Organic Chemistry

1. Give the IUPAC name for the following compounds. (6 pt.)

\[
\begin{align*}
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 & \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 & \quad \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 \\
\end{align*}
\]

2. From the following list, alkene, alkyne, halide, alcohol, aldehyde, ketone, carboxylic acid, amine, amide, or ether, identify four functional groups in the compound below. (4 pt.)

\[
\text{HO-} -\text{O-} -\text{NH}_2\text{CO}_2\text{H}
\]

triiodothyronine, T3
Chemical Kinetics

3. Kinetic data for the following reaction was determined experimentally.
   \[ yY + zZ \rightarrow \text{products} \]

<table>
<thead>
<tr>
<th>Experiment Number</th>
<th>Initial Concentration (mol/L) [Y]</th>
<th>Initial Concentration (mol/L) [Z]</th>
<th>Initial Rate of Reaction (mol/L•s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.100</td>
<td>0.100</td>
<td>4.0\times10^{-5}</td>
</tr>
<tr>
<td>2</td>
<td>0.200</td>
<td>0.100</td>
<td>1.6\times10^{-4}</td>
</tr>
<tr>
<td>3</td>
<td>0.100</td>
<td>0.200</td>
<td>8.0\times10^{-5}</td>
</tr>
</tbody>
</table>

a. Determine the rate law for the reaction. (4 pt.)

b. Determine the value of the rate constant. (2 pt.)

c. What is the overall order of the reaction? (1 pt.)

4. It takes 42.0 min for the concentration of a reactant in a first-order reaction to drop from 0.45 M to 0.32 M at 25°C. What is the half-life of the reaction? (3 pt.)
Equilibrium
5. Use the following reaction to answer questions a-e.

\[ 2 \text{HCl(g)} + \text{I}_2(s) \rightleftharpoons 2\text{HI(g)} + \text{Cl}_2(g) \quad \Delta H^\circ = -47.8 \text{ kJ/mol} \quad K_c = 4.4 \times 10^{-36} \text{ at } 600. \text{ K} \]

a. Write the expression for \( K_c \) and \( K_p \) (2 pt.)

b. Calculate the value of \( K_p \) (2 pt.)

c. If \( Q = 20.0 \), what must happen for the reaction to reach equilibrium? (Do more reactants have to be converted to products or products into reactants?) (1 pt.)

d. Are reactants or products more plentiful at equilibrium? (1 pt.)

e. Determine the effect on the equilibrium (circle one of the following: shift left, no change, shift right) when the following changes take place. (5 pt)

<table>
<thead>
<tr>
<th>Change Description</th>
<th>Shift left</th>
<th>No Change</th>
<th>Shift right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease the volume</td>
<td>Shift left</td>
<td>No Change</td>
<td>Shift right</td>
</tr>
<tr>
<td>Increase the temperature</td>
<td>Shift left</td>
<td>No Change</td>
<td>Shift right</td>
</tr>
<tr>
<td>Adding Cl_2(g)</td>
<td>Shift left</td>
<td>No Change</td>
<td>Shift right</td>
</tr>
<tr>
<td>Removing HCl(g)</td>
<td>Shift left</td>
<td>No Change</td>
<td>Shift right</td>
</tr>
<tr>
<td>Add a catalyst</td>
<td>Shift left</td>
<td>No Change</td>
<td>Shift right</td>
</tr>
</tbody>
</table>
6. A mixture of 5.0 moles of \( \text{N}_2 \) and 5.0 moles of \( \text{O}_2 \) is placed in a 1.00 liter container at a given temperature and allowed to reach equilibrium according to the following equation. Calculate the concentrations of all species present at equilibrium. (6 pt)

\[
\text{N}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}(g) \quad K_c = 100
\]
Acids and Bases

