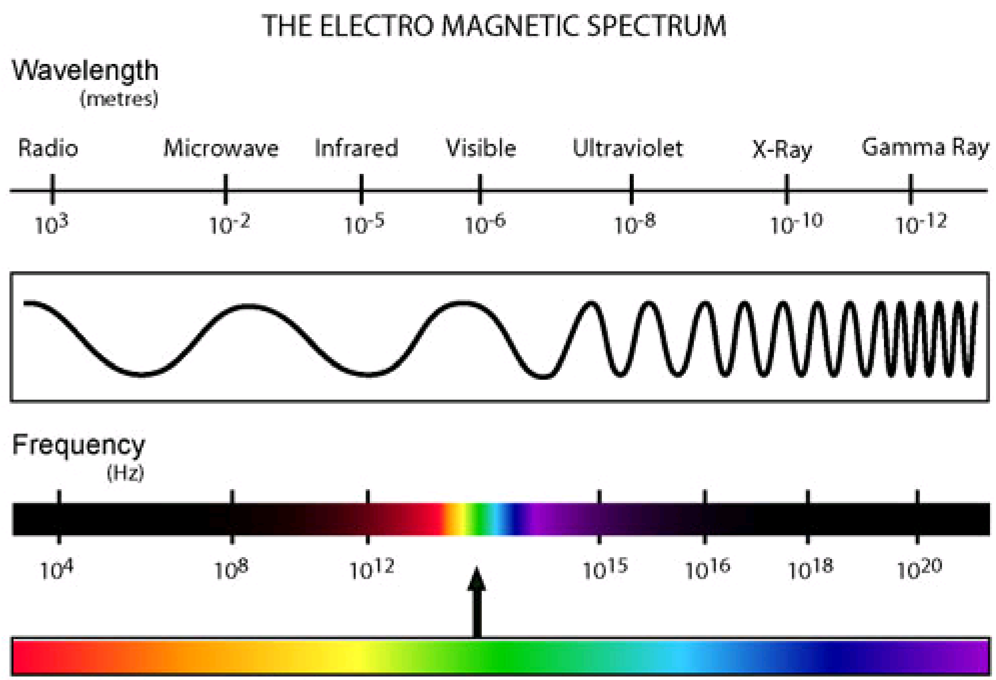
$$= -3267\text{ kJ}$$

Electronic Structure of Atoms

Electromagnetic radiation: Electromagnetic energy is a term used to describe all the different kinds of energies released **.**

Moves in waves





Electronic Structure of Atoms

Wavelength: peak to peak. Symbol = λ. Measured in meters

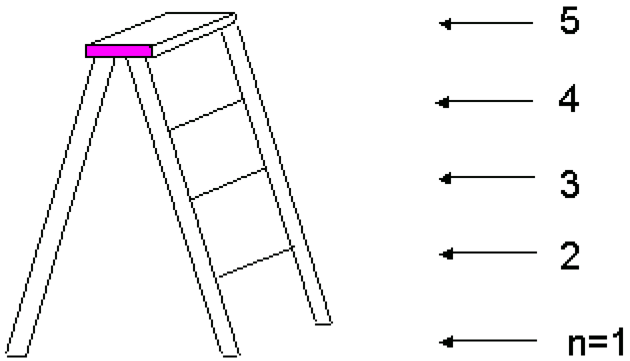
Frequency: is the number of waves that pass a fixed place in a given amount of time. Symbol = ν. Measured in s^{-1} or 1/s or hertz (Hz)

