Midterm Exam I, version D
September 19, 2000
ed book, 75 minutes, 105 points)

Name: 
Section Number: 
SID: 
T.A. Name: 

Identification Sticker

Exam information, extra directions, and useful hints to maximize your score:

- Write your name on all six pages.
- There are two parts to the exam: 1) multiple choice and 2) short answer problems.
- For the multiple choice problems, fill in the Scantron™ form AND circle the answer on your exam.
- Answer the questions you know how to do first, then work on the questions you skipped.
- Show all work on the short answer problems for which you want credit and do not forget to include units!
- You may use the back side of the exam pages to show your work and/or for scratch paper.

<table>
<thead>
<tr>
<th>Unit Prefixes</th>
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<tbody>
<tr>
<td>milli, m (x 10^{-3})</td>
<td></td>
</tr>
<tr>
<td>micro, μ (x 10^{-6})</td>
<td></td>
</tr>
<tr>
<td>nano, n (x 10^{-9})</td>
<td></td>
</tr>
<tr>
<td>kilo, k (x 10^{3})</td>
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<tr>
<td>mega, M (x10^{6})</td>
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<tr>
<td>giga, G (x 10^{9})</td>
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Some possibly useful information:

\[ E_{\text{photon}} = h \nu = \frac{hc}{\lambda} \]

\[ E_{\text{kin}} (e^+) = h \nu - \Phi = h \nu - h \nu_0 = \frac{mv^2}{2} \]

\[ \lambda_{\text{de Broglie}} = \frac{h}{p} = \frac{h}{mv} \]

(Do not write in this box; it is for official use only.)

<table>
<thead>
<tr>
<th>Page</th>
<th>Points</th>
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<tr>
<td>2-4</td>
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<tr>
<td>5</td>
<td>30/30</td>
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<td>6</td>
<td>30/30</td>
</tr>
<tr>
<td>Total</td>
<td>75/105</td>
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</tbody>
</table>

\[ 75/105 \]
Part 1: Multiple Choice.  
(3 pts each, 45 pts total)  
Instructions: Bubble in the correct answer on your Scantron sheet AND circle the answer on your exam. Each question has one correct answer.

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

2.) Which is required in the greatest quantity (mass) in order to produce 1 gram of Br₂?  
A.) HBr  
B.) NaBr  
C.) KBr  
D.) MgBr₂  
E.) CaBr₂  
\[ \frac{77.70}{\text{mol}} \quad \frac{67.00}{\text{mol}} \quad \frac{26.50}{\text{mol}} \quad \frac{79.90}{\text{mol}} \]
\[ \frac{2.37}{\text{mol}} \times \frac{46}{\text{g}} \quad \frac{39.19}{\text{mol}} \times \frac{78}{\text{g}} \quad \frac{14}{\text{mol}} \times \frac{4}{\text{g}} \]

3.) Which has \( \lambda_{\text{de Broglie}} \) equal to twice that of \(^{16}\text{O}\) at the same speed?  
A.) \(^{32}\text{S}\)  
B.) \(^{24}\text{Mg}\)  
C.) \(^{20}\text{Ne}\)  
D.) \(^{8}\text{B}\)  
E.) \(^{4}\text{He}\)

4.) Including the structure below, how many structural isomers of propanol exist?  
\[ \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{OH} \]
A.) 4  
B.) 3  
C.) 2  
D.) 1  
E.) 0

5.) Which of the following amino acids is not chiral? (note: the H atoms are not shown)

A.)  
B.)  
C.)  
D.)  
E.)

6.) Which of the following molecules has an electric dipole moment?  
A.)  
B.)  
C.)  
D.)  
E.)
7.) Shown is the graph depicting the quantity of $P_4O_{10}$ accumulated in the oxidation of $P$ as a function of added $P$ for a fixed amount of $O_2$. Through which point would the graph pass for a similar reaction with access to half the amount of $O_2$?

(A.) 5  (B.) 4  (C.) 3  (D.) 2  (E.) 1

8.) A mixture of one-third $^{12}C$, one-third $^{16}O$, and one-third $^{18}O$ reacts to form pure $CO_2$. Which is the correct mass spectrum of the $CO_2$?

9.) How many grams of $CaCO_3$ are formed from the reaction of 56 g of $CaO$ and 56 g of $CO_2$?

A.) 44  B.) 56  (C.) 100  D.) 112  E.) 128

10.) Which of the following is entirely composed of ions that are isoelectronic with $Ar$?

A.) $NaBr$  B.) $CaBr_2$  C.) $MgCl_2$  D.) $NaCl$  (E.) KCl

11.) Shown is the standing wave electron wave function for $n=1$. For which $n$ will the wave function pass through all three points?

