CHM 1220 - Dang **Practice problems – Exam 1**

DO NOT ONLY study these problems for your EXAM. You are responsible for everything else that was discussed in class.

Question I: ***Multiple choices:*** Choose one best answer for each of the following question below

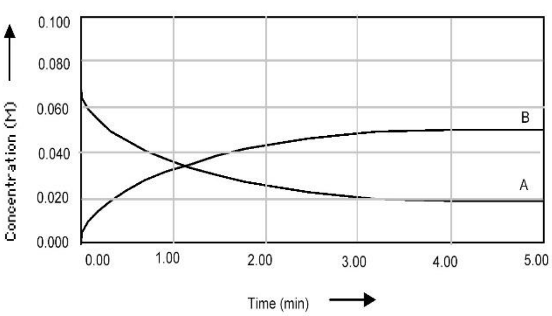
1. The equilibrium constant is given for one of the reactions below. Determine the value of the missing equilibrium constant.

$H_2(g) + Br_2(g) \rightleftharpoons 2\,HBr(g)$ $K_c = 3.8 \times 10^4$
$2\,HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$ $K_c = ?$

A) 1.9×10^4 B) 5.3×10^{-5}
C) 2.6×10^{-5} D) 6.4×10^{-4}
E) 1.6×10^3

2. Which statement is true for a reaction with K_c equal to 2.43×10^{-12}?
   A) Increasing the temperature will not change the value of K_c.
   B) There are appreciable concentrations of both reactants and products.
   C) The reaction proceeds hardly at all towards completion.
   D) The reaction proceeds nearly all the way to completion.

3. Shown below is a concentration vs. time plot for the reaction $A \rightleftharpoons 2B$. For this reaction the value of the equilibrium constant is



A) $K_c < 1$.
B) $K_c = 0$.
C) $K_c = 1$.
D) $K_c > 1$.

4. In which of the following reactions will $K_c = K_p$?

A) $4\,NH_3(g) + 3\,O_2(g) \rightleftharpoons 2\,N_2(g) + 6\,H_2O(g)$ **B) $SO_3(g) + NO(g) \rightleftharpoons SO_2(g) + NO_2(g)$**

C) $2\,N_2(g) + O_2(g) \rightleftharpoons 2\,N_2O(g)$ D) $2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$

E) None of the above reactions have $K_c = K_p$.

5. The decomposition of ammonia to nitrogen and hydrogen on a tungsten filament at 800°C is independent of the concentration of ammonia at high pressures of ammonia. What is the order of the reaction with respect to ammonia?

A) zero B) first

C) second D) Third

6. Hydroquinone, HOC_4H_4OH, can be formed by the reaction with acetylene below:

$$3\ HCCH + 3\ CO + 3\ H_2O \rightarrow 2\ HOC_4H_4OH + CO_2$$

How is the rate of disappearance of acetylene, HCCH, related to the appearance of hydroquinone (Hq)?

$$-\frac{\Delta[HCCH]}{\Delta T} = ?$$

A) $+\ \frac{\Delta[H_q]}{\Delta t}$

B) $+\ \frac{1\Delta[H_q]}{2\Delta t}$

C) $+\ \frac{2\Delta[H_q]}{3\Delta t}$

D) $+\ \frac{3\Delta[H_q]}{2\Delta t}$

7. Given the following rate law, how does the rate of reaction change if the concentration of Y is doubled?
Rate = k $[X][Y]^2$

A) The rate of reaction will increase by a factor of 2.

B) The rate of reaction will increase by a factor of 4.

C) The rate of reaction will increase by a factor of 5.

D) The rate of reaction will decrease by a factor of 2.

E) The rate of reaction will remain unchanged.

8. Which rate law is bimolecular?

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

B) rate = k [A][B]

C) rate = k $[A]^3$

D) rate = k [A][B][C][D]

E) rate = k $[A]^2[B]^2$

9. In the hydrogenation of double bonds, a catalyst is needed. In the first step, the reactants must come into contact with a metal surface. This step is known as ________.

A) adsorption

B) diffusion

C) reaction

D) desorption

E) none of the above

Question II

A. Short answers

1. What is the difference between average reaction rate and instantaneous reaction rate?

2. Explain what the exponential factor in the Arrhenius equation represents.

3. How is the reaction quotient different from an equilibrium constant for a given reaction?

4. Why is an equilibrium constant unitless?

5. Can the K_p and K_c for a reaction ever have the same value? Why or why not?

6. Define Le Chatelier's Principle.

B. Consider the following reaction

$$C(s) + 2\ H_2(g) \rightleftharpoons CH_4(g) \qquad \Delta H° = -74.8\ \text{kJ}$$

Does the amount of $H_2(g)$ increases, decreases or remain constant when equilibrium of reactants and products is subjected to the following changes?

a. The temperature decreases; Also account for the change of K_c

b. The volume increases; also account for the change of Q_c

c. CH_4 is added

d. The catalyst is added

Question III

A. Consider the following reaction:

$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$

At a certain temperature, $K_c = 8.5 \times 10^{-3}$. A reaction mixture at this temperature containing solid NH_4NS has $[NH_3] = 0.166$ M and $[H_2S] = 0.166$. Will more of the solid form or will some of the existing solid decompose as equilibrium is reached? Calculation must be shown to support your answer.

