Biochemistry Homework Set 1 (Chapters 1 and 2)

Due: Sept. 20, 2012, 5:00 PM

1. These are *basic* conversions that you should be able to do as you covered this material in Chemistry 211.
    a. (5 points) Once bacterial cells achieve log phase they will divide every 20 minutes. Assuming that no cells die, how long will it take for <u>one</u> *E. coli* cell, under optimal conditions, in a 10 L culture flask, to reach its maximum cell density of 10^{10} cells/mL (a saturated culture)?
    b. (5 points) Assuming that optimum conditions could be maintained, how long will it take for the total volume of cells to reach $10^9\, m^3$? (Assume an *E. coli* cell is a cylinder 2 µm long with a diameter of 1 µm)
2. (15 points) Draw a schematic of a bacterial cell and an animal cell. Label all the organelles and briefly describe the function of each organelle.
3. Many proteins in *E. coli* are normally present at concentrations of two molecules per cell.
    a. (5 points) What is the molar concentration of these proteins (the dimensions of an *E. coli* cell are given in Problem 1B)?
    b. (5 points) How many glucose molecules does an *E. coli* cell contain if it has an internal glucose concentration of 1 mM?
4. (5 points) What is the pH of a solution of HCl that has a concentration of 10^{-8} M?
5. (6 points) Draw the bonding pattern of water molecules with acetamide and pyridine. Identify the hydrogen bond donors and hydrogen bond acceptors. If you don't know the molecular structure of these compounds it's time to dust off your organic chemistry text.
6. (5 points) Explain why the mobility of H^+ in ice is only 10X less than in liquid water, whereas the mobility of Na^+ in solid NaCl is zero.
7. (10 points) Got to have a plug-n-chug, Chemistry 211, buffer problem. Calculate the **pH** of the following solutions. Again, if you do not recall buffers and acid base chemistry, dust off your Chemistry 211 textbook. You will be dealing with buffers in Chemistry 340, 440 (winter), and in bioPchem (spring).
    a. 0.1 M HCl
    b. 0.1 M NaOH
    c. $3x10^{-5}$ M HNO_3
    d. $5x10^{-10}$ M $HClO_4$
    e. $2x10^{-8}$ M KOH
8. Buffers are crucial systems in biochemistry. Solve the following problems (Chemistry 212).
    a. (5 points) What is the pH of an acetate buffer made up of 0.05 M acetic acid and 0.10 M sodium acetate? The pKa for acetic acid is 4.76.
    b. (5 points) What is the pH of a borate buffer made up of 0.20 M boric acid and 0.05 M sodium borate? The pKa for boric acid is 9.24.

9. (10 points) As it often happens in the laboratory, the chemical you need is not in stock. In order to continue your experiment you must make a 0.1 M glycine buffer at pH 9.4. How much (volume) 0.1 M glycine at pH 9.0 must you mix with 0.1 M glycine at pH 10.0 to obtain 200 mL of a 0.1 M glycine buffer at pH 9.4? The pKa of glycine is 9.25.

10. The biological buffer Tris-Cl is used in many buffer systems as it is cheap and has a pH range that matches biological pH. The amino group of Tris-Cl, which has a pKa of 8.06, can exist either in the protonated form (--NH3+) or as the free base (--NH2), because of reversible equilibrium.

    a. (2 points) In what pH range can Tris-Cl be used as an effective buffer due to its amino group?

    b. (5 points) In a 0.1 M solution of Tris-Cl at pH 7.5, what fraction of Tris has its amino group in the –NH3+ form?

    c. (5 points) How much 5 M KOH must be added to 1.0 L of 0.1 M glycine at pH 7.5 to bring its pH to exactly 9.00?

    d. (3 points) When 99% of the Tris-Cl is in its –NH3+ form, what is the numerical relation (i.e. the equation) between the pH of the solution and the pKa of the amino group? What does this mean?

11. (5 points) Go to the library (or online if we have electronic access) and locate where the current journals are located. Report this in your homework. Do the same for chemistry books.

    a. Locate a paper in the journal *Biochemistry*, *Cell*, *Journal of Biological Chemistry*, or *Proceedings of the National Academy of Sciences* that interests you. What is the organization of the paper? YOUR LAB REPORTS MUST MIRROR THE ORGANIZATION OF THIS ARTICLE. List the major sections of the paper you chose.