Chem. 1B Final
Practice

Name__________________________________________

Student Number _________________________________

All work must be shown on the exam for partial credit. Points will be taken off for incorrect or no units. Calculators are allowed. Cell phones may not be used for calculators. On fundamental and short answer problems you must show your work in order to receive credit for the problem. **If your cell phone goes off during the exam you will have your exam removed from you.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals</td>
<td>(of 72 possible)</td>
</tr>
<tr>
<td>Problem 1</td>
<td>(of 12 possible)</td>
</tr>
<tr>
<td>Problem 2</td>
<td>(of 11 possible)</td>
</tr>
<tr>
<td>Problem 3</td>
<td>(of 24 possible)</td>
</tr>
<tr>
<td>Problem 4</td>
<td>(of 21 possible)</td>
</tr>
<tr>
<td>Multiple Choice</td>
<td>(of 60 possible)</td>
</tr>
<tr>
<td>Extra Credit</td>
<td></td>
</tr>
<tr>
<td>Final Total</td>
<td>(of 200 possible)</td>
</tr>
</tbody>
</table>
**Fundamental Questions**

Each of these fundamental chemistry questions is worth 6 points. **You must show work to get credit.** Little to no partial credit will be rewarded. Make sure to include the correct units on your answers.

1) **6 pts**  
A bomb calorimetry experiment is performed with xylose, C₅H₁₀O₅(s), as the combustible substance. The data obtained include:
- Mass of xylose burned: 1.183g
- Heat capacity of calorimeter: 4.728kJ/°C
- Initial calorimeter temperature: 23.29°C
- Final calorimeter temperature: 27.19°C

What is the energy of combustion of xylose in kilojoules per mole?

2) **6 pts**  
Calculate the change in enthalpy using both thermodynamics data and dissociation energies for the following reaction.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) \]

3) **6 pts**  
Calculate the de Broglie wavelength associated with a 145 g baseball traveling at the speed of 168 \( \frac{\text{km}}{\text{h}} \). Do we need to use quantum mechanics to describe the properties of a baseball and why.
4) 6 pts  Balance the following in basic conditions:
\[ \text{Br}_2(l) \rightarrow \text{BrO}_5^{-(aq)} + \text{Br}^{-}(aq) \]

5a) 3 pts  How many orbitals can have the quantum numbers:
\[ n = 3 \]

2d

5b) 3 pts  How many electrons can have the quantum numbers:
\[ n = 3 \]

4d

4f_{xyz}

6) 6 pts  Calculate the wavelength of the line in the absorption line spectrum of hydrogen caused by the transition of the electron from an orbital with \( n = 8 \) to an orbital with \( n = 10 \).
7) 6 pts What are the electron configurations for:
   Tl
   Se-

8) 6 pts Calculate $E_{cell}$ for the following at 25°C
   \[ \text{Cu}(s)|\text{Cu}^{2+}(aq, 0.020 \text{ M})||\text{Cu}^{2+}(aq, 0.10 \text{ M})|\text{Cu}(s) \]

9a) 4 pts The rate of reaction
   \[ \text{NO}_2(g) + \text{CO}(g) \rightarrow \text{NO}(g) + \text{CO}_2(g) \]
   was determined in three experiments at 225°C. The results are given in the following table:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$[\text{NO}_2]_0$ (M)</th>
<th>$[\text{CO}]_0$ (M)</th>
<th>Initial Rate ($\text{mol L}^{-1} \text{s}^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.263</td>
<td>0.826</td>
<td>$1.44 \times 10^{-5}$</td>
</tr>
<tr>
<td>2</td>
<td>0.263</td>
<td>0.413</td>
<td>$1.44 \times 10^{-5}$</td>
</tr>
<tr>
<td>3</td>
<td>0.526</td>
<td>0.413</td>
<td>$5.76 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

   Determine the rate law for the reaction.

