Chemistry 1212 Name KEY
February 24, 2012
Exam #2

Write very clearly and **show all of your work** for partial credit. A list of equations and constants as well as a periodic table are on the last two pages of your exam.

1.(20 points) Fill in the space with the correct response.

(a) Write the equilibrium expression for: $2HgO_{(s)} + H_2O_{(l)} + 2Cl_{2(g)} \rightarrow 2HOCl_{(aq)} + HgO{\bullet}HgCl_{2(s)}$

$$\boxed{K_c = \frac{\left[HOCl_{(aq)}\right]^2}{\left[Cl_{2(g)}\right]^2}}$$

(b) If K_p for the reaction above at 25°C is 20.0 what is K_c?

$$K_c = \frac{K_P}{(RT)^{\Delta n_g}} = \frac{20.0}{\left(0.0821\,\frac{L\bullet atm}{mol\bullet K} \times 298.15K\right)^{-2}} = 11984 = \boxed{1.20\times10^4}$$

(c) What is the half-life if the rate constant is $1.7 \times 10^{-3}\ s^{-1}$ and $[A]_0 = 1.00$ M?

$$t_{1/2} = \frac{0.693}{1.7\times10^{-3}s^{-1}} = \boxed{4.1\times10^2 s}$$

(d) If the units on the k constant are $\underline{M}^{-19}s^{-1}$ what is the overall order of the reaction? $\boxed{20}$

(e) If the rate for the consumption of oxygen gas is 2 M/s what is the rate of production of H_2O?

$$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$$

$$-\frac{1}{5}\frac{\Delta[O_2]}{\Delta t} = \frac{1}{6}\frac{\Delta[H_2O]}{\Delta t} \rightarrow \frac{\Delta[NO]}{\Delta t} = \frac{6}{5}\frac{\Delta[O_2]}{\Delta t} = \frac{6}{5}(2\ \underline{M}/s) = \boxed{2.4\ \underline{M}/s}$$

(f) What is the order of the reaction if you get a linear plot from concentration versus time? $\boxed{0^{th}}$

(g) How does K_c change if we reverse the reaction and multiple it by 3/2? $\boxed{(K_c)^{-3/2}}$

(h) Which side of the equation is favored if $K_c > 10^3$?

$\boxed{\text{products}}$

(i) What is the name we give to the number of successful collisions?

$\boxed{\text{A = frequency factor}}$

(j) If Q > K, then the reaction must proceed in the $\boxed{\text{reverse}}$ direction to re-establish equilibrium.

2. (20 points) The following data were obtained for the reaction:

$$A + B \rightarrow C$$

T (K)	[A]	[B]	Initial Rate (M/s)
298	0.100	0.100	5.00
298	0.200	0.100	40.00
298	0.350	0.200	428.8

(a) Determine the rate law. Show your work.
Comparison between experiments 1 & 2

$$\frac{rate_1}{rate_2} = \frac{5.00}{40.00} = \frac{\cancel{k}[A]_1^m[B]_1^n}{\cancel{k}[A]_2^m[B]_2^n} = \left(\frac{0.100}{0.200}\right)^m \cancel{\left(\frac{0.10}{0.10}\right)^n} \quad (3pts)$$

$$\frac{1}{8} = \left(\frac{1}{2}\right)^m \rightarrow m = 3$$

Comparison between experiments 2 & 3

$$\frac{rate_2}{rate_3} = \frac{40}{428.8} = \frac{\cancel{k}[A]_2^1[B]_2^n}{\cancel{k}[A]_3^1[B]_3^n} = \left(\frac{0.200}{0.350}\right)^3 \left(\frac{0.10}{0.20}\right)^n \quad (3pts)$$

$$\frac{40}{428/.8} \Big/ \left(\frac{0.200}{0.350}\right)^3 = 0.5 = \left(\frac{1}{2}\right)^m \rightarrow m = 1$$

$$\boxed{rate = k[A]^3[B]} \quad (2pts)$$

(b) What is the overall order of the reaction?

$$3 + 1 = \boxed{4} \quad (2pts)$$

(c) Determine the rate constant (with correct units).

$$rate = k[A]^3[B]$$

$$5.00\frac{mol}{L\bullet s} = k\left[0.100\frac{mol}{L}\right]^3\left[0.100\frac{mol}{L}\right] \rightarrow k = \boxed{5.00\times10^4 \frac{L^3}{mol^3\bullet s}} \quad (5pts)$$

