SCHM 109 Lab Study Guide *for* Kinetics and Equilibrium Sec 001,003 & 005

A. Review all pre-lab questions, reports and post-lab questions.
B. Work the sample questions. Remember that all possible types of questions may not be represented.

Kinetics:

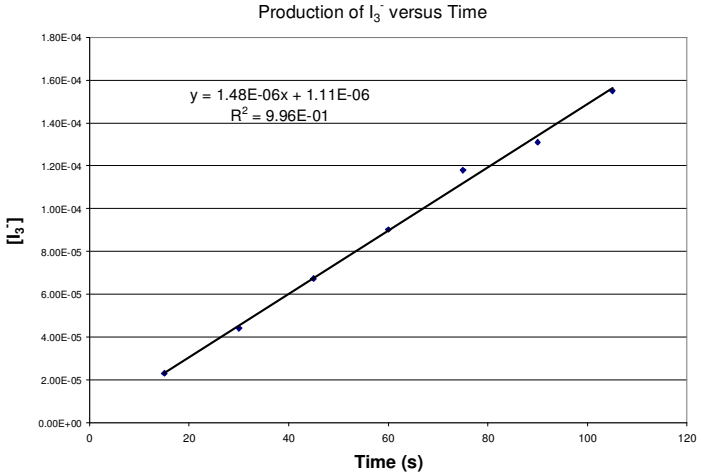
1. Based on the following results for the reaction: $A + B \rightarrow C$

Trial	[A] (in M)	[B] (in M)	Average Rate ($M \cdot s^{-1}$)	Std. Dev.
1	1.72E-03	1.38E-02	1.95E-08	5.22E-10
2	1.72E-03	2.76E-02	7.80E-08	3.72E-09
3	3.44E-03	1.38E-02	3.90E-08	4.75E-10

   a) Write a general rate law for the reaction
   b) Calculate the order (n,m) of the reaction with respect to each reactant.
   c) Calculate k for the rate law using trial 1.
   d) Propose a specific rate law for this reaction.

2. For the reaction we studied: $6H^+ + IO_3^- + 8I^- \rightarrow 3\,I_3^- + 3H_2O$
   a) Which was the species used to follow the progress of the reaction? Why?
   b) Using Beer's Law (A = a b c) calc. the concen., c, (in M) for a sample reading $A_{353} = 0.042$ ($a = 26{,}400\ cm^{-1}M^{-1}$, b = 1.08 cm)

3. Given the following plot of concentration of I_3^- versus reaction time, determine the rate of the reaction.



Equilibrium:

1. Given the following equilibrium: $2CrO_4^{2-} + 2H^+ \rightleftarrows Cr_2O_7^{2-} + H_2O$
   a) Adding sulfuric acid (H_2SO_4) to the yellow chromate solution (CrO_4^{2-}) results in a persisting orange color; explain the observed change.
   b) Adding then a sodium hydroxide solution (NaOH), reverts the color to yellow; explain the observed change with the aid of chemical equations.
   c) Write the equilibrium constant expression in terms of concentration of reactants and products.

2. Given the following data for the equilibrium: $Fe^{3+} + SCN^- \rightleftarrows Fe(SCN)^{2+}$

tube	A_{456}	$[Fe(SCN)^{2+}]$ (M)	Total $[Fe^{3+}]$ (M)	Free $[Fe^{3+}]$ (M)	Free $[SCN^-]$ (M)	K_{eq}
1	0	0.00E+00	0.0E+00	0.0E+00	2.00E-04	NA
2	0.009	1.97E-06	5.0E-05	4.8E-05	1.98E-04	

   a) Write the expression for the equilibrium constant K_{eq}
   b) Find the values for the equilibrium constant for tube 2.
   c) Why were we able to follow this equilibrium with a spectrometer?

SCHM 109 Lab **Key** Study Guide *for* Kinetics and Equilibrium Sec 001,003 & 005

A. Review all pre-lab questions, reports and post-lab questions.
B. Work the sample questions. Remember that all possible types of questions may not be represented.

Kinetics:

4. Based on the following results for the reaction: A + B → C

Trial	[A] (in M)	[B] (in M)	Average Rate ($M \cdot s^{-1}$)	Std. Dev.
1	1.72E-03	1.38E-02	1.95E-08	5.22E-10
2	1.72E-03	2.76E-02	7.80E-08	3.72E-09
3	3.44E-03	1.38E-02	3.90E-08	4.75E-10

a) Write a general rate law for the reaction

Rate = $k[A]^m[B]^n$

b) Calculate the order (m,n) of the reaction with respect to each reactant.

See the third exam Study Guide Key on my web site for an example calculation.
For determining m, compare trials 3 and 1. You must show the full work and find that m = 1.
For determining n, compare trials 2 and 1. You must show the full work and find that n = 2.

c) Calculate k for the rate law using trial 1.

