

CHE 300 ANALYTICAL CHEMISTRY  
MARIAN COLLEGE, INDIANAPOLIS

FALL, 2004

Final Exam, Paper I

Name:

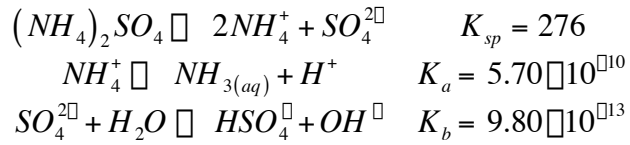
Take-home, open-book. Show all work. Use additional paper as necessary.

1. Using the systematic approach, calculate the pH of (a)  $1.00 \times 10^{-7}$  M HCl, (b) 0.050 M HClO<sub>4</sub>.

2. Nitrogen dioxide (a brown gas) dimerizes exothermically to yield dinitrogen tetroxide (colorless) with  $\Delta H = -57.2 \text{ kJ mol}^{-1}$  ( $\text{N}_2\text{O}_4$ ) and  $K_{\text{eq}} = 7.0$  (defined in terms of pressure) at 298 K. Given an initial mixture with  $P_{\text{NO}_2} = 12.4 \text{ kPa}$  and  $P_{\text{N}_2\text{O}_4} = 6.2 \text{ kPa}$ ,
- Will the reaction proceed to the left or the right to reach equilibrium? (Give an explanation.)
  - Calculate the pressures in Pa of both gases at equilibrium.
  - If the equilibrium mixture is heated to 600 K, in which direction will this drive the reaction?

3. Because weighing instruments are typically more precise than volumetric glassware, practically speaking it is often useful to prepare solutions with a given *molality*,  $m$ , rather than *molarity*,  $M$ . (a) An aqueous solution 0.1000 molal in KCl was prepared by weighing 150.00 g of water and adding a weighed amount of KCl. How much? What is the molarity of this solution at 19°C, assuming that the volume of the solution is unaffected by the KCl. (Use Table 2-7.)

4. (a) (i) Write the charge balance for sulfuric acid in water including all relevant charged species.  
 (ii) Do the same for a solution of potassium sulfate in dilute sulfuric acid.  
 (b) In ammonium sulfate,  $(\text{NH}_4)_2\text{SO}_4$ , both the anion and the cation undergo acid-base reactions, leading to a system



- (i) Write down the charge balance relationship for this system.  
 (ii) Write down the mass balance for this system.  
 (iii) With the pH fixed to 9.25 by external means, find  $[\text{NH}_3(\text{aq})]$ .

5. (a) Calculate the quantity of sodium acetate that must be added to 164 mL of 0.1 M acetic acid to yield a buffer solution of pH 4.0.  
(b) Comment on the buffer capacity of this solution.

6. Commercially available "concentrated ammonia" is 28.0 wt. %  $\text{NH}_3$ . Its density is 0.90 g/mL. Calculate (a) its molarity and (b) the volume in mL of conc.  $\text{NH}_3$  required to make up 1L of 0.1 M solution. (c) What is the fraction of actually undissociated  $\text{NH}_3$  (aq) in the 0.1 M solution?

7. A mad scientist thinks it would be a good idea to create an electrochemical cell based on plutonium and iron. The plutonium cell consists of a solution containing  $\text{Pu}^{3+}$  and  $\text{Pu}^{4+}$  in equal concentrations (0.1 M), with an inert Pt electrode, while the iron side consists of an iron electrode dipped into a solution of 0.2 M  $\text{Fe}^{2+}$ . The two half-cells are connected by a salt bridge. (a) Write the correct line notation for this cell, (b) calculate the EMF generated by the cell, (c) write the equation for the overall redox reaction taking place, and (d) state the direction in which electrons flow in the external circuit.

8. A (mad) chemist (yes, another one) decided to calibrate her bathtub by adding 500 mL of 5.0 M HCl, filling the tub to capacity with distilled H<sub>2</sub>O, then taking a 100mL sample and titrating it against 0.010 M NaOH. She observed the endpoint of the titration at 12.95 mL of NaOH solution. What is the volume of her bathtub?

9. 1.0 g of the amino acid L-tryptophan in its neutral form is dissolved in 100 mL of water. What is the pH of the solution?

10. The formula weight of a gas can be determined using a version of the ideal gas law.

$$FW = \frac{gRT}{PV}$$

where  $g$  is the mass in grams,  $R$  is the gas constant,  $T$  is the temperature in kelvin,  $P$  is the pressure in atmospheres, and  $V$  is the volume in liters. In a typical analysis the following data are obtained:  $g = 0.118 (\pm 0.002)$ ,  $R = 0.082056 (\pm 0.000001)$ ,  $T = 298.2 (\pm 0.1)$ ,  $P = 0.724 (\pm 0.005)$ ,  $V = 0.250 (\pm 0.005)$ .

- (a) What is the compound's formula weight and its estimated uncertainty?
- (b) To which variable(s) should you direct your attention if you wish to improve the uncertainty in the compound's molecular weight?

[100 points total]