Exp 2: Kinetics

1. Consider the following reaction: \[ 2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g) \]

Write expressions for the rate of the above reaction in terms of each of the products and reactants.

2. For the reaction
   \[ KMnO_4 + H_2C_2O_4 \rightarrow \text{product} \]
Write the general rate equation that describes this reaction.

3. For the reaction
   \[ A(g) + B(g) \rightarrow AB(g) \]
   whose rate expression is:
   \[ \text{Rate} = k[A]^x[B]^y \]
   a) What is \( k \)?
   b) What do \([A]\) & \([B]\) represent?
   c) What do \(x\) & \(y\) represent?
   d) Write expressions for the rate of the above reaction (indicating the change with time) in terms of each of the products and reactants.

4. For the reaction between potassium permanganate and oxalic acid, what color(s) does one expect to observe and in what sequence do the color(s) occur?

5. For the reaction
   \[ 2ClO_2(g) + F_2(g) \rightarrow 2FCIO_2(g) \]
What is the order of this reaction? Explain your answer.

6. For the reaction
   \[ 2 \text{NO}(g) + \text{Cl}_2(g) \rightarrow 2 \text{NOCl}(g) \]

   the rate of the reaction was increased by a factor of eight when the concentrations of both NO and Cl\(_2\) were doubled. When only the concentration of Cl\(_2\) was doubled, the rate of reaction increased by a factor of two. The rate equation is:
   1.) \[ \text{Rate} = k[\text{NO}][\text{Cl}_2]^2 \]
   2.) \[ \text{Rate} = k[\text{NO}][\text{Cl}_2] \]
   3.) \[ \text{Rate} = k[\text{NO}]^2[\text{Cl}_2] \]
   4.) The rate cannot be determined

7. Given:
   \[ A + B \rightarrow C \]
   1 | 0.020 | 0.070 | 1 x 10\(^{-6}\)
   2 | 0.040 | 0.070 | 2 x 10\(^{-6}\)
   3 | 0.020 | 0.140 | 1 x 10\(^{-6}\)

   a. Use the data shown to determine the rate law.
   b. Calculate the order of the reaction with respect to each reactant.
   c. Calculate the overall order of the reaction.
   d. What is the value of the rate constant, \( k \)?

8. (10 pts) Given:
   \[ \text{SO}_2(g) + 2\text{H}_2(g) \rightarrow \text{S(s)} + 2\text{H}_2\text{O(g)} \]
   \[ \text{Rate} = k[\text{SO}_2]^x[\text{H}_2]^y \]
   Which of the following are true and which are false?
   
   _____ a. If you varied the concentration of SO\(_2\) and kept the concentration of H\(_2\) constant, we could determine the exponent \( y \).
   _____ b. If you varied the concentration of H\(_2\) and kept the concentration of SO\(_2\) constant, we can determine \( y \).
   _____ c. We could only determine the exponent \( y \) if we varied the concentration of H\(_2\), kept the concentration of SO\(_2\) constant, and know the value of \( k \).
   _____ d. Based upon the balanced chemical equation given, you may say the reaction is first order with respect to SO\(_2\) and second order with respect to H\(_2\).
   _____ e. The rate constant is independent of concentration of reactants at a given temperature.
9. The following data was obtained in a series of experiments on the reaction of nitric oxide with bromine at 273°C.

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

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Initial Concentration (M) NO</th>
<th>Initial Concentration (M) Br₂</th>
<th>Initial Rate of Formation of NOBr (mol/L sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10</td>
<td>0.10</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>0.10</td>
<td>0.20</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>0.10</td>
<td>0.30</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>0.20</td>
<td>0.10</td>
<td>48</td>
</tr>
<tr>
<td>5</td>
<td>0.30</td>
<td>0.10</td>
<td>108</td>
</tr>
</tbody>
</table>

From the data given, determine the rate law for the reaction.

10. If an added reagent does not affect the rate of a chemical reaction, what is the order of the reaction with respect to the reagent?

11. Consider the reaction

\[ 2\text{ClO}_2(g) + \text{F}_2(g) \rightarrow 2\text{FClO}_2(g) \]

Circle the statement(s) that is/are always true:

a. The overall order of this reaction is based on the coefficients in the reaction.
b. The overall order of the reaction is 3.
c. The reaction is second order with respect to the concentration of ClO₂.
d. The overall order of the reaction is determined experimentally.

12. Given: \[ 2\text{ClO}_2 (aq) + 2\text{OH}^- (aq) \rightarrow \text{ClO}_3^- (aq) + \text{ClO}_2^- (aq) + \text{H}_2\text{O} (l) \]

\[
\text{Rate} = \frac{[\text{ClO}_2]}{t}
\]

<table>
<thead>
<tr>
<th>[ClO₂] M</th>
<th>[OH⁻] M</th>
<th>Initial Rate, M/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.050</td>
<td>0.100</td>
<td>(5.75 \times 10^{-2})</td>
</tr>
<tr>
<td>0.100</td>
<td>0.100</td>
<td>(2.30 \times 10^{-1})</td>
</tr>
<tr>
<td>0.100</td>
<td>0.050</td>
<td>(1.15 \times 10^{-1})</td>
</tr>
</tbody>
</table>

Determine the order of the reaction with regard to ClO₂ and OH⁻ and write the rate law.

13. For the rate expression:

\[ \text{Rate} = k[\text{SO}_2][\text{H}_2] \]

(a) What is the overall rate?

(b) What is the rate with respect to SO₂?

(c) What is the rate with respect to H₂?

14. What does "order of reaction" mean? Provide an example.