

First Hour Exam**5.111**

Write your name and your TA's name below. **Do not open the exam until the start of the exam is announced.** The exam is closed notes and closed book.

1. Read each part of each problem carefully and thoroughly.
2. Read all parts of each problem. **MANY OF THE LATTER PARTS OF A PROBLEM CAN BE SOLVED WITHOUT HAVING SOLVED EARLIER PARTS.** However, if you need a numerical result that you were not successful in obtaining for the computation of a latter part, make a physically reasonable approximation for that quantity (and indicate it as such) and use it to solve the latter parts.
3. A problem that requests you to "calculate" implies that several calculation steps may be necessary for the problem's solution. You must show these steps clearly and indicate all values, including physical constants used to obtain your quantitative result. **Significant figures** and **units** must be correct.
4. If you don't understand what the problem is requesting, raise your hand and a proctor will come to your desk.
5. Physical constants, formulas and a periodic table are given on the last page. You may detach this page **once the exam has started.**

- | | | |
|----|--------------------------------------|------------------|
| 1. | PHOTOELECTRIC EFFECT | (14 points)_____ |
| 2. | WAVELENGTHS AND ENERGY LEVELS | (14 points)_____ |
| 3. | PHOTON EMISSION | (16 points)_____ |
| 4. | SHAPES OF ORBITALS | (13 points)_____ |
| 5. | MULTI-ELECTRON ATOMS | (17 points)_____ |
| 6. | QUANTUM NUMBERS | (16 points)_____ |
| 7. | LIMITING REACTANT | (10 points)_____ |
| | Total (100 points) | _____ |

Name _____

TA _____

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.

(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.

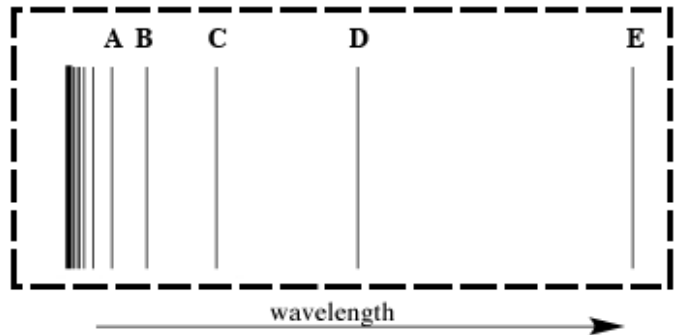
(a) (4 points) Calculate the wavelength of this free electron.

(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.

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

(ii) C

(iii) D

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

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?

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

(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} .

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

(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}

(ii) Os

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 **m_l** values.

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

Explanation/orbital type:

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

Explanation/orbital type:

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

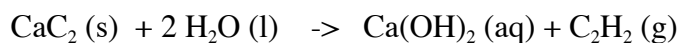
Explanation/orbital type:

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

Explanation/orbital type:

7. LIMITING REACTANT (10 points)

Calcium carbide, CaC_2 , reacts with water to form calcium hydroxide and acetylene (C_2H_2):



(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).

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

Periodic Table with constants and equations for Exam 1:

			VIII					VII		VI		V		IV		III		Transition elements										II		I	
			2																												
			4.0026																												
			He																												
			Helium																												
			10																												
			Ne																												
			Neon																												
			18																												
			Ar																												
			Argon																												
			36																												
			Kr																												
			Krypton																												
			86																												
			Xe																												
			Xenon																												
			131.29																												
			Rn																												
			Radon																												
			222																												
			At																												
			Astatine																												
			85																												
			Po																												
			Polonium																												
			210																												
			Bi																												
			Bismuth																												
			208.98																												
			Pb																												
			Lead																												
			207.2																												
			Tl																												
			Thallium																												
			81																												
			Hg																												
			Mercury																												
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