

Chemistry 1266 Exam III

Spring 2009

Chapters 14*, 15 & 16*

Name (PRINTED LEGIBLY) _____

Student ID Number _____

Please read and acknowledge the following instructions.

1. There is a periodic table attached to this exam. You may tear it off the exam, however all exam materials are to be turned in with the exam.
2. You will have 1 hour, 50 minutes to complete the exam.
3. You are responsible for any corrections announced during the first hour of the exam.
4. Anyone arriving more than 15 minutes late will not be allowed to take the exam.
5. You are only allowed a single-line, non-programmable calculator on this exam.
6. **No cell phones, PDAs, or music devices** of any kind are allowed during the exam
7. Use the spaces between questions and the backs of the exam page for scratch paper. No additional scratch paper is allowed.
8. All problems are valued at 4 points each, except where specifically noted.
9. This exam consists of 12 pages total (cover sheet, test pages, misc. information and periodic table). Be sure you have all 12 pages.
10. During the exam if you have a question please raise your hand and the instructor or proctor will come to you.

Signature _____

Date: _____

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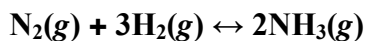
Chapters 14*, 15 & 16*: Gilbert, Kirss & Davies

Name: _____

There is a periodic table and a section of miscellaneous information at the end of this exam. Show work for all problems requiring dimensional analysis; circle your answer for multiple choice questions on this test form. **NO PROGRAMABLE (Graphing) CALCULATORS.**

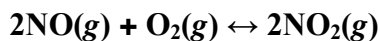
1. (5 pts) Suppose the reaction $A \leftrightarrow B$ in the forward direction is first order in A and the rate constant is $1.50 \times 10^{-2} \text{ s}^{-1}$. The reverse reaction is first order in B and the rate constant is $4.50 \times 10^{-2} \text{ s}^{-1}$ at the same temperature. What is the value of the equilibrium constant for the reaction $A \leftrightarrow B$ at this temperature?

2. (5 pts) At 500°C , the equilibrium constant K_p for the synthesis of ammonia

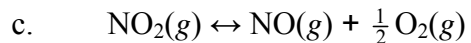
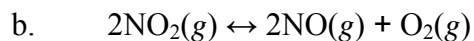
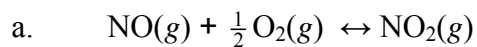


is 1.45×10^{-5} . What is the value of K_c ?

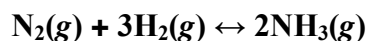
3. (6 pts) If the equilibrium constant K_c for the reaction,



is 5×10^{12} , what is the value of the equilibrium constant (K_c) of each of the following reactions at the same temperature?



4. (5 pts) At 650 K, the value of the equilibrium constant K_p for the ammonia synthesis reaction

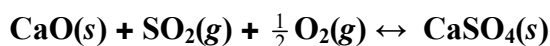


is 4.3×10^{-4} . If a vessel contains a reaction mixture in which $[\text{N}_2] = 0.010 M$, $[\text{H}_2] = 0.030 M$, and $[\text{NH}_3] = 0.00020 M$, will more ammonia form?

5. (3 pts) Write the equilibrium expression for the reaction:



6. (5 pts) Calcium oxide is used to remove the pollutant SO_2 from smokestacks and exhaust gases. The ΔG° of the overall reaction



is -418.6 kJ. What is P_{SO_2} in equilibrium with air ($P_{\text{O}_2} = 0.21$ atm) and solid CaO under standard conditions?

7. (5 pts) Ammonia decomposes at high temperatures. In an experiment to explore this behavior, 2.000 moles of gaseous NH_3 are sealed in a rigid 1 liter vessel. The vessel is heated at 800 K and some of the NH_3 decomposes in the following reaction:



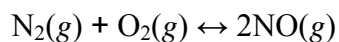
The system eventually reaches equilibrium and is found to contain 0.00400 mole of NH_3 . What is the value of K_p for the decomposition reaction at 800 K?

8. (5 pts) The equilibrium constant K_p of the reaction



is 7.69 at 830°C. If a vessel at this temperature initially contains pure SO_3 and if the partial pressure of SO_3 at equilibrium is 0.100 atm, what is the partial pressure of O_2 in the flask at equilibrium?

9. (5 pts) Automobiles and trucks pollute the air with NO. At 2000°C, K_c for the reaction



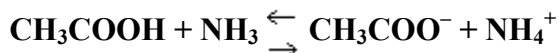
is 4.10×10^{-4} , and $\Delta H^\circ = 180.6$ kJ. What is the value of K_c at 25°C?

10. (3 pts) If the reaction quotient Q has a larger value than the related equilibrium constant, K ,

- the reaction is at equilibrium.
- the reaction will continue to make more products.
- the reaction will consume products and make reactants.
- the reaction will release heat to achieve equilibrium.