7. Circle the one in each pair below that would be a stronger acid. (4 pt.)
   a. $\text{H}_2\text{SeO}_3$ $\text{H}_2\text{SeO}_4$
   b. $\text{HBrO}_2$ $\text{HIO}_2$
   c. $\text{H}_2\text{O}$ $\text{H}_2\text{S}$
   d. $\text{NH}_3$ $\text{AsH}_3$

8. In the reaction below, label the acid (A), the base (B), the conjugate acid (CA), the conjugate base (CB). (4 pt.)

   $\text{CH}_3^- + \text{NH}_3 \rightarrow \text{CH}_4 + \text{NH}_2^-$

9. Indicate in the example below which is the Lewis acid (LA) and which is the Lewis Base (LB). (2 pt.)

   $\text{NH}_3 + \text{AlCl}_3 \rightarrow \text{NH}_3\text{AlCl}_3$
Aqueous Equilibrium
10. Of the following six (a-f) aqueous equilibrium problems, attempt to solve four (4), and only four. (9 pt. each, total of 36 pt.)

a. Calculate the pH of a 0.020 M telluric acid solution, H$_2$TeO$_4$, that has the stepwise dissociation constants of $K_{a1} = 2.1 \times 10^{-8}$, and $K_{a2} = 6.5 \times 10^{-12}$. What is the concentration of TeO$_4^{2-}$ at equilibrium?

b. The pH of 0.10 M C$_4$H$_9$NH$_2$(aq), butylamine, was measured as 11.84. What are the values of $K_b$ and $pK_b$ of butylamine?
c. The pH of a 0.15 M solution of NaZ (the sodium salt of HZ) is 10.7. What is the $K_a$ for HZ?

d. What is the pH of a solution prepared by dissolving 0.35 mol of solid NaF in 1.00 L of 1.1 M HF. $K_a = 7.1 \times 10^{-4}$ for HF.

Compare the % dissociation of HF in the buffer and that of 1.1 M HF (using calculations).
e. The solubility of AuCl₃ (as Au³⁺ and Cl⁻) in water at 298 K is 3.3x10⁻⁷ M. What is $K_{sp}$ for AuCl₃?

f. The $K_{sp}$ of Ag₂S is 1.0x10⁻⁵¹. What is the molar solubility of Ag₂S?

11. Which of the following compounds will be more soluble in acidic solution than in water? (3 pt)
(a) Ag₂S (b) Ag₂CO₃ (c) SnI₂
Thermodynamics and Electrochemistry.

12. The entropy change on vaporization ($\Delta S_{\text{vap}}$) of a compound or element is: (1 pt)
   
   A. always negative.
   B. always positive.
   C. sometimes is positive and sometimes is negative.

13. Hydrogen peroxide ($\text{H}_2\text{O}_2$) decomposes according to the equation
   \[ \text{H}_2\text{O}_2(\text{l}) \rightarrow \text{H}_2\text{O}(\text{l}) + (1/2)\text{O}_2(\text{g}). \]

   Calculate K for this reaction at 25°C. ($\Delta H^\circ = -98.2 \text{ kJ/mol}, \Delta S^\circ = 70.1 \text{ J/K-mol}$) (3 pt)
Consider the following electrochemical cell: \( \text{Zn(s)} \mid \text{Zn}^{2+} (aq) \parallel \text{Ag}^+ (aq) \mid \text{Ag(s)} \)

14. Identify the anode and cathode compartments. (2 pt)

15. Calculate the cell potential, at 25°C, given the following reduction potentials (3 pt)
   \[
   \begin{align*}
   \text{Ag}^+ (aq) + e^- & \rightarrow \text{Ag(s)} \quad +0.80 \text{ V} \\
   \text{Zn}^{2+} (aq) + 2e^- & \rightarrow \text{Zn(s)} \quad -0.76 \text{ V}
   \end{align*}
   \]

16. Calculate \( \Delta G^\circ \) for the reaction. (3 pt.)

17. Calculate the equilibrium constant, \( K \), for the reaction. (2 pt.)