(d) What would be the initial rate for an experiment with [A] = 0.0508M and [B] = 0.0844 M?

$$rate = k[A]^3[B]$$

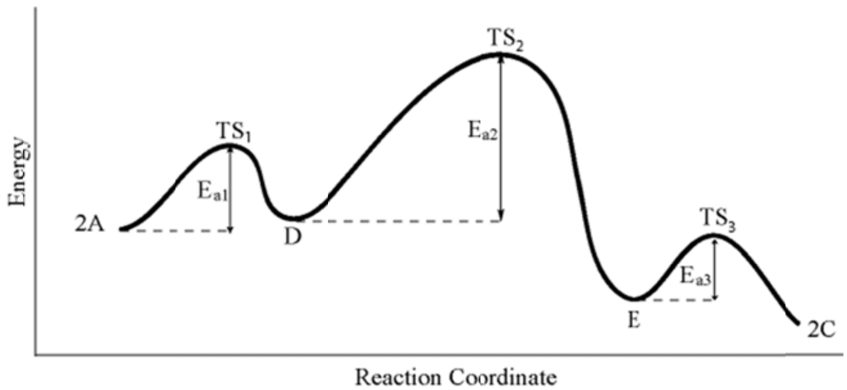
$$rate = 5.00\times10^4 \frac{L^3}{mol^3\bullet s}\left[0.0508\frac{mol}{L}\right]^3\left[0.0844\frac{mol}{L}\right] \rightarrow rate = \boxed{0.553\frac{mol}{L\bullet s}} \quad (5pts)$$

3. (10 points) For the reaction mechanism below draw the reaction profile showing each elementary step, the transition state(s), and the E_a(s). Make sure to properly place each species.

$$Step\,1: \quad 2A \rightarrow D\ (fast)$$

$$Step\,2: \quad D \rightarrow E\ (slow)$$

$$Step\,3: \quad E \rightarrow 2C\ (fast)$$



(1 pt) for axes labels
(3 pts) TS labels
(1 pt) for humps
(3 pts) Ea labels and hump size
(2 pts) for species placement

4. (18 points) When 1.000 mol of $C_5H_{11}N$ is introduced into a 1.000 L container at 500 K, only 3.63% will dissociate to give an equilibrium mixture. What is the equilibrium constant? In which direction would we go to re-attain equilibrium if we have the following concentrations: $\left[C_5H_{11}N_{(aq)}\right] = 0.100M$, $\left[OH^-_{(aq)}\right] = 0.100M$, and $\left[C_5H_{11}NH^+_{(aq)}\right] = 0.0100M$?

$$C_5H_{11}N_{(aq)} + H_2O_{(l)} \rightleftharpoons C_5H_{11}NH^+_{(aq)} + OH^-_{(aq)}$$

$$[C_5H_{11}N]_0 = \frac{1.000\ mol}{1.000\ L} = 1.000\ \underline{M} \quad (2\,pts)$$

$$x = \frac{3.63\%}{100\%} \bullet 1.000\ \underline{M} = 0.0363\underline{M} \quad (3\,pts)$$

	$C_5H_{11}N$	$C_5H_{11}N\ H^+$	OH-
Initial	1.000	0.0	0.0
Change	-0.0363	+0.0363	+0.0363
Eq	+0.9637	+0.0363	+0.0363

(2*pts* for table)

$$K_c = \frac{\left[H^+\right]\left[Cl^-\right]}{\left[HF\right]} = \frac{0.0363^2}{0.9637} = \boxed{1.37\times10^{-3}} \quad (3\,pts)$$

$$Q_c = \frac{\left[H^+\right]\left[Cl^-\right]}{\left[HF\right]} = \frac{0.100 \bullet 0.0100}{0.100} = 0.0100 \quad (3\,pts)$$

$Q_c > K_c$ the reaction need to go in the reverse direction to get back to eq $(3\,pts)$

5. (12 points) Will the amount of $NaHCO_3$ increase, decrease or remain the same when the equilibrium below is disturbed by one of the following stressors?

$$2NaHCO_{3(s)} \rightleftharpoons Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)} \quad \Delta H^\circ = +136\ kJ$$

(a) a decrease in volume	increase
(b) an increase in temperature	decrease
(c) an addition of water vapor	increase
(d) an addition of a catalyst	remain the same
(e) an addition of Ne	remain the same
(f) an increase in pressure	increase