Logan Pachulski

1. PHOTOELECTRIC EFFECT (14 points)
Electrons with a kinetic energy of 4.01×10^{-19} J are ejected from the surface of a metal plate upon irradiation by a light source with a wavelength of 171 nm and an intensity of 359 Watts.

(a) (8 points) Calculate the **workfunction** of the metal.

$$\text{Output} = \text{input} - \text{workfunction}$$

$$\Downarrow$$

$$\Psi = \frac{hc}{171\text{nm}} - 4.01 \cdot 10^{-19}\text{J}$$

$$= 7.607 \cdot 10^{-19}\text{J}$$

(b) (6 points) Circle the correct answer. Increasing the **intensity** of this light will

(i) (increase decrease (leave unchanged) the kinetic energy of the ejected electrons

(ii) (increase decrease (leave unchanged) the incident energy needed to eject electrons

(ii) (increase) decrease leave unchanged) the number of electrons ejected

2. WAVELENGTHS AND ENERGY LEVELS (14 points)

A free electron is traveling at 4.0×10^6 m/s.

(**a**) (4 points) Calculate the wavelength of this free electron.

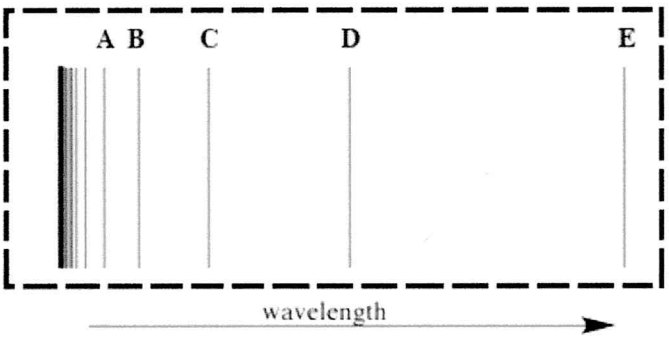
$$\lambda_{deBroglie} = \frac{h}{m \cdot v} = \frac{6.626 \cdot 10^{-34}}{9.109 \cdot 10^{-31} \cdot 4 \cdot 10^6} = 1.819 \cdot 10^{-10} \text{ m}$$

(**b**) (10 points) Now suppose that this free electron is captured by an ion. Calculate the change in energy for this electron from its free state, in which it is traveling at 4.0×10^6 m/s, to its captured state, in which it is stably bound in the 1s orbital of a He^+ ion.

$-1.6 \cdot 10^{-17}$ J

3. PHOTON EMISSION (16 points)

The figure to the right represents the emission spectrum for a one-electron atom in the gas phase. All of the lines shown result from electronic transitions from excited states to the n = 3 state.



(a) (6 points) State the electron transitions that corresponds to lines:

(i) A ~~n=1 → n=5~~ 8 → 3

(ii) C ~~n=1 → n=3~~ 6 → 3

(iii) D 5 → 3

(b) (10 points) If the wavelength of line D is 142. nm, calculate the wavelength of line C to 3 significant figures.

121 nm

4. SHAPES OF ORBITALS (13 points)

Answer the following questions for 3s, 3p, and 3d orbitals

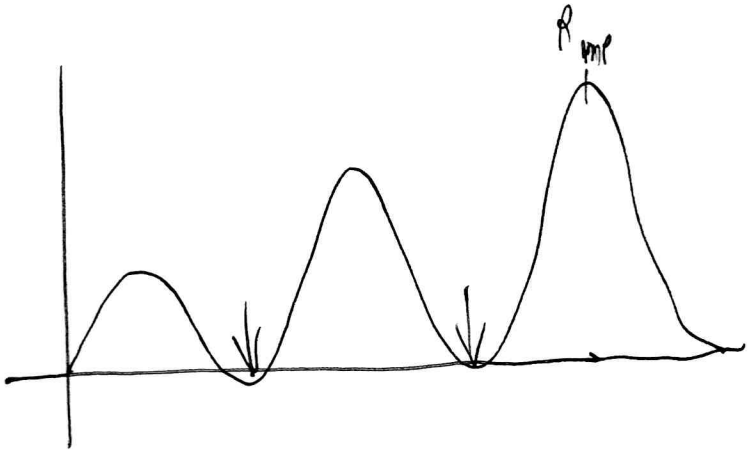
(a) (3 points) Which of these three orbitals has the highest number of angular nodes?

3d

(c) (3 points) Which of these three orbitals has the largest r_{mp}?

3s

(d) (7 points) Draw the radial probability distribution (RPD) for the electron in a 3s orbital. Label axes, any nodes, and the r_{mp}.



5. MULTI-ELECTRON ATOMS (17 points)

(a) (9 points) For a 2s electron of Li that has an ionization energy of 8.64×10^{-19} J, answer the following:

(i) (5 points) Calculate the Z_{eff}.

$Z_{eff} = 1.26$

(ii) (4 points) State whether the Z_{eff} value calculated above indicates that this 2s electron is being shielded. Briefly explain your answer.

Yes; a $Z_{eff} \leq Z$ implies some of the pull towards the nucleus is being nullified by something of the same charge in the way.

(b) (8 points) Write the electron configurations for the following atoms/ion. *You may use the noble gas configurations as a means to abbreviate the full configurations.*

(i) Co^{+2} : $[Ar]\ 4s^2\ 4f^9$

(ii) Os $[Xe]\ 6s^2\ 6f^{13}\ 6d^6$

6. QUANTUM NUMBERS (16 points)

Circle the correct answer to indicate whether the following sets of quantum numbers are allowed or are not allowed.

For each set that is not allowed, briefly explain why it is not allowed.

For each set that is allowed, identify the orbital in terms of **n** and **l** and $\mathbf{m}_l$ values.

(a) $n = 3, l = 3, m_l = 0$ (allowed (not allowed)

Explanation/orbital type: $L = 3 \not\leq n-1$

(b) $n = 2, l = 1, m_l = 0$ (allowed) not allowed)

Explanation/orbital type: 2p

(c) $n = 4, l = 0, m_l = 0$ (allowed) not allowed)

Explanation/orbital type: 4s

(d) $n = 3, l = 1, m_l = 2$ (allowed (not allowed)

Explanation/orbital type: $m_l = 2 > L$

7. LIMITING REACTANT (10 points)
Calcium carbide, CaC_2, reacts with water to form calcium hydroxide and acetylene (C_2H_2):

$$CaC_2\,(s) + 2\,H_2O\,(l) \rightarrow Ca(OH)_2\,(aq) + C_2H_2\,(g)$$

(a) (6 points) Determine which reactant is limiting when 20. g of water reacts with 50. g of calcium carbide. (Show your work to receive credit).

Molar mass $CaC_2 = 68$
" $H_2O = 18$

$\frac{20}{18}$ reaction units $H_2O = 1.1$, $\frac{50}{68} = 0.735$ RU CaC_2 (rel)

CaC_2 is the limiting reactant.

(b) (4 points) Calculate the mass of C_2H_2 that will be produced, assuming a complete 100.% yield.

19.12 grams