$1.95E-08 = k(1.72E-03)(1.38E-02)^2$
Solve for k. The value for $k = 5.95 \times 10^{-2}\ M^{-2}\ s^{-1}$

d) Propose a specific rate law for this reaction.

Rate = $5.95 \times 10^{-2}\ M^{-2}\ s^{-1}\ [A]\ [B]^2$

5. For the reaction we studied: $6H^+ + IO_3^- + 8I^- \rightarrow 3\ I_3^- + 3H_2O$

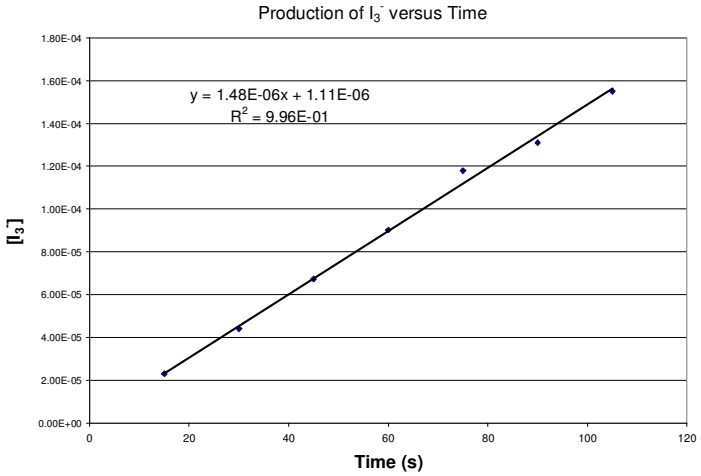
a) Which was the species used to follow the progress of the reaction? Why?

The species that was followed was I_3^-. This ion is colored and absorbs light in the range we are studying. The other ions are colorless.

b) Using Beer's Law (A = a b c) calc. the concen., c, (in M) for a sample reading $A_{353} = 0.042$ ($a = cm^{-1}M^{-1}$, b = 1.08 cm)

A = abc so c = A/(a)(b)
c = 0.042/ (26,400 x 1.08) = 1.5E-6

6. Given the following plot of concentration of I_3^- versus reaction time, determine the rate of the reaction.



The rate of the reaction is given by the slope of the trendline, which is 1.48E-6

Equilibrium:

1. Given the following equilibrium: $2CrO_4^{2-} + 2H^+ \rightleftarrows Cr_2O_7^{2-} + H_2O$

a) Adding sulfuric acid (H_2SO_4) to the yellow chromate solution (CrO_4^{2-}) results in a persisting orange color; explain the observed change.

$H_2SO_4 \rightarrow H^+ + HSO_4^-$

This increases the concentration of H^+. The collision rate between H^+ and CrO_4^{2-} increases. The rate of the forward reaction increases and the reaction shifts to the right.

b) Adding then a sodium hydroxide solution (NaOH), reverts the color to yellow; explain the observed change with the aid of chemical equations.

$NaOH \rightarrow Na^+ + OH^-$ and $OH^- + H^+ \rightarrow H_2O$

Sodium hydroxide dissociates completely in water to produce OH^-. This reacts with the H^+ in the solution, which reduces the concentration of H^+. The collision rate between H^+ and CrO_4^{2-} decreases. The rate of the forward reaction decreases and the reaction shifts to the left.

c) Write the equilibrium constant expression in terms of concentration of reactants and products.

$$K_{eq} = [Cr_2O_7^{2-}] / ([CrO_4^{2-}]^2[H^+]^2)$$

2. Given the following data for the equilibrium: $Fe^{3+} + SCN^- \rightleftarrows Fe(SCN)^{2+}$

tube	A_{456}	$[Fe(SCN)^{2+}]$ (M)	Total $[Fe^{3+}]$ (M)	Free $[Fe^{3+}]$ (M)	Free $[SCN^-]$ (M)	K_{eq}
1	0	0.00E+00	0.0E+00	0.0E+00	2.00E-04	NA
2	0.009	1.97E-06	5.0E-05	4.8E-05	1.98E-04	

a) Write the expression for the equilibrium constant K_{eq}

$$K_{eq} = [Fe(SCN)^{2+}] / ([Fe^{3+}][SCN^-])$$

b) Find the values for the equilibrium constant for tube 2.

$$K_{eq} = [1.97x10^{-6}] / ([4.8x10^{-5}][1.98x10^{-4}]) = 207$$

c) Why were we able to follow this equilibrium with a spectrometer?

Because our product is not colorless, we can measure its absorbance and determine its concentration. Because we know the balanced chemical equation, we can determine what amounts of Fe^{3+} and SCN^- are remaining at equilibrium.

Do not forget to review the other equilibria studied. Remember that heating and cooling can affect an equilibrium. Do you remember what exothermic and endothermic mean?