

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 it 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.

When working equilibrium problems, be sure to clearly state and verify any assumptions.

Note that the last two problems are worth over 50% of the total points!

Problem 1 _____/10

Problem 4 _____/7

Problem 2 _____/16

Problem 5 _____/7

Problem 3 _____/8

Problem 6 _____/24

Problem 7 _____/28

Total _____

A few constants are given here:

$$d_{\text{H}_2\text{O}} = 1.00 \text{ g/mL}$$

$$S_{\text{H}_2\text{O}} = 4.184 \text{ J/g}\cdot^\circ\text{C}$$

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

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

Problem 1. Will a solution of 0.10 M NH_4NO_2 be acidic, basic or neutral? Explain your reasoning in one or two sentences. Two useful equilibrium constants are:

$$K_{\text{a,HNO}_2} = 5.1 \times 10^{-4} \text{ and } K_{\text{b,NH}_3} = 1.8 \times 10^{-5}.$$

Problem 2. Arrange the following solutions in order of increasing pH:

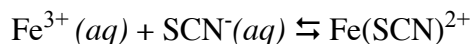
0.10 M HNO_3 0.10 M HNO_2 0.10 M NaNO_2 0.10 M NH_4NO_3
0.10 M NH_3 0.10 M NaOH 0.10 M KCl 0.50 M KOH

Useful equilibrium constants are in Problem 1.

Lowest pH $\rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow$ Highest pH

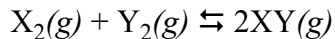
Space for thinking (or doodling)!

Problem 3. Ferric ion, Fe^{3+} , and thiocyanate, SCN^- , are colorless ions. When separate solutions containing these ions are mixed together, a blood-red solution of $\text{Fe}(\text{SCN})^{2+}$ results. The equilibrium reaction is

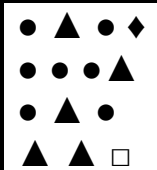
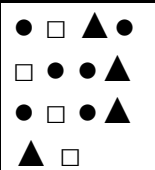


Upon adding NaNO_3 the solution's absorbance changes. Does the absorbance increase or does it decrease? Explain your reasoning in two to four sentences.

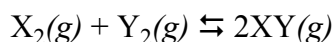
Problem 4. Consider the reaction



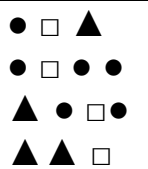
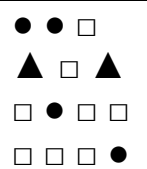
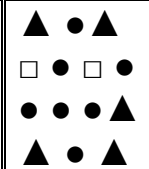
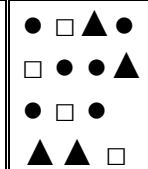
Suppose that at a particular temperature, the equilibrium position is represented by the frame on the left, where the symbol ● represents X_2 , the symbol ▲ represents Y_2 and the symbol □ represents XY. When the temperature increases, the new equilibrium position is shown by the frame on the right. Is ΔH° for the reaction greater than zero, less than zero, equal to zero, or is there insufficient information to answer. Justify your answer in one or two sentences.

	
Left Frame	Right Frame

Problem 5. Consider the reaction



Suppose that at a particular temperature, the equilibrium position is represented by the frame on the left, where the symbol ● represents X_2 , the symbol ▲ represents Y_2 and the symbol □ represents XY. Suppose that at a particular volume, the original equilibrium position is represented by the frame on the far left. If the volume is decreased, which of the remaining frames will best represent the new equilibrium position. Clearly indicate your choice and explain your reasoning in one or two sentences.

			
Original Equilibrium	A	B	C

Problem 6. Bromocresol green (HBg) is a weak acid ($\text{pK}_a = 4.9$) that is yellow in its acidic form and blue in its conjugate base form, Bg^- . As a result, a solution of the dye is green when there are roughly equivalent amounts of HBg and Bg^- . Suppose that you make a solution by dissolving 9.00×10^{-3} moles of NaBg in 1.00 L of water. What is the pH and the color of the solution?

To study the activity of a particular enzyme that releases H_3O^+ , you add it to your solution of NaBg. As the enzymatic reaction occurs, the color of your solution changes. What is the pH of the solution when it just turns yellow and what is the concentration of HBg? You may assume that adding the enzyme does not change the solution's volume. Explain your reasoning with precisely chosen words and appropriate calculations.

Problem 7. A microbiologist needs to prepare a buffer with a pH of 7.00 that she can use for preparing bacterial cultures. Solutions of 0.10 M K_2HPO_4 and 0.10 M KH_2PO_4 are available. The pK_a values for H_3PO_4 are 2.15, 7.20 and 12.38.

One method of preparing the buffer is to take 0.100 L of the K_2HPO_4 solution and to add an appropriate volume of the KH_2PO_4 solution. How many mL should she use?

Having prepared this buffer, will it be better at protecting against the addition of strong acid or strong base. Explain your answer in one or two sentences.

What will be the pH of the buffer if the bacteria excrete 1.2×10^{-3} moles of H_3O^+ ?

What is the original buffer's capacity to neutralize strong base? Report your answer as the amount, in grams, of NaOH that can be neutralized by the buffer.