CHEMISTRY 0120  Exam 1, Spring 2003  
Time limit 75 minutes

DO NOT START THIS EXAM UNTIL DIRECTED

The University of Pittsburgh Honor system strongly condemns all forms of academic dishonesty. If you are convicted of receiving aid or helping others on this test, including discussion of this material with other students that have not taken the exam, you will be issued a failing grade for the test and you will be required to participate in the legal procedural process as outlined in the University Guidelines on Academic Integrity (http://www.fcas.pitt.edu/academicintegrity.html).

Instructions:

1. There are a total of 16 questions and 100 points on this Exam. Individual point amounts are stated at each of the questions.
2. Record your answers to the multiple-choice problems on the second page of this exam.
3. Refer to the periodic table and information sheet supplied with this Exam when answering the questions.
4. Write LEGIBLY and SHOW ALL YOUR STEPS in the problems. Use the back of the pages for “scratch” or initial calculations.
5. Report answers to calculations with a reasonable number of significant digits.
6. Calculators may not be shared during the exam.
7. TURN IN ALL EXAM MATERIALS (exam, scratch sheets, periodic table) when you have completed the exam. You are allowed to turn in your exam and leave early.
8. This exam is administered under the University of Pittsburgh Code of Academic Integrity (http://www.fcas.pitt.edu/academicintegrity.html). After you finish the exam, sign the statement at the bottom of this page. Your exam will not be graded unless you sign this statement.
9. All complaints concerning grading errors of this Exam must be submitted in writing by Feb. 24th. You may write your note on the front of this exam.

I have neither given nor received unauthorized help or information on this exam.

________________________________________
Your name (printed)

________________________________________
Your Signature

Circle your recitation section:

Mon. am, room 217  Mon. nite, room 214  Tues am, room 301  Tues. nite, room 214
Wed am, room 301  Wed. pm, room 306  Thurs. am, room 301

Exam score (points)
MULTIPLE CHOICE ANSWER SHEET: Record your answer for questions 1 through 12 by filling in the circle corresponding to your answer choice. You must record your answers here. No other marking for answers will be accepted. (4 points each)

1. a b c d e
2. a b c d e
3. a b c d e
4. a b c d e
5. a b c d e
6. a b c d e
7. a b c d e
8. a b c d e
9. a b c d e
10. a b c d e
11. a b c d e
12. a b c d e
MULTIPLE CHOICE: record your answers on the MC answer sheet. (4 points each)

1. For the reaction system $\text{CoO(s) + H}_2(g) \rightleftharpoons \text{Co(s) + H}_2\text{O(g)}$ at 550ºC, $K = 67$. The equilibrium constant expression is
   a. $\frac{[\text{CoO}][\text{H}_2]}{[\text{Co}][\text{H}_2\text{O}]}$
   b. $\frac{[\text{Co}][\text{H}_2\text{O}]}{[\text{H}_2]}$
   c. $\frac{[\text{H}_2\text{O}]}{[\text{H}_2]}$
   d. $\frac{[\text{Co}][\text{H}_2\text{O}]}{[\text{CoO}][\text{H}_2]}$
   e. $\frac{[\text{H}_2]}{[\text{H}_2\text{O}]}$

2. For which of the following equilibria would $K_c = K_p$?
   a. $2\text{CO(g) + 3H}_2(g) \rightleftharpoons \text{CH}_4(g) + \text{H}_2\text{O(g)}$
   b. $2\text{CO(g) + H}_2\text{O(g) }\rightleftharpoons \text{CO}_2(g) + \text{H}_2(g)$
   c. $\text{CO(g) + 2H}_2(g) \rightleftharpoons \text{CH}_2\text{OH(g)}$
   d. $\text{CO(g) + }\frac{1}{2}\text{O}_2(g) \rightleftharpoons \text{CO}_2(g)$
   e. $2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g)$

3. Given the equilibrium constants for the following reactions
   $4\text{Cu(s) + O}_2(g) \rightleftharpoons 2\text{Cu}_2\text{O(s)} \quad K_1$
   $2\text{CuO(s) }\rightleftharpoons \text{Cu}_2\text{O(s) + }\frac{1}{2}\text{O}_2(g) \quad K_2$
what is $K$ for the system $2\text{Cu(s) + O}_2(g) \rightleftharpoons 2\text{CuO(s)}$ equivalent to?
   a. $(K_1)(K_2)$
   b. $(K_1^{1/2})(K_2)$
   c. $(K_1^{1/2})(1/K_2)$
   d. $(1/K_1)(K_2^{1/2})$
   e. $(K_1)(K_2^{1/2})$

4. In which of the following reactions does a decrease in the volume of the reaction vessel at constant temperature favor formation of the products (move the reaction in the forward direction)?
   a. $\text{H}_2(g) + I_2(g) \rightleftharpoons 2\text{HI(g)}$
   b. $\text{MgCO}_3(s) \rightleftharpoons \text{MgO(s) + CO}_2(g)$
   c. $\text{NO}_2(g) + \text{CO(g) }\rightleftharpoons \text{NO(g) + CO}_2(g)$
   d. $2\text{H}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{H}_2\text{O(g)}$
   e. $2\text{O}_3(g) \rightleftharpoons 3\text{O}_2(g)$
5. In the reversible reaction \[ \text{HCOO}^- (aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{HCOOH}(aq) + \text{OH}^- (aq) \] which are the Bronsted bases?
   a. HCOO\(^-\) and HCOOH
   b. HCOO\(^-\) and OH\(^-\)
   c. H\(_2\)O and OH\(^-\)
   d. H\(_2\)O and HCOOH
   e. H\(_2\)O, HCOOH, and OH\(^-\)

