Chem332-Homework Set 1 – Photoelectric Effect,

Show just enough work and equations to indicate how you arrived at your answer. Show units and reasonable number of significant figures.

1. The photoelectric work function for tungsten metal is 4.52 electron volts (ev). (a) What is the cutoff wavelength in nm for tungsten? (b) What is the maximum kinetic energy of an electron ejected from tungsten by incident light of 198 nm wavelength? (a couple of convenient unit conversions 1 ev = 1.602×10^{-19} Joules, hc=1.986×10^{-25} J•m)

cutoff wavelength = _**275 nm**___

KE of electron ejected by 198 nm photon = __**1.75 ev**__

The work function for tungsten metal is 4.52 eV. (a) What is the cutoff wavelength λ_c for tungsten? (b) What is the maximum kinetic energy of the electrons when radiation of wavelength 198 nm is used? (c) What is the stopping potential in this case?

(a) Starting from Einstein's photoelectric equation $KE_{max} = hf - \phi$, *the cutoff frequency is when the electron has received just enough energy to overcome the binding energy (a.k.a. the work function). Mathematically,*

$$0 = hf_c - \phi = \frac{hc}{\lambda_c} - \phi$$

$$\lambda_c = \frac{hc}{\phi} = \frac{(6.63x10^{-34} J \cdot s)(3x10^8 m/s)}{(4.52 eV)(1.60x10^{-19} J/eV)} = \mathbf{275\ nm\ (in\ the\ UV)}$$

(b) The maximum kinetic energy is just given by,

$$KE_{max} = hf - \phi = \frac{hc}{\lambda} - \phi$$

$$= \frac{(6.63x10^{-34} J \cdot s)(3x10^8 m/s)}{198x10^{-9} m} - 4.52 eV(1.602x10^{-19} J/eV) = \mathbf{1.75\ eV}.$$

(c) The stopping potential is the voltage corresponding to KE_{max}:

$$V_{stopping} = \frac{KE_{max}}{e} = \frac{1.75 eV}{e} = \mathbf{1.75\ Volts}.$$

2. What is the energy in Joules of a photon of deep purple light with wavelength 400 nm?

Energy = __**4.96×10^{-19} Joule**____

E=hv=hc/λ=hc(nu bar) = 6.63×10^{-34} J-s x 2.99×10^{8} m/s / 400×10^{-9} m = **4.96×10^{-19} Joule**

3. A single photon with energy of 2.00 ev has its electric and magnetic field vectors oscillating at what frequency? (Hertz Hz = 1 cycle per second = 1 sec^{-1})

Frequency = ___**6.63×10^{-34} J-s** ___

E=hv=hc/λ=hc(nu bar) v=E/h = 2.00 ev x 1.602×10^{-19} J/ev / 6.63×10^{-34} J-s = **4.38×10^{-14} Hz**

4. A 1.00 mW laser emitting photons in the red with wavelength 633 nm emits how many photons per second? (1 Watt = 1 W = 1 Joule/sec W is a power unit, J is an energy unit)

Photons emitted per second = __**$3.19x10^{15}$** ___

E=hv=hc/λ=hc(nu bar) E=$6.63x10^{-34}$ J-s x $2.99x10^{8}$ m/s / $633x10^{-9}$ m = $3.13x10^{-19}$ Joules/photon number photons per second to make $1x10^{-3}$ W (or J/sec) = $1x10^{-3}$ J/s / $3.13x10^{-19}$ Joules/photon = $3.19x10^{15}$ photons per second

5. Based on Bohr theory, how many times larger is the radius of a H atom in the n=3 excited state than one in the ground state? (you may need to look over equations for Bohr theory in Adkins and/or a freshman text)

Times larger a n=3 H atom is compared to ground n=1 H atom = _**9**____

Bohr model of H atom radius of level n = $n^2 (h/2\pi)^2 / Zk_e e^2 m_e$ for n=1 Bohr radius=$5.29x10^{-11}$ m in the equation for radius all are constants except n^2 if n=1 r=$5.29x10^{-11}$ m if n=2 radius is 4x this if n=3 radius is 9 times this or **$4.76x10^{-10}$ meter** k_e is Coulomb's constant in SI units = 8.98755x109 Nm^2/C^2

Chem332-Homework Set 1 Name ________________________

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cutoff wavelength = __________

KE of electron ejected by 198 nm photon = ___________

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