PHY 1120 - Dr. Rowley

Wrap up

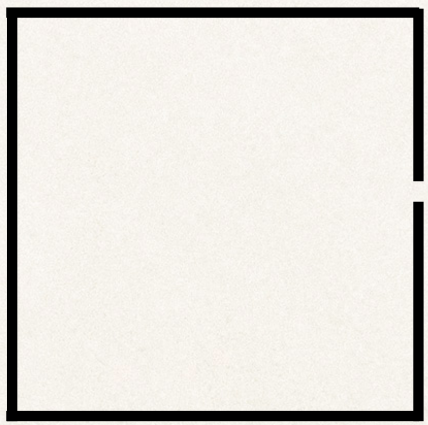
Summer 2020

Polarization

Polarization

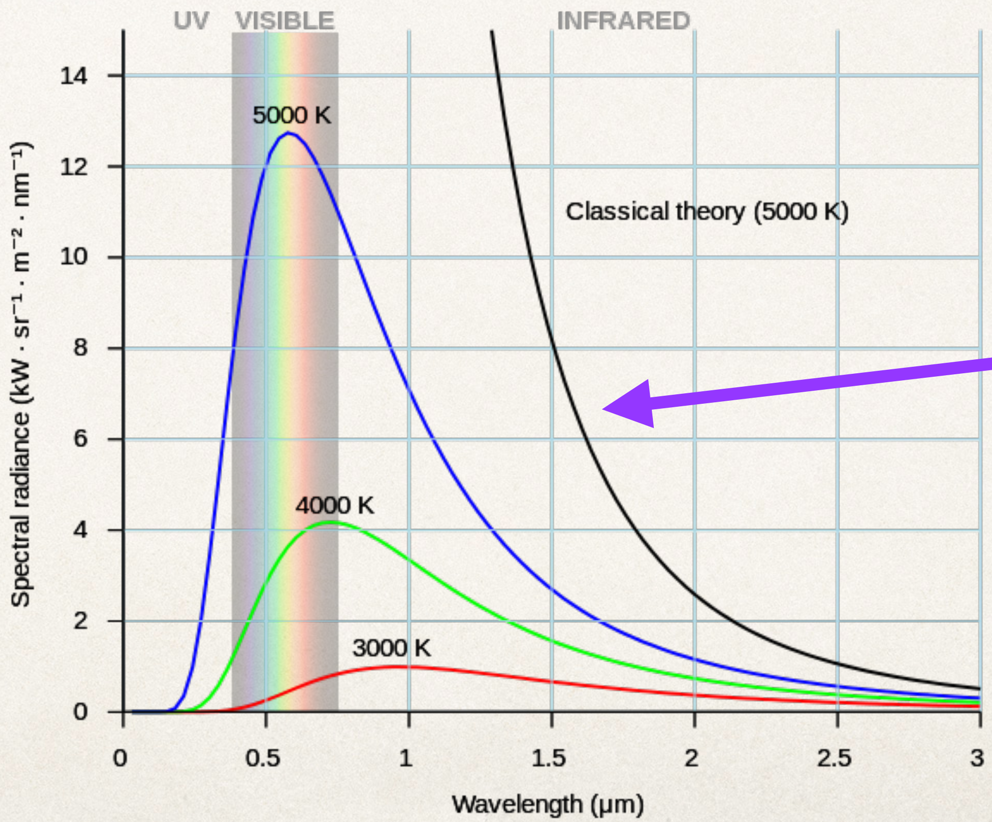
Blackbody Radiation

- A Blackbody is one that when cold will absorb ALL incident radiation.



Blackbody Radiation

- Any emissions are then based on temperature. (Wien's Law)



The Ultraviolet Catastrophe

Blackbody Radiation

- The <u>experimental</u> results known before the explanation.

$$\lambda_{peak} T = 2.90x10^{-3} \text{ m} \cdot \text{K}$$

- Max Planck proposed the <u>theoretical model</u> to explain the curve.

$$E = nhf$$

n = 1, 2, 3

h = $6.63x10^{-34}$ J•s
(Planck's Constant

Blackbody Radiation

- Energy is quantized.
  - It has discrete levels.
- The beginning of quantum mechanics.

