Exam 2 Chm 205 (Dr Mattson) 29 February 2016

Academic Integrity Pledge: *In keeping with Creighton University's ideals and with the Academic Integrity Code, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.*

Signature:

Name:

Chemistry Student Number: _____

Instructions: **Show all work whenever a calculation box is provided!** Write legibly. Include units whenever appropriate. You will receive credit for **how** you worked each problem as well as for the correct answer. If you need more space, you may use the back of the data sheet provided — Write: "See data sheet" in the answer box – then write your name on the data sheet. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks, bags, and purse-like items must be stored in the rear section of the room. Cell phones must be silent and placed in your backpack/bag/purse – not in your pocket.

1. Chalcocite is the mineral $Cu_2S(s)$. It is "roasted" with oxygen to replace the sulfide with oxide, which is subsequently reduced to copper metal. The roasting portion of the process is:

$$2\ Cu_2S(s) + 3\ O_2(g) \rightleftharpoons 2\ Cu_2O(s) + 2\ SO_2(g)$$

1a. (2 pts) Write the K_c expression for this equilibrium.

1a. (2 pts) Write the K_p expression for this equilibrium.

1c. (4 pts) Suppose at some temperature $K_p = 4.5 \times 10^5$, and at equilibrium $P_{SO_2} = 0.420$ atm. What is P_{O_2}?

Answer with units: _____

2. Consider this reaction to answer the questions that follow.

$$H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g) \qquad K_c = 57 \text{ at } 700\ K.$$

2a. (5 pts) Starting with 5.400 mol HI(g) in a 5.00 L vessel, what are the equilibrium concentration of all three gases?

Answers: $[H_2]$ = _____ $[I_2]$ = _____ [HI] = _____

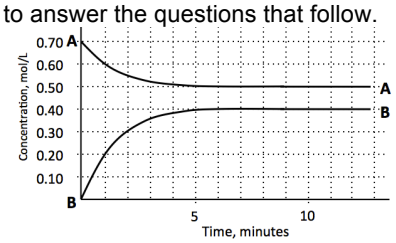
2b. (3 pts) What is the value for the equilibrium constant, K_p?

2c. (3 pts) What is the value for the equilibrium constant, K_c, for the reaction written as:

$$2\ HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad K_c = ? \text{ at } 700\ K.$$

3. Consider this graph to answer the questions that follow.

3a. (2 pts) Label the regions of the graph "kinetics" and "equilibrium": Carefully draw a distinct vertical line where you believe equilibrium starts.



3b. (4 pts) What is the balanced reaction using the smallest whole number coefficients? (example: A → 3B)

3c. (5 pts) Create a MICE table in order to determine a numerical value for K_c.

Answer with units: _____

3d. (2 pts) If the volume of the vessel were increased by 10%, in which direction would a shift occur in order to reestablish equilibrium? **Circle: Right Left No Shift**

3e. (7 pts) Suppose the reaction is known to be endothermic in the forward direction (as answered in 3b). Will increasing the temperature…

decrease $[B]_E$? **Circle: Yes No Cannot tell**

decrease $[A]_E$? **Circle: Yes No Cannot tell**

increase K_c? **Circle: Yes No Cannot tell**

increase k_{fwd}? **Circle: Yes No Cannot tell**

increase k_{rev}? **Circle: Yes No Cannot tell**

increase the time it takes to reach equilibrium? **Circle: Yes No Cannot tell**

decrease $E_{act(fwd)}$? **Circle: Yes No Cannot tell**

3f. (4 pts) Will adding a catalyst…

decrease $[B]_E$? **Circle: Yes No Cannot tell**

decrease $[A]_E$? **Circle: Yes No Cannot tell**

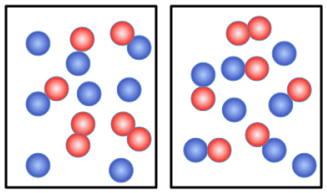
decrease K_c? **Circle: Yes No Cannot tell**

increase the time it takes to reach equilibrium? **Circle: Yes No Cannot tell**

4. The vessel shown on the left is an equilibrium mixture of the reaction:

$2B(g) + R_2(g) \rightleftharpoons 2\,BR(g)$

(Assume the molecules shown are representative of the molar concentrations.)



4a. (3 pts) What is the value of K_c? 4b. (3 pts) What is the value of Q_c in the vessel at right? Which direction must the reaction shift in order to establish equilibrium?

4a.	4b.