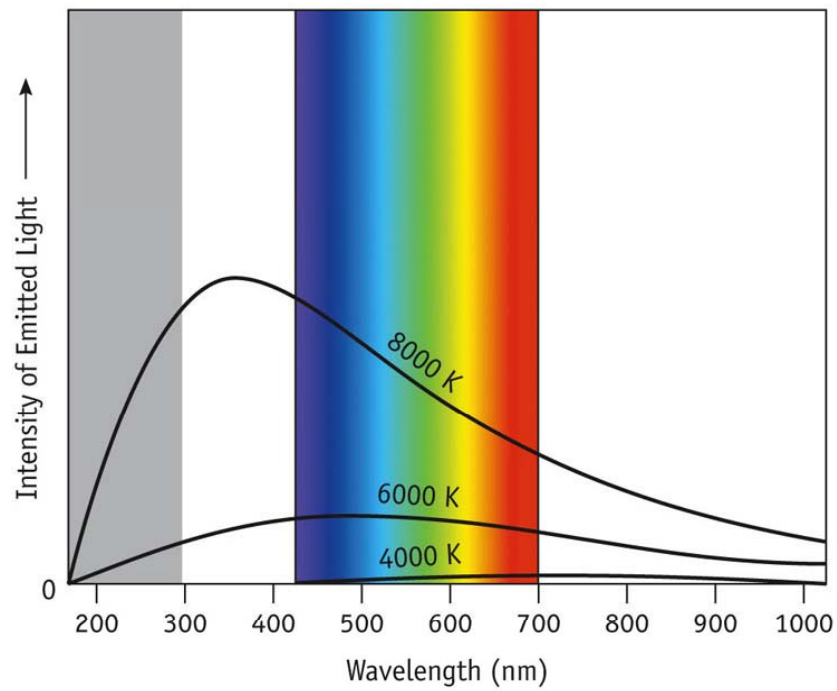
The speed of light through a vacuum, c, is 3.00×10^{8} m/s.

$$\mathbf{c} = \lambda\nu$$

Blackbody Radiation

Heating up a piece of metal. Physics could not explain this. Planck → Energy can be released (or absorbed) by atoms only in “chunks” of some minimum size. The chunks are called quantums.





Electromagnetic Radiation

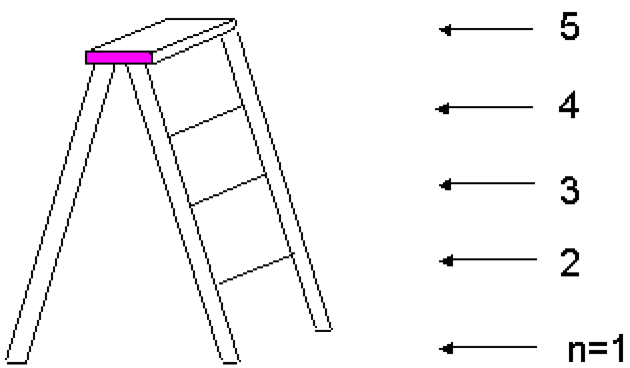
$$E = h\nu$$

h, Planck's constant $= 6.63 \times 10^{-34}$ (Js)

Atoms will absorb release:

$$E = nh\nu$$

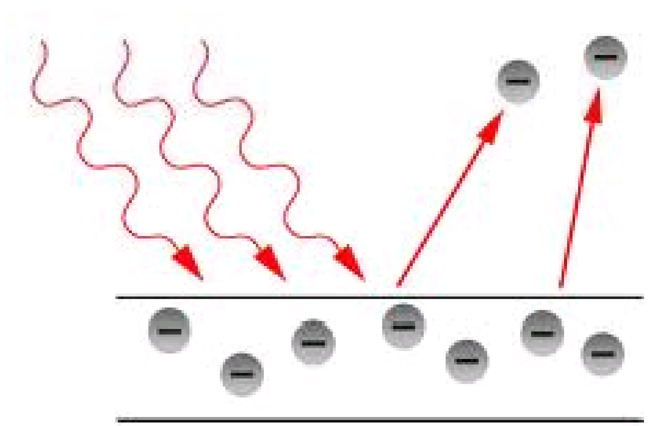
n is a whole number

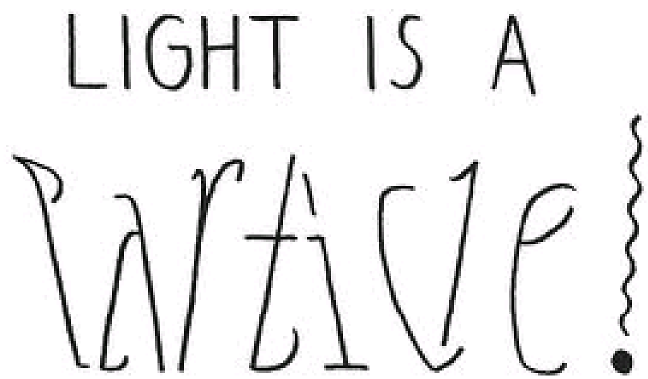


The Photoelectric Effect

Einstein used Planck's quantum theory to explain the photoelectric effect.

