**Chemistry 3322 – Assignment Set 1 (Part A)**

**Due: February 2, 2021 by 11:59 pm. Assignment Set 1 (Part B) will be assigned that day.**

**Answers must be: (a) typed in MS Word; (b) provided in the correct order; (c) provided with the number of significant figures appropriate to the information supplied; (d) properly identified in document name; provided using appropriate grammar and punctuation as appropriate. Will not be graded otherwise.**

**Where a question stipulates “Answer Only,” please give only that. Material from Sections 1 and 2.**

1. Calculate (a) the energy per photon in **J** and (b) the **number** of photons emitted per second from a 200-W yellow (589.3 nm) sodium lamp. (Such lamps produce virtually [monochromatic](http://en.wikipedia.org/wiki/Monochromatic) light at an average wavelength of 589.3 [nm](http://en.wikipedia.org/wiki/Nanometre); the actual output are two lines that are very close together at wavelengths of 589.0 and 589.6 nm. The actual colors of objects illuminated by these lamps are not easily distinguished since they are seen almost entirely by the reflection of this narrow bandwidth of orange light). [Hint: see Quick Problem (QP) Set 1]. **Answers Only.** [5 + 5 = 10 points]

2. For the 100 face of silver metal, the velocity of electrons emitted in a photoelectron experiment [⇐ Hint] using 200-nm photons is 7.420 × 105 ms-1. Calculate the Work function for this Ag surface in units of **(a) J** and **(b) eV**. **Answers Only.** [9 + 1 = 10 points]

3. A 58.4 nm photon from a Helium gas discharge tube is absorbed by a H2 molecule that is at rest. Use the principle that momentum is conserved to determine the **velocity** of the H2 molecule in units of **m/s** after it absorbs the 58.4 nm photon. **Answer Only.** [10 points]

4. (a) Show the energy density of a blackbody, depends on temperature as T4. [Hint for 4(a): Use the substitution x = hν/kBT and definite integral: ].

(b) Use the result in 4(a) to calculate the energy density radiated by a blackbody at a temperature of 3.60 million F, (the estimated temperature of our Sun’s outermost corona), in units of **J/m3**. [15 + 4 = 19 points]

5. The lifetime of a molecule in a certain electronic state is 1.00 nanoseconds. (a) What is the uncertainty in energy of this electronic state in units of **J** for a single molecule? (b) Give your answer also in units of **J mole-1** for one mole of such molecules. [Hint: What recently encountered QM principle is used here?] **Answers Only.** [6 + 4 = 10 points]

6. In this question, be sure to consider the refractive index of the medium and **provide your 3 answers for this question to 8 significant figures**. A stabilized helium-neon laser operates at a wavelength of 6328.1650 Å in air. The refractive index of air is 1.0002759 at this wavelength. (a) What is the vacuum wavelength of the He-Ne laser in **Å**? (b) What is the vacuum wavenumber (in **cm-1**) of this radiation? (c) What is the speed of light in **m/s** in this medium? [Hint: you need to use material provided in the lecture about c & the refractive index.] **Answers Only.**

[7 + 7 + 7 = 21 points]

7. In the Compton effect, the change in the wavelength of scattered X-rays is related to the angle of scattering (θ) by the formula Δλ = (1 – Cosθ) h/mc. (a) Calculate the wavelength of the X-rays scattered at 90° for incident X-rays of wavelength 3.00 Å in **m**. (b) Determine the velocity of the scattered electron in **m/s**. [5 + 10 = 15 points]

8. Give **Answers Only** for the following:

(a) Calculate the wavenumber (**cm-1**) of the line in hydrogen’s atomic spectrum that corresponds to the electron’s transition from n1 = 2 to n2 = 4 determined from the Rydberg equation using the appropriate Rydberg constant, which is not R.

(b) Repeat the calculation giving answers in **cm-1** for n2 = 9 and n2 = 10 i.e., for larger values of n2.

(c) What is wavenumber (**cm-1**) for the series limit when n1 = 2? [What is the value of n2 then?]

(d) What is the wavenumber (**cm-1**) for the series limit when n1 = 1?

(e) What phenomenon does the latter situation (i.e., the series limit when n1 = 1) correspond to for the atom?

[4 + 3 + 3 + 3 + 2 = 15 points]

[Point Total for 2021 = 110]