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 and for the incorrect number of significant figures. Calculators are allowed. On 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.**

<table>
<thead>
<tr>
<th>Fundamentals</th>
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<table>
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<th>Problem 1</th>
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<th>Problem 2</th>
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<thead>
<tr>
<th>Multiple Choice</th>
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<th>Extra Credit</th>
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<td>(of 200 possible)</td>
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Fundamental Questions
Each of these fundamental chemistry questions is worth 5 points. **You must show work to get credit.** Little to no partial credit will be rewarded. Make sure to report answers in the correct number of significant figures and with the proper units.

1) **5 pts** Draw a heating curve (Temperature vs. Heat Supplied) of H₂O. Make sure to include the value of the temperatures at boiling and freezing, clearly label where H₂O is a solid, a liquid, and a gas and indicate where ΔHᵥap and ΔH₉us are located.

![Heating Curve Diagram]

2) **5 pts** In class we had a balloon filled with H₂(g) and O₂(g). The balloon did not appear to undergo a chemical reaction until it was touched by a lit candle. At this point the balloon turned into a fireball. Students in the front row could feel heat from the fireball. The reaction was determined to be O₂(g) + 2H₂(g) → 2H₂O(g). Determine the signs of the following:

<table>
<thead>
<tr>
<th></th>
<th>w&lt;0</th>
<th>w&gt;0</th>
<th>w=0</th>
</tr>
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<tbody>
<tr>
<td>q&lt;0</td>
<td>q&gt;0</td>
<td>q=0</td>
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<tr>
<td>ΔH&lt;0</td>
<td>ΔH&gt;0</td>
<td>ΔH=0</td>
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<tr>
<td>ΔS&lt;0</td>
<td>ΔS&gt;0</td>
<td>ΔS=0</td>
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<tr>
<td>ΔG&lt;0</td>
<td>ΔG&gt;0</td>
<td>ΔG=0</td>
<td></td>
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3) **5 pts** The following data was collected for the reaction

A + B → C + D

Eₐ=161 kJ/mol

k=1.94×10⁻⁴ s⁻¹/mol at 30.0°C

What is k at 40.0°C?
4) 5 pts  What is wavelength associated with an electron traveling at $3.0 \times 10^7 \text{ m/s}$?

5) 5 pts  Determine the number of orbitals that can have the following designation 3f

\[ n = 2 \]

Determine the number of electrons that can have the following designation 3d$_{\pi 2}$

6d

6) 5 pts  Identify if the following reactions are redox reactions or not. If they are redox reactions, specify what is oxidized and what is reduced.

\[
\text{Cu(OH)}_2(s) + 2\text{HNO}_3(aq) \rightarrow \text{Cu(NO}_3)_2(aq) + 2\text{H}_2\text{O(l)}
\]

\[
\text{Fe}_2\text{O}_3(s) + 3\text{CO(g)} \rightarrow 2\text{Fe(s)} + 3\text{CO}_2(g)
\]
7) 5 pts  
Determine the rate law from the following mechanism.

\[ \text{H}_2\text{S} \rightleftharpoons \text{H}^+ + \text{HS}^- \text{ fast equilibrium} \]
\[ \text{Cl}_2 + \text{HS}^- \rightarrow \text{H}^+ + 2\text{Cl}^- + \text{S} \text{ slow} \]

Indicate if the reaction contains intermediates or catalysts and which substances they are.

8) 5 pts  
Circle the option that best fits each of the following descriptions:

- Smallest atomic radius: Na, Si, S, Al
- Largest ionic radius: Na\(^+\), O\(^2-\), Mg\(^{2+}\), F
- Least polar bond: C-N, C-O, O-H
- Greatest electronegativity: Al, C, Na, N
- Smallest first ionization energy: K, Na, Mg

9) 5 pts  
Determine if energy is absorbed or emitted when an electron transitions from the n=7 to the n=2 level of C\(^{5+}\) and the wavelength of the photon associated with the transition?
10) 5 pts  A piece of iron of mass 20.0 g at 100.°C is placed in a vessel of negligible heat capacity but containing 50.7 g of water at 22.0°C. Calculate the final temperature of the water. Assume that there is no energy lost to the surroundings.

11) 5 pts  What is ΔS for 2.00 mol of CO₂ undergoing the following reaction at constant pressure CO₂(s,150 K) → CO₂(g, 195 K)? Given the following data: $T_{\text{sub}} = 195 \text{ K}$, $\Delta H_{\text{sub}} = 25.2 \frac{\text{kJ}}{\text{mol}}$, $C_{p_{\text{CO}_2(s)}} = 47.11 \frac{\text{J}}{\text{mol K}}$, and $C_{p_{\text{CO}_2(g)}} = 34.8 \frac{\text{J}}{\text{mol K}}$.