6. Sulfur dioxide combines with O\(_2\) in the presence of a catalyst as represented by the equation
   \[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \]
   If the equilibrium is established by adding 0.10 mol each of SO\(_2\) and O\(_2\) to a 1-L vessel, then which of the following must be true at equilibrium?
   a. [SO\(_2\)] = [O\(_2\)]
   b. [SO\(_2\)] = [O\(_2\)] = [SO\(_3\)]
   c. [O\(_2\)] = 2[SO\(_3\)]
   d. [SO\(_2\)] > [O\(_2\)]
   e. [SO\(_2\)] < [O\(_2\)]

7. All the following species would be expected to be able to function as Lewis bases EXCEPT
   a. F\(^-\)
   b. O\(^2-\)
   c. OH\(^-\)
   d. H\(_2\)O
   e. BF\(_3\)

8. Which of the following acids has the STRONGEST conjugate base?
   a. HClO\(_4\)
   b. HClO\(_3\)
   c. HClO\(_2\)
   d. HClO
   e. HCl

9. A 0.010 M aqueous solution of a weak acid HX has a pH of 4.00. What is the percentage dissociation of HX in the solution?
   a. 0.0010%
   b. 0.010%
   c. 0.10%
   d. 1.0%
   e. 10%
10. The strongest acid in each of the following three sets are:

Set 1  HF  HCl  HBr
Set 2  H₂S  H₂Se  H₂Te
Set 3  CH₄  NH₃  H₂O

a.  HF, H₂S, H₂O
b.  HBr, H₂Te, H₂O
c.  HCl, H₂Te, CH₄
d.  HCl, H₂S, NH₃
e.  HBr, H₂S, CH₄

11. Which salt is the least soluble (mol/L) in water?
   a. CaCO₃  Ksp = 5.0 x 10⁻⁹
   b. PbI₂   Ksp = 8.5 x 10⁻⁹
   c. AgBr   Ksp = 5.4 x 10⁻¹³
   d. Fe(OH)₂ Ksp = 4.9 x 10⁻¹⁷
   e. Co(OH)₂ Ksp = 1.1 x 10⁻¹⁵

12. Which of the following precipitates could be solubilized (made more soluble) by the addition of nitric acid?
   1.  Ag₂CO₃
   2.  AgC₂H₅O₂
   3.  AgI

   a.  1 only
   b.  2 only
   c.  3 only
   d.  1 and 2 only
   e.  1 and 3 only
FREE RESPONSE: Show all of your work for each problem. Be complete and organized with your calculations and steps taken to solve the problem.

13a) For each of the following salts, indicate whether the aqueous solution will be acidic, basic, or neutral. Indicate your reasoning by showing the chemical equilibrium that most affects the pH. (3 points each)

- \( K_a \text{H}_2\text{CO}_3 = 4.3 \times 10^{-7} \)
- \( K_a \text{HCO}_3^- = 4.8 \times 10^{-11} \)
- \( K_a \text{HSO}_4^- = 1.2 \times 10^{-2} \)
- \( K_b \text{NH}_3 = 1.8 \times 10^{-5} \)

0.10 M \( \text{KHCO}_3 \)

0.10 M \( (\text{NH}_4)_2\text{SO}_4 \)

0.10 M \( \text{Ca(ClO}_4)_2 \)

13b) Pick one of the salts and calculate the pH of the solution. (6 points)
14. Only one of the following mixtures will create a buffer solution. Determine which one is the buffer and then calculate the pH of the solution. (10 points)

\[ K_a \text{ HClO}_2 = 1.1 \times 10^{-2} \quad K_b \text{ NH}_3 = 1.8 \times 10^{-5} \quad K_a \text{ HNO}_2 = 4.5 \times 10^{-4} \]

A) 1 L of 1 M NaOH and 1 L of 2 M HNO\textsubscript{2}

B) 1 L of 2 M HClO\textsubscript{2} and 2 L of 1 M KOH

C) 1 L of 2 M NaNO\textsubscript{3} and 1 L of 1 M NaNO\textsubscript{2}
15. Calcium chloride, CaCl₂, is added to 3.0 L of 0.050 M K₂SO₄ until a precipitate forms. How many grams of CaCl₂ were added? Assume the volume of the solution is not changed significantly by the addition of the CaCl₂. \[ K_{sp} \text{CaSO}_4 = 2.4 \times 10^{-5} \] (10 points)
16a. How many moles of NH₄Cl(s) need to be added to 500 mL of 0.25 M NH₃ (K_b = 1.8 x 10⁻⁵) to make a solution with a pH= 9.0. Assume volume change is negligible. (10 points)
16b. After making the solution in 16a, 0.075 moles of HCl(g) are added. Assuming there is no volume change with the addition of the HCl, what is the pH of the resulting solution? If you could not solve 16a, then assume the answer from 16a to be 0.30 mol of NH₄Cl(s). (Hint: There was a HW problem just like this one.) (7 points)