11. (3 pts) For a given chemical equilibrium, which of the following will *not* change the value of the equilibrium constant?
- the temperature of the equilibrium system
 - the total concentration of all the reactants and products
 - how the reaction is written
 - the value of Q used to set up the reaction system
12. (3 pts) A particular drain cleaner contains NaOH. What is the pH of a solution produced when 5.0 g of NaOH dissolves in enough water to make 250 mL of solution?
13. (3 pts) Nitrous acid and nitric acid are similar in that
- they are both weak acids.
 - they are both strong acids.
 - they both have one ionizable proton.
 - they both have nitrogen in the +3 oxidation state.
14. (3 pts) Which two mean the same thing?
- acid and base
 - $H^+(aq)$ and $H_3O^+(aq)$
 - proton and hydrogen atom
 - base and proton donor
15. (3 pts) Which of these is a strong acid that ionizes to make a weak acid?
- H_2SO_3
 - H_2SO_4
 - H_3PO_4
 - HNO_3

16. (3 pts) In the following reaction, which is the acid reactant and its conjugate base product?



- a. CH_3COOH and CH_3COO^- c. NH_3 and CH_3COO^-
b. CH_3COOH and NH_4^+ d. NH_3 and NH_4^+

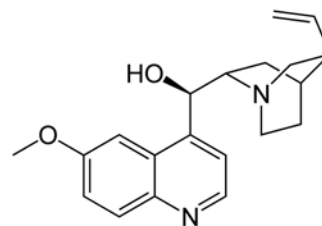
17. (4 pts) Calculate the pH and pOH of a $6.9 \times 10^{-8} M$ solution of HBr.

18. (5 pts) The odor of spoiled butter is due in part to butanoic acid, which results from the chemical breakdown of butter fat. A $0.100 M$ solution of butanoic acid is 1.23% ionized. Calculate the value of K_a for butanoic acid.

19. (5 pts) A weather system moving through the American Midwest produced rain with an average pH of 5.02. By the time the system reached New England, the rain it produced had an average pH of 4.66. How much more acidic was the rain falling in New England?

20. (5 pts) The K_b of dimethylamine $[(CH_3)_2NH]$ is 5.9×10^{-4} at $25^\circ C$. Calculate the pH of a $1.20 \times 10^{-3} M$ solution of dimethylamine.

21. (5 pts) Quinine occurs naturally in the bark of the cinchona tree. For centuries it was the only treatment for malaria. Quinine contains two weakly basic nitrogen atoms, with $K_{b1} = 3.31 \times 10^{-6}$ and $K_{b2} = 1.35 \times 10^{-9}$ at $25^\circ C$. Calculate the pH of a $0.01050 M$ solution of quinine in water.



22. (4 pts) If the K_{a1} value of chromic acid (H_2CrO_4) is 0.16 and its K_{a2} value is 3.2×10^{-7} , what are the values of K_{b1} and K_{b2} of the CrO_4^{2-} anion? Hint: Write the equilibrium reactions before you calculate.

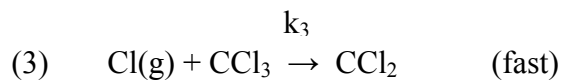
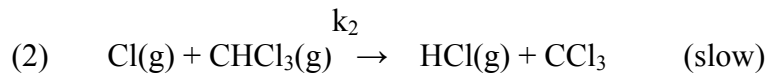
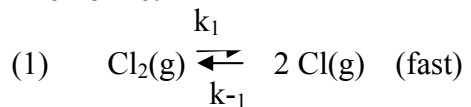
23. (4 pts) Determine the pH and pOH of 0.250 L of a buffer that is 0.0250 M boric acid and 0.0200 M sodium borate; pK_{a1} for $H_3BO_3 = 9.00$ at $25^\circ C$.

24. (3 pts) Which of the following salts forms aqueous solutions with $pH = 7$?

a. Na_2S	c. $NaClO_2$
b. $NaBr$	d. $NaNO_2$

Extra Credit (5 points)

The following mechanism has been proposed for the gas-phase reaction of chloroform (CHCl_3) and chlorine:



(a) What is the overall reaction?

(b) What is the molecularity of each elementary reaction?

(c) What is the rate-law predicted by this mechanism that could be experimentally tested?

Miscellaneous Information and Formulae:

$$R = 0.082057 \text{ L}\cdot\text{atm}/(\text{mole}\cdot\text{K}) = 8.314 \text{ J}/(\text{mole}\cdot\text{K})$$

$$N_A = 6.0221\text{E}23/\text{mole}$$

$$E = 2.31 \times 10^{-19} \text{ J}\cdot\text{nm}[(Q_1 \cdot Q_2)/d]$$

$$\Delta G = \Delta H - T\Delta S$$

$$\Delta G^\circ_{\text{rxn}} = \sum n\Delta G^\circ_{\text{f,prod}} - \sum n\Delta G^\circ_{\text{f,react}}$$

$$K_p = K_c(RT)^{\Delta n}$$

$$pK_w (298 \text{ K}) = 14.00$$

$$\text{pH} = -\log[\text{H}^+]$$

$$\text{pH} + \text{pOH} = 14.00 (25^\circ\text{C})$$

$$\Delta G = \Delta G^\circ + RT \cdot \ln(Q)$$

$$\Delta G^\circ = -RT \cdot \ln(K_{\text{eq}})$$

$$\Delta G^\circ = \Delta H^\circ - T \Delta S^\circ$$

$$\ln(K_2/K_1) = (\Delta H^\circ/R)(1/T_1 - 1/T_2)$$

$$\text{pH} = \text{pK}_a + \log ([\text{conj.base}]/[\text{acid}])$$

$$x = \left[\frac{(-b \pm \sqrt{b^2 - 4 \cdot a \cdot c})}{2 \cdot a} \right]$$