12) 5 pts  What wavelength of light is needed to excite an e⁻ from the ground state of a particle in a box that is 5.00×10⁻⁷ m long to the n=5 state?
**Short Answer Questions**

Each of the following short answer questions are worth the noted points. Partial credit will be given. Make sure to show work, report answers to the correct number of significant figures and use the proper units.

1a) 5 pts  Consider the galvanic cell based on the following half-reactions:

   \[
   \begin{align*}
   \text{Au}^{3+} + 3e^- & \rightarrow \text{Au} \quad E^\circ = 1.50 \text{ V} \\
   \text{Tl}^+ + e^- & \rightarrow \text{Tl} \quad E^\circ = -0.34 \text{ V}
   \end{align*}
   \]

   Determine the overall cell reaction and calculate \( E^\circ_{\text{cell}} \).

1b) 5 pts  Calculate \( \Delta G^\circ \) and \( K \) for the cell reaction at 25°C.

1c) 6 pts  Calculate \( E_{\text{cell}} \) at 25°C when \( [\text{Au}^{3+}] = 1.0 \times 10^{-2} \text{ M} \) and \( [\text{Tl}^+] = 1.0 \times 10^{-4} \text{ M} \).
It takes 208.4 kJ of energy to remove one mol of electrons from the atoms on the surface of rubidium metal. If rubidium metal is irradiated with 254-nm light, what is the maximum kinetic energy the released electrons can have?
3a) \(6 \text{ pts}\) 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.
2) Assign formal charges to every atom.

\(\text{XeOF}_4\)

3b) \(6 \text{ pts}\) \(\text{NO}_3^-\)

3c) \(5 \text{ pts}\) The following Lewis structure was drawn for a Period 3 element. Identify the element

\[
\begin{array}{c}
\text{Cl} \quad \text{Cl} \\
\text{O} \quad \text{O} \\
\text{Cl} \quad \text{Cl}
\end{array}
\]
4a) 6 pts The bromination of acetone is acid-catalyzed:

\[
\text{CH}_3\text{COCH}_3 + \text{Br}_2 \xrightleftharpoons{H^+} \text{CH}_3\text{COCH}_2\text{Br} + \text{H}^+ + \text{Br}^-
\]

<table>
<thead>
<tr>
<th>[CH\text{\textsubscript{3}}COCH\text{\textsubscript{3}}]\text{\textsubscript{o}} (M)</th>
<th>[Br\text{\textsubscript{2}}]\text{\textsubscript{o}} (M)</th>
<th>[H\text{\textsuperscript{+}}]\text{\textsubscript{o}} (M)</th>
<th>Rate of Disappearance of Br\text{\textsubscript{2}} (\text{mol L\textsuperscript{-1 s\textsuperscript{-1}}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>0.050</td>
<td>0.050</td>
<td>5.7\times10\textsuperscript{-3}</td>
</tr>
<tr>
<td>0.30</td>
<td>0.10</td>
<td>0.050</td>
<td>5.7\times10\textsuperscript{-5}</td>
</tr>
<tr>
<td>0.30</td>
<td>0.050</td>
<td>0.10</td>
<td>1.2\times10\textsuperscript{-4}</td>
</tr>
<tr>
<td>0.40</td>
<td>0.050</td>
<td>0.20</td>
<td>3.1\times10\textsuperscript{-4}</td>
</tr>
<tr>
<td>0.40</td>
<td>0.050</td>
<td>0.050</td>
<td>7.6\times10\textsuperscript{-5}</td>
</tr>
</tbody>
</table>

What is the rate law?

4b) 5 pts If the rate law was determined to be

\[
\text{rate} = k[\text{CH}_3\text{COCH}_3][\text{Br}_2]^{0.7}[\text{H}^+]^2
\]

And the following data was collected

<table>
<thead>
<tr>
<th>[CH\text{\textsubscript{3}}COCH\text{\textsubscript{3}}]\text{\textsubscript{o}} (M)</th>
<th>[Br\text{\textsubscript{2}}]\text{\textsubscript{o}} (M)</th>
<th>[H\text{\textsuperscript{+}}]\text{\textsubscript{o}} (M)</th>
<th>Rate of Disappearance of Br\text{\textsubscript{2}} (\text{mol L\textsuperscript{-1 s\textsuperscript{-1}}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>0.20</td>
<td>0.050</td>
<td>6.3\times10\textsuperscript{-4}</td>
</tr>
</tbody>
</table>

What is k? Remember to include units.
5a) 4 pts What is the electron configurations and number of unpaired e\(^-\) of: 
Po

5b) 4 pts What is the electron configurations and number of unpaired e\(^-\) of: 
As\(^{2-}\)

5c) 4 pts An ion having a 4\(^+\) charge and a mass of 8.286\times10^{-26} \text{ kg} has two s electrons with n=1, eight electrons with n = 2, and nine electrons with n = 3. What is the atomic number of the ion?
A technician carries out the reaction \(2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})\) at 25°C and 1.00 atm in a constant-pressure cylinder fitted with a piston. Initially, 0.0300 mol \(\text{SO}_2\) and 0.0300 mol \(\text{O}_2\) are present in the cylinder. The technician then adds a catalyst to initiate the reaction. How much work takes place, and is it done by the system or on the system. Assume that the reaction goes to completion and the temperature of the system is constant.