9b) 2 pts If the rate law was determined to be
   \[ \text{Rate} = k[\text{NO}_2]^{2.5}[\text{CO}]^{-0.33} \]
   Find $k$ (make sure to include units), using:

<table>
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<th>Initial Rate ($\text{mol L}^{-1} \text{s}^{-1}$)</th>
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<tr>
<td>1</td>
<td>0.263</td>
<td>0.826</td>
<td>$1.44 \times 10^{-5}$</td>
</tr>
</tbody>
</table>
10)  

For the reaction \( A \rightarrow B \) the following data was taken. Determine the order of the reaction and the value of \( k \) based on the following data:

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>( [A] \left( \frac{\text{mol}}{L} \right) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2.0</td>
<td>0.50</td>
</tr>
<tr>
<td>3.0</td>
<td>0.33</td>
</tr>
</tbody>
</table>

11a)  1 pts  
What is the Lewis symbol for Ga:

11b)  2.5 pts  
What is the Lewis structure of \( \text{CaCl}_2 \):

11c)  2.5 pts  
What is the Lewis structure of \( \text{H}_2\text{CO} \):

12)  6 pts  
What current is required to produce 2.5 g of chromium metal from chromium (VI) oxide in 12 h?
**Short Answer Questions**

Each of the following short answer questions are worth the noted points. Partial credit will be given. You must show your work to get credit. Make sure include proper units on your answer.

1a) 2 pts  The following mechanism is proposed for the reduction of $\text{NO}_3^-$ by $\text{MoCl}_6^{2-}$

\[
\begin{align*}
\text{MoCl}_6^{2-} & \rightleftharpoons k_1 \text{MoCl}_5^- + \text{Cl}^- \\
\text{NO}_3^- + \text{MoCl}_5^- & \rightarrow k_2 \text{OMoCl}_5^- + \text{NO}_2^-
\end{align*}
\]

What is the intermediate?

1b) 10 pts  Derive an expression for the rate law $\left(rate = \frac{d[\text{NO}_2^-]}{dt}\right)$ for the overall reaction using the steady-state approximation.
2) 11 pts Photodissociation of water

\[ \text{H}_2\text{O}(l) + \nu \rightarrow \text{H}_2(g) + \frac{1}{2}\text{O}_2(g) \]

has been suggested as a source of hydrogen. The \( \Delta H^\circ_{\text{rxn}} \) for the reaction, calculated from thermochemical data, is 285.8 kJ per mole of water decomposed. Calculate the maximum wavelength (in nm) that would provide the necessary energy. In principle is it feasible to use sunlight as a source of energy for this process?
3) 24 pts  A sample of water weighing 18.02 g, initially at 30.0°C, is heated to 140.0°C at a constant pressure of 1.00 atm. Calculate q, w, ΔE, ΔH, and ΔS for this process. The molar heat capacities (C_p) for liquid and gaseous water are 75.3 J/K·mol and 36.4 J/K·mol respectively — are assumed to be temperature independent. The enthalpy of vaporization is 40.7 kJ/mol. Assume ideal gas behavior.
4a) 6 pts  For each of the following
1) Write out the Lewis dot structure including all relevant resonance structures. Make sure all structures have minimized formal charges. Assume all structures have one central atom and all other atoms are bonded to the central atom.
2) Assign formal charges to every atom.
XeOF$_2$

4b) 6 pts  NCIO$_2$

4c) 9 pts  Arrange in order of increasing bond length:
SO$_2$, SO$_3$, and SO$_3^{2-}$.
You must show Lewis structures and give justification for your answer to receive full credit for this problem.
Lewis structures must obey the octet rule.
Multiple Choice Questions

Each of the following multiple choice questions are worth 5 points. **Your answers need to be filled in on the Scantron provided.**

Note: Your Scantrons will not be returned to you, therefore, for your records, you may want to mark your answers on this sheet. On the Scantron you need to fill in your perm number, test version, and name. **Failure to do any of these things will result in the loss of 1 point.** Your perm number is placed and bubbled in under the “ID number”. Do not skip boxes or put in a hyphen. In addition, leave bubbles blank under any unused boxes. The version number (A) is bubbled in under the “test form.”

