Chemistry 121 Name:

Sample exam 3 (Chapters 8, 9 and 10)

Open book, homework, notes, calculators allowed; 50 minutes, no collaboration. Partial credit for problems can be awarded only with a clear setup of the problem. Answer all questions.

1. (3 points) You buy exactly 200 grams of very hot coffee (45°C) beverage in a cup and immediately dissolve 50.0 grams of sugar (you like very sweet coffee). However, you forget about the coffee and it cools to 5°C without you taking a sip or any of it evaporating. You read that the **solubility** of sugar in coffee at 5°C is "10.0g sugar per 100g coffee". What **mass** of sugar awaits you in solid form at the bottom of the cup?

2. a. (5 points) Recall from exercise 8 the **ascorbate** ion ($C_6H_7O_6^-$, but you can write "Asc^-"). **Write the products** of and **balance** the following double replacement reaction:

$$FeAsc_2\ (aq) + \quad H_2S\ (aq) \rightarrow$$

b. (4 points) Write the **net ionic equation** for the reaction in part a.

3. Hydrogen phosphate ion (HPO_4^{2-}) dissociates in water to form hydronium ion and the phosphate ion (PO_4^{3-}), as shown below:

$$HPO_4^{2-}\ (aq) + H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + PO_4^{3-}\ (aq)$$

a. (4 points) Identify the **conjugate acid/base pairs** (there should be two pairs). Clearly label each acid and each base.

b. (4 points) Write the **equilibrium constant expression** for hydrogen phosphate ion.

c. (4 points) According to the handout, hydrogen phosphate ion has a **K_a of 2.2×10^{-13}**. In a solution of 1.0 M hydrogen phosphate ion, which is there **more** of: hydrogen phosphate ion or phosphate ion? For full credit, you *must* justify your answer.

d. (4 points) The addition of calcium ions to the solution will **remove phosphate ions** by precipitation of calcium phosphate. According to **LeChatelier's principle**, in which direction will the equilibrium shift? You *may* justify your answer, if you wish.

4. (3 points) Draw an **energy diagram**, and demonstrate how the addition of a **catalyst** speeds up a reaction.

5. a. (2 points) Fill in the blanks in the recipe for your buffer:

"To make 50.00 mL of pH 4.30 acetic acid/potassium acetate buffer:

In a 50.00 mL volumetric flask, add about 30 mL of distilled water. To this add

_____ mL of stock 6.00 M acetic acid solution and _____ g potassium acetate, and stir until dissolved. Bring the solution up to 50.00 mL by adding distilled water in a squirt bottle, and mix thoroughly."

b. (8 points) *Explain* how you derived the two numbers (the mass of the potassium acetate and the volume of the acetic acid) in the recipe. The more clearly, neatly and logically you explain the derivation of your numbers, the more points you will be awarded. For instance, simply writing a bunch of math equations with no other words will get you about *half* credit.

c. (4 points) How will your buffer guard against excess base causing a big pH change? Use a **chemical equilibrium equation** to demonstrate how the buffer will work.

6. (5 points) In Lab 5, one partnership made the small but critical mistake of not letting the tip of the buret fill with base *before* starting the titration of the unknown acid. Using a semi-quantitative argument, show how this mistake would have affected the molarity of the unknown acid that they calculated. Hint: would their molarity have been higher? Lower? The same?