Chem 260 – Second Exam

On the following pages are problems covering material in equilibrium chemistry. Read each question carefully and consider how you will approach it before you put pen or pencil to paper. If you are unsure how to answer one question, then move on to another question; working on a new question may suggest an approach to the one that is more troublesome. If a question requires a written response, be sure that you answer in complete sentences and that you directly and clearly address the question. No brain dumps allowed! Generous partial credit is available, but only if you include sufficient work for evaluation.

Be sure to clearly state and verify any assumptions you make when solving an equilibrium problem.

Problem 1_____/10   Problem 2_____/10   Problem 3_____/10   Problem 4 _____/10

Problem 5_____/17   Problem 6_____/17   Problem 7_____/26

Total_____

A few constants are given here:

$$d_{H_2O} = 1.00 \text{ g/mL} \qquad S_{H_2O} = 4.184 \text{ J/g} \cdot \text{oC}$$

$$R = 8.314 \text{ J/mol}_{rxn} \cdot \text{K} \qquad F = 96{,}485 \text{ J/V} \cdot \text{mol e}^-$$

$$K_w = 1.00 \times 10^{-14}$$

Problem 1. When you ingest a drug, it is absorbed into the bloodstream in either the stomach, the intestines, or both the stomach and the intestines. For a drug that is a weak acid or a weak base, absorption happens when the compound is in its neutral, unionized form. Quinidine, $C_{20}H_{24}N_2O_2$, is used to treat arrhythmia; it is a weak base with a K_b of 3.63×10^{-6} at body temperature. Knowing that the pH of stomach fluid is approximately 2 and that the pH of intestinal fluid is approximately 8, is quinidine absorbed in the stomach, in the intestines, or in both? Circle your choice and explain the reason for your decision in no more than three sentences.

the stomach only   the intestines only   both the stomach and intestines

Problem 2. To investigate an equilibrium reaction between the gases A, B, and C, you fill a 0.500-L flask with 0.800 mol A, 0.400 mol B, and 0.100 mol C and allow the system to reach equilibrium. Once equilibrium is reached, you find that the flask contains 0.500 mol A, 0.300 mol B, and 0.300 mol C. Using this information, determine (a) the reaction's stoichiometry and (b) the reaction's equilibrium constant.

Problem 3. The decomposition of ammonium chloride into ammonia and hydrogen chloride

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

is endothermic with an equilibrium constant of 0.0167 at 500 K. Will the reaction's equilibrium constant increase, decrease, or remain the same if you increase the temperature to 1000 K? Circle your choice and explain the reason for your decision in no more than two sentences.

the equilibrium constant will: increase   decrease   remain the same

A 1.00–L flask is filled with 0.0500 mol each of $NH_3(g)$, $HCl(g)$, and $NH_4Cl(s)$ and heated to 500 K. Will the mass of NH_4Cl increase, decrease, or remain the same? Circle your choice and explain the reason for your decision in no more than two sentences.

the mass of NH_4Cl will: increase   decrease   remain the same

A 1.00–L flask containing $NH_3(g)$, $HCl(g)$, and $NH_4Cl(s)$ is at equilibrium. Will the concentration of NH_3 increase, decrease, or remain the same if additional NH_4Cl is added? Circle your choice and explain the reason for your decision in no more than two sentences.

the mass of NH_3 will: increase   decrease   remain the same

Problem 4. When the soluble salt BHY(s) dissolves in water, it forms a slightly basic solution of $BH^+(aq)$ and $Y^-(aq)$. Knowing that the pK_a for BH^+ is 5.00, is the pK_a for the weak acid HY greater than 5.00, less than 5.00, or equal to 5.00? Circle your choice and explain the reason for your decision in no more than three sentences.

the pK_a for HY is: greater than 5.00   less than 5.00   equal to 5.00

Problem 5. Barbituric acid, $HC_4H_5N_2O_3$, which we abbreviate as HB, was discovered by Adolph von Baeyer and named for Saint Barbara, on whose feast day the discovery occurred. Knowing that a solution that contains 1.6 g of HB per 0.250 L has a pH of 2.66, what is the K_a for HB?

Problem 6. Many household bleaches are dilute solutions of sodium hypochlorite, NaOCl. For example, the bleach in my laundry room states that it contains 5.5 g NaOCl per 0.100 L. What is the pH of this solution? The K_a for HOCl is 3.0×10^{-8}.

Problem 7. A biochemist wishes to use X-ray diffraction to determine the structure of a crystalline protein. To isolate crystals of the protein, she needs a buffer with a pH of 5.20. How many grams of sodium acetate, CH_3COONa, does she need to add to 2.00-L of 0.500 M acetic acid, CH_3COOH, to prepare this buffer. The pK_a for acetic acid is 4.757.

Does this buffer have a greater capacity to neutralize strong acid or strong base? Circle your choice and explain the reason for your decision in no more than two sentences.

           the buffer capacity is greatest against: a strong acid   a strong base

What is the pH if you add 5.00 mL of 6.00 M NaOH to one-half of this buffer?

How many mL of 6.00 M HCl can the other half of this buffer neutralize before the pH falls below 5.00?