Each energy packet behaves like a tiny packet of light and is called a **photon.**





Let’s Practice

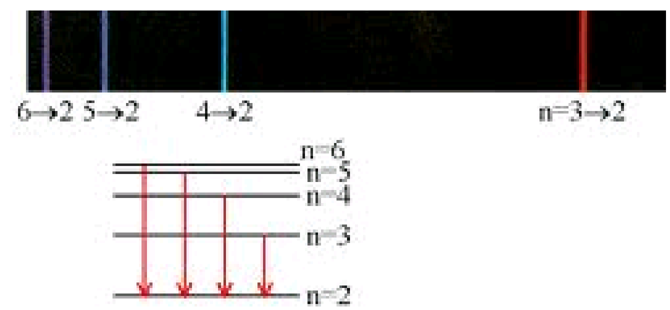
What wavelength of radiation has photons of energy 8.23×10^{-19} J?

Emission

Radiation composed of 1 wavelength = *monochromatic*
Radiation can be composed of many wavelengths
When separated a **spectrum** is produced:

Continuous Spectrum

Neon
Sodium Vapor

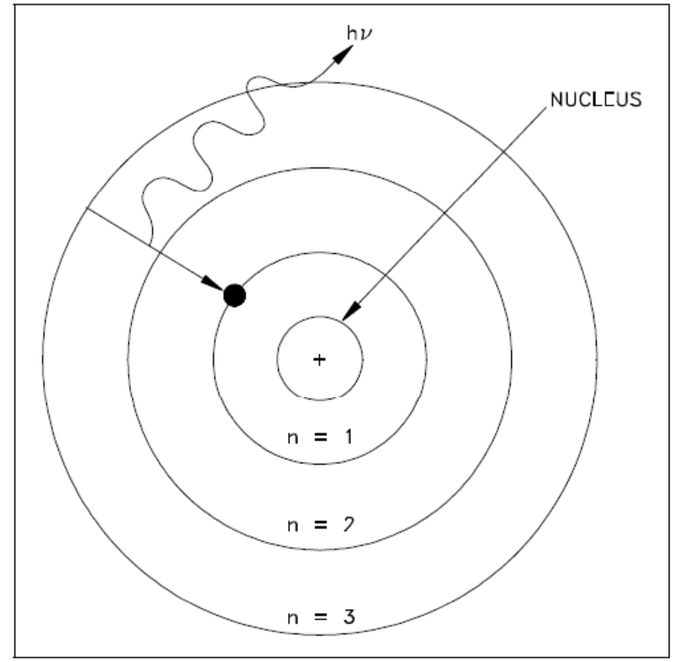


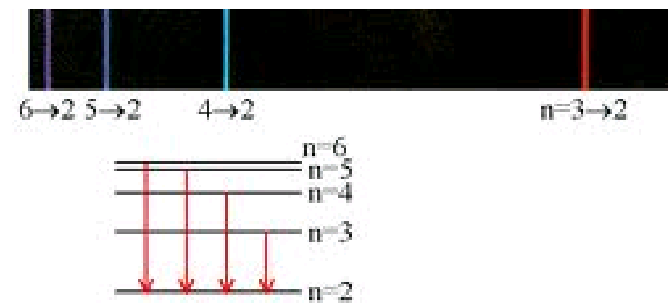
$$\frac{1}{\lambda} = (R_H)\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

$R_h = 1.0974 \times 10^7\ m^{-1}$

Bohr Model

- “Microscopic solar system”
- Lower the energy (more negative) the more
- The lowest energy state, n = 1, is called the **ground state.**
- When the electron is in a higher state (n=2,3…) the atom is said to be in an **excited state.**





$$E_n = -\frac{R_H hc}{n^2}$$

Bohr Model

- Electrons can "jump" from one allowed energy level by emitting/absorbing a photon of light.

$\Delta E = E_f - E_i = h\nu$