General Chemistry II Test II

1. Vapor pressure of dichloromethane(CH₂Cl₂) is 0.98 atm at 15°C. If 0.12 grams of camphor (C₁₀H₁₆O) is dissolved in 150 grams of CH₂Cl₂, what will be the vapor pressure of the solution?

2. a. What is the Van't Hoff factor value for the solutions of NaNO₃?
b. What is the osmotic pressure of a 0.005 M aqueous solution of NaNO₃ at 36.9 °C?

3. For the reaction 2NO₂ + Cl₂ → 2 NO₂Cl following observations were made.
   When the concentration of NO₂ was increased by a factor of 3 (maintaining the concentration of Cl₂ the same) the rate of the reaction increased by a factor of 9. At constant NO₂ concentration changing the concentration of Cl₂ does not affect the rate of the reaction.
   a. Determine the rate law for this reaction.
   b. If you start with 0.425 M of Cl₂ and 0.150 M NO₂, what will be the concentration of NO₂ after 59.5 minutes if the rate constant for this reaction is 1.35 x 10⁻³ M/Sec?
   c. What is the half life for this reaction?

4. The concentrations each species in the following reaction were analyzed at equilibrium
   2 NO₂(g) + O₂(g) ⇌ 2 NO₃(g)
   \([NO₂]_{eq} = 2.5 \times 10^{-2} \text{ M}, [O₂]_{eq} = 2.5 \times 10^{-3} \text{ M}, [NO₃]_{eq} = 5.5 \times 10^{-7} \text{ M} \]
   a. Calculate the equilibrium constant
   b. If 25 % of NO₂ were removed from the reaction mixture, determine which direction the equilibrium shifts.

5. The reaction of decomposition of H₂O₂ has a half life of 6.82 min. at 39 °C and follows the rate law Rate = k [H₂O₂] . If you start with 2.5 x 10⁻² moles of H₂O₂, determine the amount H₂O₂ reacted in 2.5 hours.

6. Compounds CH₃OH, CH₃COOH and H⁺ react according to the following equation:
   CH₃OH + CH₃COOH + H⁺ ⇌ CH₃COOCH₃ + H₃O⁺
   Following are the data collected at 78.2 °C

<table>
<thead>
<tr>
<th>Exp #</th>
<th>[CH₃OH]</th>
<th>[CH₃COOH]</th>
<th>[H⁺]</th>
<th>Initial rate (sec⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.15</td>
<td>0.25</td>
<td>0.50</td>
<td>2.4 x 10⁻⁶</td>
</tr>
<tr>
<td>2.</td>
<td>0.15</td>
<td>0.75</td>
<td>0.50</td>
<td>7.3 x 10⁻⁶</td>
</tr>
<tr>
<td>3.</td>
<td>0.15</td>
<td>0.25</td>
<td>0.10</td>
<td>2.5 x 10⁻⁶</td>
</tr>
<tr>
<td>4.</td>
<td>0.30</td>
<td>0.75</td>
<td>0.20</td>
<td>2.9 x 10⁻⁵</td>
</tr>
<tr>
<td>5.</td>
<td>0.60</td>
<td>0.25</td>
<td>0.40</td>
<td>3.8 x 10⁻⁵</td>
</tr>
</tbody>
</table>

   a. Write the general rate expression
   b. Determine the order of reaction with respect to each of the reactant
   c. Determine the overall order of the reaction
   d. Determine the rate constant for this reaction
7. The reaction $2 \text{H}_2\text{O}_2(\text{aq}) \rightarrow 2 \text{H}_2\text{O}(l) + \text{O}_2(\text{g})$ is found to be a first order reaction. The rate constant for this reaction is $1.06 \times 10^{-3} \text{ min}^{-1}$. If a reaction is started with 0.020 moles of $\text{H}_2\text{O}_2$, how long will it take for 0.002 moles of it to disappear?

8. A reaction follows the following mechanistic steps:
   1. $\text{O}_3 + \text{NO} \rightarrow \text{O} + \text{NO}_3$
   2. $\text{O} + \text{CF}_3\text{Cl} \rightarrow \text{CF}_3 + \text{ClO}$
   3. $\text{ClO} + \text{O}_3 \rightarrow \text{Cl} + 2\text{O}_2$
   4. $\text{Cl} + \text{CF}_3 \rightarrow \text{CF}_3\text{Cl}$
   5. $\text{NO}_3 + \text{O}_3 \rightarrow \text{NO}_2 + 2\text{O}_2$
   a. Determine the overall reaction.
   b. Is this reaction a catalytic reaction? If so what is the catalyst?
   c. If there are any intermediates in this reaction, mention them.
   d. If this reaction is an overall 4th order reaction and it is first order in $\text{CF}_3\text{Cl}$ and first order in $\text{NO}$, give the rate law for this reaction.
   e. In that case, which of the shown steps must be the slow step? Why?

9. Draw an energy diagram for an exothermic reaction that occurs in two steps. Label activation energy, transition state(s) and intermediate(s).

10. a. Name the three major factors that affect the rate of a chemical reaction.
   b. With the help of an energy diagram, show how any two of these affect the rate of reaction in terms of activation energy. (Use backside of this page)

**Bonus:** For a reaction with activation energy ($E_a$) of 20 kJ/mole, at what temperature does the rate of the reaction triple compared to that at 280 K?

**Part II** Multiple Choice Select the best answer (33 points)

1. If the rate constant of the forward reaction is 5 times larger compared to that of reverse reaction, the equilibrium constant for that reaction is
   a. 4   b. 6   c. 5   d. 0.2

2. If the concentration of reactant is determined at regular intervals of time and if the plot of $\ln [A]t$ versus time is found to be non linear, the reaction must
   a. be first order   b. be zero order   c. not be first order   d. be second order

3. The initial rate of chemical reactions does not depend on
   a. concentration of products   b. temperature   c. catalyst   d. pressure of gaseous reactants

4. If a reaction is second order with respect to one of the reactants (say $A$), a reduction in the concentration of $A$ by a fourth will change the rate of reaction by a factor of
5. At the end of 2 half lives, the fraction of reactant disappeared is
   a. 1/4   b. 1/2   c. 3/4   d. 1/8

6. A third order reaction has
   a. three molecules on the reactant side of the chemical equation
   b. a total of three molecules involved
   c. three molecules reacting in the fastest step of the reaction
   d. three molecules reacting in the slowest step of the reaction

7. Increasing the temperature of the reaction would accelerate the reaction because at higher temperatures,
   a. bond making is easy b. the concentration of reactants increases
   c. bond breaking is easy d. product molecules do not compete with reactants

8. At equilibrium,
   a. the rates of forward and reverse reactions are equal
   b. the rate constants of forward and reverse reactions are equal
   c. concentrations of reactants and products are equal
   d. the ratio of product concentrations to reactant concentrations is 1

9. Catalysts increase the rate of reaction because
   a. they increase the concentration of reactants
   b. they remove the products as they are formed
   c. they provide an easier pathway for the reactants to react
   d. they will increase the temperature thereby speeding up the reaction

10. This is not a colligative property of a solution
    a. elevation in boiling point b. depression in freezing point c. depression in the meniscus d. decrease in the vapor pressure

11. A reaction has a half life of 68.5 seconds. The fraction of the starting material reacted in 274 seconds is
    a. 0.25 b. 0.875 c. 6.25 d. 0.9375