CHEM-01A
Work Session # 6: The Structure of Atoms

Name ______________________ Date ______ Grade ____

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Q1. a) A red laser pointer emits light with a wavelength of 650 nm. What is the frequency of this light?

b) The laser pointer emits light because electrons in the material are excited (by a battery) from their ground state to an upper excited state. When the electrons return to the ground state they lose the excess energy in the form of 650 nm photons. What is the energy gap between the ground state and excited state in the laser material?

c) What is the energy of 1 mole of these photons?

Q2. a) Using the equation for H atom $E_n = (-hcR_H)\left(\frac{1}{n^2}\right) = (-2.18x10^{-18}\,J)\left(\frac{1}{n^2}\right)$ calculate the energy of an electron in the hydrogen atom when n = 2 and when n = 6.

b) Calculate the wavelength of the radiation released when an electron moves from $n = 6$ to $n = 2$. Is this line in the visible region of the electromagnetic spectrum? If so, what color is it?

c) Calculate the energy for an electron in the hydrogen atom moving from $n = 1$ to $n = \infty$.

d) According to Bohr, the amount of energy in part c is required to move the electron out of the atom completely (from $n = 1$ to $n = \infty$). How much is it in kJ/mol unit?

e) The energy for the process H + energy → $H^+ + e^-$ is called the ionization energy of hydrogen. The experimentally determined value for the ionization energy of hydrogen is 1310 kJ/mol. How does this compare to your calculations in part d?

Q3. For $n = 4$, what are the possible values of l?

For l = 2, what are the possible values of m_l?

For m_l = 2, what are the possible values for l?

Q4. Which of the following represent impossible combinations of n and l?
a) 1p b) 4s c) 5f d) 2d

Write a set of 4 quantum numbers for each of the above possible combination.

Q5. What is the maximum number of electrons that can occupy each of the following subshells?
a) 3p b) 5d c) 2s d) 4f

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Q6. The energy required to break one mole of chlorine-chlorine bonds in Cl_2 is 242 kJ/mol. What is the longest wavelength of light capable of breaking a single chlorine-chlorine bond? Which regions of the electromagnetic spectrum does this light belong to?

Q7. Use de Broglie expression $\lambda = \frac{h}{mv}$ to determine:

a) the velocity of an electron of wavelength 555 nm and mass 9.1 x10^{-31} kg.

b) the wavelength of a 120 g golf ball traveling at 65 km/h.

Q8. The watt is the derived SI unit of power, the measure of energy over unit time: 1 W = 1 J/s. A semiconductor laser in a CD player has an output wavelength of 780 nm and a power level of 0.10 mW. How many photons strike the CD surface during the playing of a CD 69 minutes in length?

Q9. What is the wavelength of a photon that has a frequency of 2.10×10^{14} Hz? Answer in nm and determine what type of radiation this is.

Q10. A classical radio station broadcasts at 93.5 MHz ($M = 10^6$). Find the wavelength of this radiation, in meters, and the energy of one of these photons, in J. What type of radiation is this?

Q11. What is the energy of a photon with:
a) a wavelength of 827 nm? What type of radiation is it?

b) a wavelength of 1 nm? What type of radiation is it?

Q12. Calculate the ΔE for the n = 4 to the n = 2 transition in hydrogen. Where on the EMS would this appear? What does the sign mean?

Q13. a) Calculate the energy needed to remove the electron from hydrogen in its ground state.

b) This is the energy to remove an electron from the ground state of hydrogen. What wavelength of light would work? Where is this on the EMS?

Q14. What is the energy needed to remove the remaining electron from He^+ in its ground state? Is it easier or harder to remove the electron from He^+ than from H?