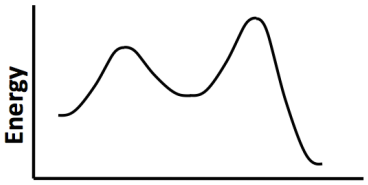
5. (4 pts) **Clearly** label or indicate on the figure the following:

(a) Steps 1 and 2;

(b) ΔH for the overall reaction.

(c) Is the first or second step rate-determining? Circle: **First** or **Second**

(d) E_{act}(fwd) for Step 1 and E_{act}(fwd) for Step 2;



6a. (2 pts) Define the equilibrium constant, K_a for chlorous acid, $HClO_2$ in terms of concentrations.

6b. (2 pts) What is the conjugate base of $HClO_2$?

6c. (2 pts) Write the K_b expression for chlorite, ClO_2^- (in terms of concentrations: K_b = [ ]…)

6d. (2 pts) Given $K_a = 1.1 \times 10^{-2}$ for chlorous acid, what is K_b for chlorite ion at this temperature?

7a. (4 pts) What is the hydronium ion concentration in a solution made by dissolving 0.778 g KOH (MM = 56.1 g/mol) in water to make 500.0 mL solution?

Answer with units: _____

7b. (3 pts) Convert this to pH and report it to the correct number of significant figures.

8. (6 pts) Write the equilibrium expression that is represented by K_{a1} and K_{a2} for phosphorous acid, H_2PO_3. (*question continued next column*)

First equilibrium:

Second equilibrium:

9a. (5 pts) A 0.300 M solution of HA gives a pH of 3.18. What is the value of K_a?

Answer: _____

9b. (6 pts) True/False

T F pK_b for A^- is 11.82.

T F HA must be a carboxylic acid.

T F Adding water would dilute the acid and raise the pH.

T F Weak acid dissociations are endothermic, accounting for their small values.

T F Based on your answer to the previous question, increasing the temperature would increase K_a.

T F A 0.115 M solution of this acid requires the quadratic equation in order to calculate the pH.

10. (5 pts) What is the pH of a 0.1884 M solution of benzoic acid, pK_a = 4.19?

Answer: _____

11. (5 pts) What is the pH of a 0.290 M NaF solution, given pK_a = 3.46 for HF?

Answer with units: _____

12. (5 pts) Identify the following aqueous solutions as strong acids (sa), weak acids (wa), neutral (n), weak bases (wb) or strong bases (sb).

a. NaOH(aq)	**sa**	**wa**	**n**	**wb**	**sb**
b. HOCl(aq)	**sa**	**wa**	**n**	**wb**	**sb**
c. KCl(aq)	**sa**	**wa**	**n**	**wb**	**sb**
d. NaOCl(aq)	**sa**	**wa**	**n**	**wb**	**sb**
e. HCl(aq)	**sa**	**wa**	**n**	**wb**	**sb**

Total score (out of 100): _____

A+ ≥ 95% A ≥ 90% B+ ≥ 85% B ≥ 80% C+ ≥ 75% C ≥ 70% D ≥ 60%

Answers.

1a. $K_c = [SO_2]^2 / [O_2]^3$

1a. $K_p = P_{SO_2}{}^2 / P_{O_2}{}^3$

1c. $P_{O_2} = 7.3 \times 10^{-3}$ atm

2a. $[H_2] = 0.113$ mol/L; $[I_2] = 0.113$ mol/L; and $[HI] = 0.854$ mol/L

2b. $K_p = 57$ because $\Delta n_{gas} = 0$

2c. $K_c = 0.0175$

3a. Vertical line should occur at 6 minutes

3b. A → 2 B

3c. $K_c = 0.32$

3d. Right

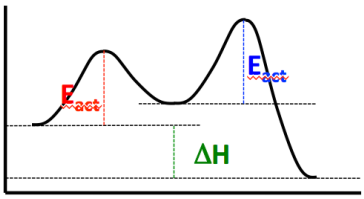
3e. No Yes Yes Yes Yes Yes No No

3f. No No No No

4a. $K_c = 0.18$

4b. $Q_c = 2.78$, must shift left

5.



6a. $K_a = [H_3O^+][ClO_2^-]/[HClO_2]$

6b. ClO_2^-

6c. $K_b = [OH^-][HClO_2]/[ClO_2^-]$

6d. $K_b = 9.1 \times 10^{-13}$

7a. $[H_3O^+] = 3.6 \times 10^{-13}$

7b. 12.44

8a. $H_2PO_3 + H_2O \rightleftharpoons H_3O^+ + HPO_3^-$

$HPO_3^- + H_2O \rightleftharpoons H_3O^+ + PO_3^{2-}$

9a. $K_a = 1.46 \times 10^{-6}$

9b. F F T T T F

10. 2.46

11. 8.46

12. sb wa n wb sa