Chem 260 – Second Exam

On the following pages are six problems covering material in equilibrium chemistry. Read each problem carefully and think about how best to approach the problem before you begin work. If you aren't sure how to begin a problem, then move on; working on a new problem may stimulate an idea that helps you solve the more troublesome one. For problems requiring a written response, be sure that your answer directly and clearly answers the question. No brain dumps allowed! Generous partial credit is available, but only if you include sufficient work for evaluation.

Problem 1 _____/14 Problem 4 _____/18

Problem 2 _____/14 Problem 5 _____/18

Problem 3 _____/18 Problem 6 _____/18

Total__________

A few constants are given here:

d_{H_2O} = 1.00 g/mL S_{H_2O} = 4.184 J/g·^oC

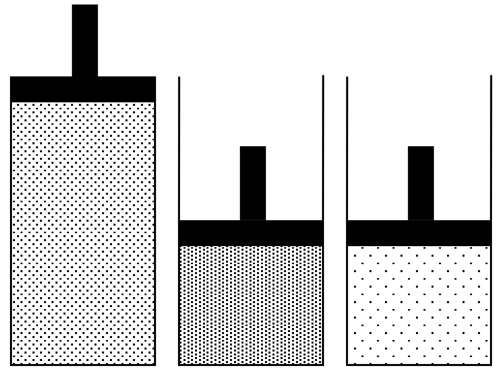
R = 8.314 J/mol_{rxn}·K F = 96,485 J/V·mol e^-

$K_w = 1.00\times10^{-14}$

and some equilibrium constants here:

acid	K_{a1}	K_{a2}	K_{a3}
NH_4^+; ammonium	5.6×10^{-10}		
HF; hydrofluoric acid	7.2×10^{-4}		
HN_3; azoic acid	1.9×10^{-5}		
H_3PO_4; phosphoric acid	7.5×10^{-3}	6.2×10^{-8}	4.8×10^{-13}

Problem 1. Shown to the right is a cylinder containing a mixture of NO_2, which is a reddish-colored gas, and N_2O_4, which is a colorless gas. The cylinder on the left shows the system's initial equilibrium due to the reaction:



$$2NO_2(g) \leftrightarrows N_2O_4(g)$$

Note that the black part is a piston and that the shading represents the color of the gas mixture (the denser the dots, the darker the color). The middle cylinder shows the system immediately after compressing the gases and the cylinder on the right shows the system after it establishes its new equilibrium position. In two or three concise, but well-written sentences, use equilibrium theory to explain the differences in the color of the gas mixtures in the three cylinders.

When a flask containing an equilibrium mixture of NO_2 and N_2O_4 is cooled, the color of the gas becomes lighter. What conclusion can you reach about ΔH^o based on this observation. Explain your answer in one or two concise, but well-written sentences.

Problem 2. Dave Roberts has prepared equimolar solutions for the Chem 130 lab of the following compounds: HCl, NaOH, NH_4Cl, HF, NH_3, KNO_3 and NaF. Being in a mischievous mood, one of his storeroom helpers relabeled the solutions as A, B, C, D, E, F and G. Rather than preparing the solutions again, Dave used pH paper to determine whether each solution was acidic, basic or neutral. He also measured the conductivity of each solution, knowing that a "high" value means that the solution has lots of dissolved ions. The results are shown here:

test	A	B	C	D	E	F	G
pH	basic	acidic	basic	acidic	acidic	basic	neutral
conductivity	high	high	low	high	low	high	high
identity							

This information was not quite enough to determine the identity of all seven solutions. When Dave mixed equal volumes of solutions A and B and determined that the resulting solution was basic, he had enough information to correctly label each solution. Complete the table by filling in the identity of each solution. No written explanation is required, but you are welcome to include one here (or on the reverse side of this page):

Problem 3. Those of you who have completed Chem 130 may recall that solutions of many transition metal ions are acidic. For example, the pH of 0.100 M $Fe(NO_3)_3$ is 1.66 due to the following equilibrium reaction:

$$Fe(H_2O)_6^{3+} + H_2O \leftrightarrows H_3O^+ + Fe(H_2O)_5(OH)^{2+}$$

What is the value of K_a for $Fe(H_2O)_6^{3+}$?

Problem 4. Sodium azide, NaN_3, sometimes is used to prevent bacteria from growing in biological media. For example, one set of directions for preparing samples for the detection of recombinant proteins makes use of a stock solution containing 2.0 g of NaN_3 in 20.0 mL of water. What is the pH of a solution prepared by diluting 10.0 mL of this stock solution to 100.0 mL?

Problem 5. A common buffer used in biochemistry is phosphate buffered saline (PBS). One recipe for a PBS buffer is given as follows: transfer 10.9 grams of Na_2HPO_4, 3.2 g of NaH_2PO_4 and 90 g of NaCl (saline) to a 1-L volumetric flask and dilute to volume. What is the expected pH of this buffer?

Problem 6. Suppose that you need the actual pH of the buffer in Problem 5 to be 0.50 pH units less than the value you calculated. How many mL of 6.0 M HCl do you need to add to accomplish this?