What is the change in enthalpy for the reaction in J?

What is the change in internal energy for the reaction in J?
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.

1. As the number of bonds between two carbon atoms increases, which one of the following decreases?
   A) the bond energy
   B) the bond length
   C) the number of electrons between the carbon atoms
   D) all of these
   E) none of these

2. Of the following five ions or molecules, which is the strongest reducing agent?
   A) Cl₂
   B) Fe²⁺
   C) Cr²⁺
   D) F⁻
   E) H₂

3. Ammonium metavanadate reacts with sulfur dioxide in acidic solution as follows (hydrogen ions and H₂O omitted):
   \[ x\text{VO}_3^- + y\text{SO}_2 \rightarrow x\text{VO}^{2+} + y\text{SO}_4^{2-} \]
   The ratio \( x : y \) is
   A) 2 : 1
   B) 1 : 1
   C) 1 : 3
   D) 1 : 2
   E) None of the Above

4. Cations are ________ than/as their parent atom.
   A) the same size
   B) Larger
   C) Smaller
5. Which of the following statements is(are) true?
   I. An excited atom can return to its ground state by absorbing electromagnetic radiation.
   II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
   III. The energy of electromagnetic radiation increases as its frequency increases.
   IV. An electron in the \( n = 4 \) state in the hydrogen atom can go to the \( n = 2 \) state by emitting electromagnetic radiation at the appropriate frequency.
   V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.
   A) III, IV, V
   B) I, II, IV
   C) II, III, IV
   D) III, V
   E) I, II, III

6. Which of the following statements is false?
   A) The spin quantum number of an electron must be either \( +\frac{1}{2} \) or \( -\frac{1}{2} \).
   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 electron density at a point is proportional to \( \psi^2 \) at that point.
   E) 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.

7. The following reaction has a \( \Delta G^\circ \) value of 42.6 kJ/mol at 25°C.
   \[
   \ce{HB(aq) + H2O(l) <=> H3O^+(aq) + B^-(aq)}
   \]
   Calculate \( K_a \) for the acid HB.
   A) \( 3.41 \times 10^{-8} \)
   B) 14.0
   C) 42,600
   D) \(-17.2\)
   E) 1.63

8. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be \( 3.31 \times 10^{-3} \) pm. Which element is this?
   A) P
   B) He
   C) Ca
   D) F
   E) Be
9. Using the following bond energies:

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond Energy (kJ/mol)</th>
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<tbody>
<tr>
<td>C≡C</td>
<td>839</td>
</tr>
<tr>
<td>C-H</td>
<td>413</td>
</tr>
<tr>
<td>O=O</td>
<td>495</td>
</tr>
<tr>
<td>C=O</td>
<td>799</td>
</tr>
<tr>
<td>O-H</td>
<td>467</td>
</tr>
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estimate the heat of combustion for 1 mol of acetylene:
C\(_2\)H\(_2\)(g) + 5/2O\(_2\)(g) → 2CO\(_2\)(g) + H\(_2\)O(g)

A) –447 kJ  
B) +365 kJ  
C) –1228 kJ 
D) 1228 kJ  
E) +447 kJ

10. At constant pressure, the reaction
2NO\(_2\)(g) → N\(_2\)O\(_4\)(g)
is exothermic. The reaction (as written) is

A) never spontaneous.  
B) always spontaneous.  
C) spontaneous at low temperatures but not at high temperatures.  
D) spontaneous at high temperatures but not at low temperatures.

11. At 25°C, the following heats of reaction are known:

\[
\begin{align*}
2\text{C}_2\text{H}_2 + 5\text{O}_2 & \rightarrow 4\text{CO}_2 + 2\text{H}_2\text{O} & \Delta H = –2600.0 \text{ kJ} \\
\text{C} + \text{O}_2 & \rightarrow \text{CO}_2 & \Delta H = –394 \text{ kJ} \\
2\text{H}_2 + \text{O}_2 & \rightarrow 2\text{H}_2\text{O} & \Delta H = –572 \text{ kJ}
\end{align*}
\]

At the same temperature, calculate \(\Delta H\) for the following reaction:

\[
2\text{C} + \text{H}_2 \rightarrow \text{C}_2\text{H}_2
\]

\(\Delta H = ?\)

A) 2422 kJ  
B) 226 kJ  
C) -2422 kJ  
D) -226 kJ  
E) none of these

12. The rate constant \(k\) is dependent on

A) the temperature.  
B) the concentration of the reactant.  
C) the order of the reaction.  
D) the concentration of the product.  
E) none of these