More solid

B. The decomposition of ammonia is: $2\ NH_3(g) \rightleftharpoons N_2(g) + 3\ H_2(g)$. If the partial pressure of ammonia is 1.6×10^{-3} atm and the partial pressures of N_2 and H_2 are each 0.25 atm at equilibrium, what is the value for K_c at 400°C for the forward reaction?

0.50

C. Consider the reaction:

$NiO(s) + CO(g) \rightleftharpoons Ni(s) + CO_2(g)$ $K_c = 4.0 \times 10^3$ at 1500K

If a mixture of solid nickel (II) oxide and 0.20 M carbon monoxide comes to equilibrium at 1500K. What is the equilibrium concentration of CO_2?

Answer: 0.20 M

Question IV (make sure all appropriated formulas are used to receive Full Credit!!!)

1. Hydrogen iodide decomposes at 800 K via a second-order process to produce hydrogen and iodine according to the following chemical equation.

   $2\ HI(g) \rightarrow H_2(g) + I_2(g)$

At 800 K it takes 142 seconds for the initial concentration of HI to decrease from 6.75×10^{-2} M to 3.50×10^{-2} M. What is the rate constant for the reaction at this temperature?

Answer: $9.69 \times 10^{-2}\ M^{-1}s^{-1}$

2. In aqueous solution, hypobromite ion, BrO^-, reacts to produce bromate ion, BrO_3^-, and bromide ion, Br^-, according to the following chemical equation.

$$3\,BrO^-(aq) \rightarrow BrO_3^-(aq) + 2\,Br^-(aq)$$

A plot of $1/[BrO^-]$ vs. time is linear and the slope is equal to 0.056 $M^{-1}s^{-1}$. If the initial concentration of BrO^- is 0.80 M, how long will it take one-half of the BrO^- ion to react?

Answer: 22 s

3. In the presence of excess thiocyanate ion, SCN^-, the following reaction is first order in iron(III) ion, Fe^{3+}; the rate constant is 1.27 s^{-1}.

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons Fe(SCN)^{2+}(aq)$$

a) What is the half-life in seconds?

0.546 *s*

b) How many seconds would be required for the initial concentration to drop to 6.25% remaining?

2.18 s.

4. A reaction of the form *a*A → Products is zero order with a rate constant of 4.68 x 10^{-3} Ms^{-1}.

a) What is the half-life when the initial concentration of A is 0.813 M?

86.9 *s*

b) If [A] = 0.625 M, is the half-life the same, larger, or smaller than when [A] = 0.813 M. Show your calculation

5. For the second-order reaction 2 A → B + C, 4.58 hours is required for the concentration of A to decrease from an initial concentration of 0.398 M to 0.183 M at 40°C. Calculate the rate constant for this reaction at 40°C.

6. The thermal decomposition of nitryl chloride, NO_2Cl, is believed to occur by the following mechanism:

$$NO_2Cl(g) \xrightarrow{k_1} NO_2(g) + Cl(g) \qquad \text{Slow}$$

$$Cl(g) + NO_2Cl \xrightarrow{k_2} NO_2(g) + Cl_2(g) \qquad \text{Fast}$$

a. What is the overall reaction?

b. What is the molecularity of each of the elementary steps?

c. What is the intermediate?

d. What rate law is predicted by this mechanism?

7. The reaction of NO with oxygen has several proposed mechanism, one of which the following

Step 1:	$NO(g) + O_2(g) \rightleftharpoons NO_3(g)$	Fast	
Step 2:	$NO(g) + NO_3(g) \rightarrow 2\ NO_2(g)$	Slow	
Overall	$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$		Rate = $k\,[NO]^2[O_2]$

Show the mechanism is consistent with the observed rate law

8. The first-order isomerization reaction: cyclopropane → propene, has a rate constant of $1.10 \times 10^{-4}\ s^{-1}$ at 470°C and $5.70 \times 10^{-4}\ s^{-1}$ at 500°C. What is the activation energy, E_a, for the reaction?

260 kJ/mol

9. The aquation of tris(1,10-phenanthroline)iron(II) in acid solution takes place according to the equation: $Fe(phen)_3^{2+} + 3\ H_3O^+ + 3\ H_2O \rightarrow Fe(H_2O)_6^{2+} + 3\ phenH^+$.
If the activation energy, E_a, is 126 kJ/mol and the rate constant at 30°C is $9.8 \times 10^{-3}\ min^{-1}$, what is the rate constant at 35°C?

Answer: $2.2 \times 10^{-2}\ min^{-1}$