The Photo-Electric Effect

- An EM wave incident on a charged plate should force electrons free from the plate.

$$KE_{\max} = eV_o$$ V_o = Stopping Voltage

- Using Planck's Hypothesis…

$$hf = KE_{\max} + W_o$$ W_o = Work Function

The Photo-Electric Effect

- Both the Stopping Voltage and Work Function are based on the material properties of the metal used.
    - $W_o(Ag) = 4.3\ eV = (4.3\ eV)(1.6x10^{-19}\ J/eV)$
    - $W_o(Au) = 5.1\ eV = (5.1\ eV)(1.6x10^{-19}\ J/eV)$

$$\boxed{1eV = 1.6x10^{-19}\ J}$$

The Photo-Electric Effect

- What is the minimum frequency of light required to eject an electron from a silver electrode? ($W_o(Ag) = 6.88x10^{-19}$ J)

$$hf = KE_{\max} + W_o$$

$$f = \frac{W_o}{h}$$

@ minimum frequency
the electron will be ejected
with zero KE.

$$f = \frac{6.68x10^{-19}\ \text{J}}{6.63x10^{-34}\ \text{J}\cdot s} = 1.04x10^{15}\ \text{Hz}$$

The Photo-Electric Effect

- What "color" of light is this? (Hint: find the wavelength)

$$\lambda = \frac{c}{f}$$

$$\lambda = \frac{3.00x10^{8}\ {}^{m}\!/_{s}}{1.04x10^{15}\ \text{Hz}}$$

$$\lambda = 2.9x10^{-7}\ \text{m}$$

Ultraviolet

Ionizing vs. Non-Ionizing Radiation

- Ionizing:
  - e^- is stripped from atoms.
  - UV or greater frequency
- Non-Ionizing: Smaller than UV frequency
  - Frequency not high enough to remove electrons

The Photo-Electric Effect

- Radiation with a frequency of 1.00 THz is incident on a plate of metal ($W_o = 1.5$ eV). What is the velocity of the electrons as they leave the plate?

$$hf = KE_{\max} + W_o$$

$$KE_{\max} = hf - W_o$$

$$\tfrac{1}{2}mv^2 = hf - W_o$$

$$v^2 = \frac{2\left(hf - W_o\right)}{m}$$

$$v = \sqrt{\frac{2\left(hf - W_o\right)}{m}}$$

Remember to convert to Joules

The Photo-Electric Effect

- Radiation with a frequency of 1.00 THz is incident on a plate of metal ($W_o = 1.5$ eV). What is the velocity of the electrons as they leave the plate?

$$v = \sqrt{\frac{2\left(\left(6.63x10^{-34}\ {}^{m^2kg}/_{s}\right)\left(1x10^{12}\ \text{Hz}\right) - \left(1.5\ \text{eV}\right)\left(1.6x10^{-19}\ {}^{\text{J}}/_{eV}\right)\right)}{9.11x10^{-31}\ \text{kg}}}$$

$$v = \sqrt{\frac{2\left(\left(6.63x10^{-22}\ J\right) - \left(2.4x10^{-19}\ \text{J}\right)\right)}{9.11x10^{-31}\ \text{kg}}}$$

$$v = \sqrt{\left(NEGATIVE!\right)}$$

$\boxed{\therefore \text{ the electron is NOT ejected}}$

Group Work

- X-Rays ($\lambda = 1.00$ nm) are incident on a plate of metal ($W_o = 3.0$ eV). What is the velocity of the electrons as they leave the plate?
  - Is this electron going fast? TOO fast? What would be TOO fast for an electron?

$$c = f \bullet \lambda \qquad f = \frac{c}{\lambda} \qquad f = \frac{3.00x10^{8}\ {}^{m}\!/\!{}_{s}}{1.00x10^{-9}\ \text{m}} \qquad f = 3.00x10^{17}\ \text{Hz}$$

Group Work

$$v=\sqrt{\frac{2\left(hf-W_o\right)}{m}}$$

$$v=\sqrt{\frac{2\left(\left(6.63x10^{-34}\ {m^2kg}/{s}\right)\left(3x10^{17}\ \text{Hz}\right)-\left(3.0\ \text{eV}\right)\left(1.6x10^{-19}\ \text{J}/{eV}\right)\right)}{9.11x10^{-31}\ \text{kg}}}$$

$$v=\sqrt{\frac{2\left(\left(1.989x10^{-16}\ J\right)-\left(4.8x10^{-19}\ \text{J}\right)\right)}{9.11x10^{-31}\ \text{kg}}}$$

$$v=\sqrt{\frac{2\left(\left(1.9842x10^{-16}\ J\right)\right)}{9.11x10^{-31}\ \text{kg}}}$$

$$\boxed{v=2.09x10^{7}\ {m}/{s}}$$

Velocity is not too high.

v > 3x10^8 m/s would be too high

Heisenberg Uncertainty Principle

$$\Delta x \Delta p \approx \hbar$$

Chapter 30

- Pay attention to the timeline
  - Atomic Models: Dalton, Plum Pudding, Planetary, Bohr
  - Sub-atomic Particles: Electron, Proton, Neutron

Nucleus

$${}^{A}_{Z}N$$

A = Atomic Mass

Z = Atomic Number

N = Atomic Symbol

- What happens if you increase/decrease the number of electrons/protons/neutrons?