1. Of the following five ions or molecules, which is the strongest reducing agent?
   A) \( \text{Cr}^{2+} \)
   B) \( \text{F}^- \)
   C) \( \text{H}_2 \)
   D) \( \text{Zn}^{2+} \)
   E) \( \text{Fe}^{2+} \)

2. The reaction
   \[
   2\text{A} + \text{B} \rightarrow \text{C}
   \]
   has the following proposed mechanism.
   
   Step 1: \( \text{A} + \text{B} \rightleftharpoons \text{D} \) (fast equilibrium)
   
   Step 2: \( \text{D} + \text{B} \rightarrow \text{E} \)
   
   Step 3: \( \text{E} + \text{A} \rightarrow \text{C} + \text{B} \)

   If step 2 is the rate-determining step, what should be the rate of formation of \( \text{C} \)?
   A) \( k[\text{A}][\text{B}] \)
   B) \( k[\text{A}]^2[\text{B}]^2 \)
   C) \( k[\text{A}] \)
   D) \( k[\text{A}]^2[\text{B}] \)
   E) none of these

3. Which of the following statements is false?
   A) A 2p orbital is more penetrating than a 2s; that is, it has a higher electron density near the nucleus and inside the charge cloud of a 1s orbital.
   B) An orbital can accommodate at most two electrons.
   C) In the usual order of filling, the 6s orbital is filled before the 4f orbital.
   D) The spin quantum number of an electron must be either +1/2 or –1/2.
   E) The electron density at a point is proportional to \( \psi^2 \) at that point.
4. For the elements Rb, F, and O, the order of increasing electronegativity is
   A) O < F < Rb.
   B) Rb < F < O.
   C) F < Rb < O.
   D) Rb < O < F.
   E) none of these

5. Which of the following statements is true?
   A) Only three quantum numbers are needed to uniquely describe an electron.
   B) Ni has 2 unpaired electrons in its 3d orbitals.
   C) We can determine the exact location of an electron if we know its energy.
   D) An electron in a 2s orbital can have the same $n$, $l$, and $m_l$ quantum numbers as an electron in a 3s orbital.
   E) In the building up of atoms, electrons occupy the 4f orbitals before the 6s orbitals.

6. An elementary process has an activation energy of 92 kJ/mol. If the enthalpy change for the reaction is $-62$ kJ/mol, what is the activation energy for the reverse reaction?
   A) 30 kJ/mol
   B) 92 kJ/mol
   C) 154 kJ/mol
   D) 62 kJ/mol
   E) none of these

7. Which of the following exhibits the correct orders (increasing) for atomic radius and ionization energy, respectively?
   A) F, S, O, and O, S, F
   B) S, F, O, and S, F, O
   C) F, O, S, and S, O, F
   D) S, O, F, and F, O, S
   E) none of these

8. From the following list of observations, choose the one that most clearly supports the conclusion that electrons have wave properties.
   A) the photoelectric effect
   B) cathode "rays"
   C) diffraction
   D) the emission spectrum of hydrogen
   E) the scattering of alpha particles by metal foil
9. Given the standard reaction enthalpies below:

\[
\begin{align*}
\text{N}_2(g) + \text{O}_2 &\rightarrow 2\text{NO}(g) \quad \Delta H^o = +180.5 \text{ kJ mol}^{-1} \\
2\text{NO}_2(g) &\rightarrow \text{N}_2(g) + 2\text{O}_2(g) \quad \Delta H^o = -66.4 \text{ kJ mol}^{-1}
\end{align*}
\]

calculate the standard reaction enthalpy for the oxidation of nitric oxide to nitrogen dioxide, shown below:

\[
2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g)
\]

A) \(+246.9 \text{ kJ mol}^{-1}\)  \\
B) \(-114.1 \text{ kJ mol}^{-1}\)  \\
C) \(-294.6 \text{ kJ mol}^{-1}\)  \\
D) \(+114.1 \text{ kJ mol}^{-1}\)  \\
E) none of these

10. Which of the following has the smallest radius?

A) \(\text{Br}^-\) \\
B) \(\text{Sr}^{2+}\) \\
C) \(\text{Rb}^+\) \\
D) \(\text{Se}^{2-}\) \\
E) \(\text{Kr}\)

11. In which of the following cases must \(E\) be equal to zero?

I. In any cell at equilibrium  
II. In a concentration cell  
III. \(E\) can never be equal to zero.

A) II only  
B) I and II  
C) I only  
D) III  
E) none of these

12. The reaction

\[
2\text{Cu}(s) + \text{CO}_2(g) \rightarrow 2\text{CuO}(s) + \text{C}(s)
\]

is endothermic. Which of the following statements is true?

A) The reaction will be spontaneous only at high temperatures.  
B) The reaction will be spontaneous only at low temperatures.  
C) The reaction is not spontaneous at any temperature.  
D) It is impossible to determine if the reaction is spontaneous without calculations.  
E) The reaction is spontaneous at all temperatures.