CHEM106 Midterm Exam
You must show all equations and all work to receive any credit

1. The amino acid cysteine has pKa's of 2.05, 10.25, and 8.00 (the 8.00 pKa is for cysteine's side group).

    a. Draw the complete Lewis structures—showing all atoms, bonds, lone electron pairs and full charges--of the two most abundant forms of cysteine that would be present at a pH of 8.20. Clearly show which is the more concentrated.

    b. For a pH of 8.20, calculate the ratio of the two most concentrated forms of cysteine.

2. Phosphoric acid (H_3PO_4) has pKa's of 2.16, 6.86, and 12.32.

    a. Draw the complete Lewis structure—showing all atoms, bonds, lone electron pairs and full charges-- for the most concentrated form present at a pH of 7.4.

    b. Draw the mechanism for the reaction of glycerol with the most abundant form of phosphoric acid that would be present at a pH of 7.4. Show all atoms, all bonds, and all charges for both reactants and expected products. Clearly show the mechanism for the reaction.

    c. Write a balanced chemical equation for the reaction of H_3PO_4 with water.

    d. Write a balanced chemical equation for the reaction of a phosphate ion (PO_4^{-3}) with water.

3. As a chemist in a leading pharmaceutical firm, you have been assigned the tasking of measuring the partition coefficient, P, for 4-Pentyl Pyrazole. This substance is one of the drug candidates being considered for Phase I human clinical trials testing. The pharmaceutical industry uses a substance's P value to help predict drug activity and biological effectiveness. From a mixture of 1000.0 mL of water with 100.0 mL of 1-octanol, you determined that the water phase had 1.1×10^{-3} moles of 4-Pentyl Pyrazole and that the 1-octanol phase for this mixture contained 9.1×10^{-4} moles of 4-Pentyl Pyrazole.

    a. Calculate the partition coefficient, P, for 4-Pentyl Pyrazole.

    b. Comment on whether 4-Pentyl Pyrazole is hydrophobic or hydrophilic. Clearly explain why using fundamental scientific principles.

4. A Lineweaver-Burk plot gave a slope of 0.833 min and an intercept of 5.4496 min/mM.

    a. Calculate V_{max} for this reaction. Show all equations, substitutions and units.

    b. Calculate K_M for this reaction. Show all equations, substitutions and units.

    c. Discuss the physical significance of K_M.

    d. The Lineweaver-Burk data were obtained for an enzyme concentration of 1.2×10^{-4} mM. Use this and your answers to part a to calculate the turnover number for this enzyme.

    e. Clearly and simply explain what is specifically meant by the enzyme turnover number.

5. Nonsteroidal anti-inflammatory drugs (NSAIDs) are used primarily to treat inflammation, mild to moderate pain, and fever. Their primary mechanism of action as an anti-inflammatory involves inhibition of the COX-2 enzyme that is upregulated and expressed in response to injury. NSAIDs vary in their potency, duration of action, and the way in which they are eliminated from the body. A recent research article reported the IC50s on human recombinant COX-1 enzymes of three widely used NSAIDS: Indomethacin 0.1 μM, Naproxen 32 μM, and Diclofenac 0.03 μM.

    a. Rank order these three medications in terms of increasing (from lowest to highest) potency.

    b. Discuss specifically, at the molecular level, why these potencies are different; be very specific.

6. One rule of thumb often used to predict changes in reaction rates with temperature is that reaction rates approximately double for each ten degree increase in temperature. Determine the activation energy, in units of kJ/mole, for a reaction whose rate constant k doubles (i.e. the ratio of k's is 2) between 298 K and 308 K.

7. Draw the molecular structure for each of the following amino acids in the form that is most abundant at a physiological pH of 7.4. Except for aromatic rings, show all atoms, bonds, lone pairs, and full charges (not partial charges) for these compounds:

    a. Tyrosine

    b. Aspartic Acid

    c. Lysine

    d. Glycine

    e. Valine