Constituant Masses (C-12)

$$n^o = 1.67493\text{x}10^{-27}\ \text{kg} = 1.008665\ \text{u}$$

$${}^1_1H = 1.67353\text{x}10^{-27}\ \text{kg} = 1.007825\ \text{u}$$

- What is the mass of C-12?
  - 12.000000 u (this is the benchmark)

Constituant Masses (C-12)

$$n^o = 1.67493 \text{x} 10^{-27} \text{ kg} = 1.008665 \text{ u}$$

$$^1_1H = 1.67353 \text{x} 10^{-27} \text{ kg} = 1.007825 \text{ u}$$

- What is the total mass of "pieces" of C-12?

6 ($^1_1$H)	6(1.007825 u)	6.04695
6 (n^o)	6(1.008665 u)	6.05199
	Sum of the pieces	12.09894

Constituant Masses (C-12)

- Mass of Pieces = 12.09894 u
- Mass of C-12 = 12.00000 u
- Δm = 0.09894 u
- Where did the mass go?

Einstein’s Theory of Relativity

- General Relativity
  - Gravity vs. Acceleration
- Special Relativity
  - How light behaves
  - $E=mc^2$ (relationship between mass and energy)

… back to C-12

- How much energy is 0.09894 u?

$$\left(\frac{0.09894\ \text{u}}{1}\right)\left(\frac{1.6605x10^{-27}\ \text{kg}}{1\ \text{u}}\right)$$

$$1.64290x10^{-28}\ \text{kg}$$

$$E = \left(1.64290x10^{-28}\ \text{kg}\right)\left(3.00x10^{8}\ {}^{m}\!/\!_{s^2}\right)^2$$

$$E = 1.47861x10^{-11}\ \text{J}$$

… back to C-12

- 1.47861×10^{-11} J

$$\left(\frac{1.47861x10^{-11}\ \text{J}}{\text{atom!}}\right)\left(\frac{6.02x10^{23}\ \text{atoms}}{\text{mole}}\right)$$

$$8.90418x10^{12}\ \text{J!}$$

Radioactive Decay

- Few isotopes are stable, most are unstable.
- Most abundant isotopes are stable.
- Parent vs. Daughter Products

α decay

$$^{A}_{Z}N = ^{A-4}_{Z-2}N' + ^{4}_{2}He$$

$$^{208}_{84}Po = ^{204}_{82}Pb + ^{4}_{2}He$$

β- decay

$$ {}_{Z}^{A}N = {}_{Z+1}^{A}N' + e^{-} + \overline{\nu} $$

$$ {}_{47}^{111}Ag = {}_{48}^{111}Cd + e^{-} + \overline{\nu} $$

β^+ decay

$$ {}^{A}_{Z}N = {}^{A}_{Z-1}N' + e^{+} + \nu $$

$$ {}^{10}_{6}C = {}^{10}_{5}B + e^{+} + \nu $$

Electron Capture

$$ {}^{A}_{Z}N + e^{-} = {}^{A}_{Z-1}N' + \nu $$

$$ {}^{73}_{33}As + e^{-} = {}^{73}_{32}Ge + \nu $$

Electron Capture

$$ {}_{Z}^{A}N + e^{-} = {}_{Z-1}^{A}N' + \nu $$

$$ p^{+} + e^{-} = n^{o} + \nu $$

γ decay

$$^{A}_{Z}N^{*} = {}^{A}_{Z}N + \gamma$$

$$^{74}_{33}As = {}^{74}_{33}As + \gamma$$

Decay Chains

- You must be prepared to predict either the parent **or** the daughter product given the other in a series of decays
    - U-235 undergoes α, β^-, then α-decay what is the daughter product
- You must be prepared to determine the type of decay based on the parent AND daughter products

NOTE: My examples may not be real decay chains.