**Sample Midterm 2 Exam**

**Part 1: Multiple Choice.**
(5 pts each, 40 pts total)

Instructions: Bubble in the correct answer on your Scantron™ form AND circle the answer on your exam. Each question has one correct answer.

1.) The answer to question 1 is **A**. Bubble in **A** on your Scantron™ form.

2.) To which orbital does the plot of $|\psi|^2$ vs $\phi$ correspond?

A.) 1s  
B.) 2s  
C.) 2p_x  
D.) 2p_y  
E.) 2p_z

![Graph of $|\psi|^2$ vs $\phi$]

3.) The ionization of which with UV light at 90 nm will produce electrons with the longest de Broglie wavelength?

A.) H (1s)  
B.) H (2s)  
C.) H (4s)  
D.) He$^+$ (4s)  
E.) He$^+$ (8s)

4.) Identify the atom or ion with the electronic configuration [Ne]3s3p$^6$?

A.) Ar$^+$  
B.) K$^+$  
C.) Ar  
D.) K  
E.) Cl$^-$

5.) Which has the largest atomic or ionic radius?

A.) Ar$^+$  
B.) K$^+$  
C.) Ar  
D.) K  
E.) Cl$^-$
6.) Which is the most electronegative?

7.) Which is *not* paramagnetic in its ground state?
   A.) O   B.) O\(^-\)   **C.) O\(^{2-}\)**   D.) O\(_2\)   E.) O\(_2^-\)

8.) After diving, which ascent poses the gravest danger to a diver holding his or her breath?
   A.) 10m→0m   B.) 20m→10m   C.) 40m→20m
   **D.) 60m→30m**   **E.) 100m→40m**

9.) The atoms or molecules of which ideal gas have the greatest average kinetic energy?
   A.) Ar at 200 °C   **B.) He at 400 °C**   C.) He at 100 °C
   D.) H\(_2\) at 200 °C   E.) H\(_2\) at 100 °C
Part 2: Short Answer Problems (105 pts total)
Instructions: Enter answers in the boxes provided. Show your work and justify your answer.

(25 pts)
1.) Consider the H atom and He$^+$ ion.

a) What is the maximum wavelength of light that will ionize H(2s)?

\[ E = \frac{hc}{\lambda} = -R_{\infty}(Z^2 / n^2) \]

\[ \lambda = \frac{hc}{R_{\infty}Z^2} = 364 \text{ nm} \]

b) Light of what wavelength will induce the n=4 \rightarrow n=8 transition in He$^+$?

\[ \Delta E = -R_{\infty}Z^2 \left( \frac{1/n_f^2}{1/n_i^2} \right) \]

\[ \Delta E = \frac{hc}{\lambda} \]

\[ \lambda = \frac{hc}{(-R_{\infty}Z^2)(1/n_f^2 + 1/n_i^2)} = 486 \text{ nm} \]

(30 pts)
2.) Consider an atom of the element aluminum (Al) in its ground state.

a) Write the electron configuration for an atom of Al.

Answer: $[\text{Ne}] 3s^2 3p^1$

b) Write down the values of the quantum numbers for an electron in the highest occupied orbital.

n: 3  l: 1  m$_l$: -1 or 0 or 1  m$_s$: -1/2 or 1/2

c) Sketch the highest occupied atomic orbital and indicate number and type of nodes.

2 nodes total:

1 angular node
1 radial node
(25 pts)
3.) Consider 4.4 g of a hydrocarbon (hc) gas with the empirical formula C₃H₈.

a) The hydrocarbon fills a balloon to 0.56 L at 4.4 atm and 300 K. What is the molecular formula of the hydrocarbon?

\[ P V = n R T ; \quad n = \text{mass} / M \]
\[ P V = (\text{mass} / M) R T \]
\[ M = \text{mass} R T / P V = 44 \text{ g/mol} \]

b) Shown is a plot of the molecular speed distribution, F(v), and \( v_{\text{rms}} \) for CO₂ at 300 K. Sketch F(v) and indicate \( v_{\text{rms}} \) for the hydrocarbon gas at 300 K and 600 K.

![CO₂ at 300 K](image1)

![hc at 300 K](image2)

![hc at 600 K](image3)

(25 pts)
4.) Two sunscreen products (X and Y) have the following extinction coefficients, \( \varepsilon \), at 310 nm:
\( X = 3.0 \text{ cm}^2/\text{g} \) and \( Y = 1.0 \text{ cm}^2/\text{g} \). For the following questions, the absorbance should be calculated for a 1 cm sample path length.

a) What is the absorbance of a 0.1 g/mL sample of X?

\[ A = \varepsilon l c = 0.3 \]

Answer: \( 0.3 \)

b) A 0.10 g/mL sample of either X or Y is placed in the spectrometer. The measured ratio of the intensity of the transmitted light to the intensity of the incident light is 0.80 at 310 nm. Is the sample sunscreen X or Y?

\[ A = \log (I_o / I_t) = \varepsilon l c \]
\[ \varepsilon = [ \log (I_o / I_t) ] / l c = 1.0 \text{ cm}^2/\text{g} \]

Answer: Y