A.) 0  B.) 1  (C.) 2  (D.) 3  E.) 4
12.) The absorption spectrum of a given compound is shown below. What color does it appear under illumination with green light?

A.) black  B.) red  C.) green  D.) blue  E.) white

13.) Consider the electrolysis of 10 g of liquid water into hydrogen and oxygen gas. Approximately what volume of gas will be formed?

A.) ~ 1 m³  B.) ~ 1 L  C.) ~ 10 mL  D.) ~ 10 L  E.) ~ 1 kL

14.) Which of the following has a linear molecular structure?

A.) SO₂  B.) H₂S  C.) IF₂  D.) Cl₂  E.) NH₂

15.) Ionization energy (IE) is the energy required to remove an electron from an atom. For which pair X + Y below will transfer of an electron from X to Y occur at the longest distance to form ions X⁺ and Y⁻?

Part 2: Short Answer Problems (60 pts total)
Instructions: Enter answers in the boxes total. Show your work. Where requested write explanations in fifteen words or less.

(30 pts)
1. The minimum amount of energy a photon needs to eject an electron from a metal M, occurs in the infrared at $\lambda = 800 \text{nm}$.
   a) Sketch the photoelectric graph (i.e. $E_{\text{kinetic}}$ vs. $v$) for this metal using the given axes.
      \[ E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}) (3 \times 10^8)}{8 \times 10^{-9}} \approx 2.48 \times 10^{-19} \text{J} \]
      \[ \text{Plot: } E_{\text{kinetic}} = 2.48 \times 10^{-19} \text{J} \]
   b) What is the energy of an incident blue photon with $\lambda = 400 \text{nm}$?
      \[ E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}) (3 \times 10^8)}{4 \times 10^{-7}} = 5 \times 10^{-19} \text{J} \]
      Answer: $5 \times 10^{-19} \text{J}$
   c) What is the kinetic energy of an electron ejected from M by the photon in part b)?
      \[ E_{\text{kinetic}} = \frac{1}{2} mv^2 = \frac{1}{2} (2.5 \times 10^{-9}) v^2 \]
      \[ E_{\text{kinetic}} = 2.5 \times 10^{-9} \text{J} \]
      Answer: $2.5 \times 10^{-9} \text{J}$
   d) Calculate the de Broglie wavelength for the electron ejected in part c).
      \[ \lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{2.5 \times 10^{-9} \times 2.48 \times 10^{-19}} \approx 9.8 \times 10^{-10} \text{m} \]
      Answer: $9.8 \times 10^{-10} \text{m}$
   e) 800 nm light corresponds to transition $3 \rightarrow 1$ in the energy level diagram shown below. What $\lambda$ corresponds to the $4 \rightarrow 1$ transition?
      \[ \lambda = \frac{h}{E} = \frac{6.626 \times 10^{-34}}{5 \times 10^{-19}} \approx 1.3 \times 10^{-15} \text{m} \]
      Answer: 600 nm
2.) A compound containing only carbon and hydrogen, is combusted with oxygen.

a) Shown is a mass spectrum of the combustion products. Identify the products.

\[ C_2H_2 + 5O_2 \rightarrow 2CO_2 + H_2O \]

<table>
<thead>
<tr>
<th>Product 1:</th>
<th>Product 2:</th>
</tr>
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<tbody>
<tr>
<td>1 mol H_2O</td>
<td>2 mol CO_2</td>
</tr>
</tbody>
</table>

b) Based on the ratio of peak heights in the mass spectrum, determine the empirical formula of the unknown.

\[ C_xH_y + \frac{5}{2}C_2 \equiv 2CO_2 + H_2O \]
\[ 2C + H_2 + \frac{5}{2}O_2 \equiv 2CO_2 + 2H_2O \]

Answer: \( \text{CH} \)

c) The molecular mass of the unknown is 26 g/mol. What is its molecular formula?

\[ \frac{m}{\text{molar mass}} = \frac{26.02}{12.01} = 2.17 \]

Answer: \( C_2H_2 \)

d) Draw the Lewis electron dot structure for the unknown.

\[ H - C = C - H \]

Structure:

\[ H: C::C:H \]

e) Which is true for the H–C–C bond angle (\( \theta \)) in the unknown? Circle the appropriate answer and explain.

\[ \theta = 109.5^\circ \quad \theta = 120^\circ \quad \theta = 180^\circ \]

\[ \theta = 109.5^\circ \]

Explanation: The molecular structure is linear, and the central carbon, C, is bonded to another C and an H, and there are no lone pairs. The bond \( \theta \) is therefore 109.5°.