CHEM106 Midterm Examination *Name on back only please*

Please show all equations and all work to receive any credit

1. Carbonic acid (H_2CO_3) is a diprotic acid that reacts with water as an acid with two K_a equilibrium constants having the following values: K_{a1} =4.3 x 10^{-7} and K_{a2} = 4.7 x 10^{-11}.

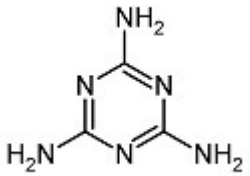
    a. For a pH=7.4, draw the Lewis structures (showing all bonds, all lone pairs, and all charges—not partial charges) for the two most concentrated forms of carbonic acid. Clearly show which of the two forms is present at a greater concentration and clearly explain why.

    b. For the two forms drawn in part a, calculate the relative amounts present at a pH = 7.4.

    c. For a pH=1, draw the complete Lewis structure of the most concentrated form of carbonic acid.

    d. For pH=13, draw the complete Lewis structure of the most concentrated form of carbonic acid.

2. A recent global food scandal involved infant formula from China that had been adulterated with toxic melamine to increase the "apparent" milk protein content (determined by measuring the amount of nitrogen). Several infants died; hundreds more were hospitalized. Melamine has a log P of -1.37.



    a. Define what exactly P is and calculate the value of P for melamine.

    b. Clearly explain why melamine has the P value that it does; use diagrams to support your answer.

3. Draw the complete Lewis structures of reactions and products and clearly show the mechanism of action for each of the following reactions:

    a. Methanol (CH_3OH) with acetic acid

    b. Glycerol with a dihydrogen phosphate ion.

    c. Alanine with cysteine

4. Alcohol dehydrogenase has a K_M of approximately 0.040 mM and catalyses the oxidation of ethanol in the liver as blood continually cycles through this organ.

    a. Determine the ethanol (substrate) concentration at which 80% of the alcohol dehydrogenase molecules are saturated with ethanol.

    b. Plot the rate (velocity) of ethanol oxidation as a function of increasing ethanol concentration. Clearly label the plot.

    c. For both competitive and noncompetitive inhibitors of alcohol dehydrogenase, plot the rate (velocity) of ethanol oxidation as a function of increasing ethanol concentration. Clearly label.

    d. The allowable blood alcohol level is 80 mg / dL; this corresponds to an ethanol blood concentration of 17.4 mM. Comment on the ability of the alcohol dehydrogenase enzyme to rapidly metabolize these high blood alcohol concentrations.

5. Find the pH, $[H_3O^+]$, $[OH^-]$, and pOH for a 0 .020 M HCl solution.

6. For the combustion of ethanol,

    a. Write the balanced reaction.

    b. The change in Gibbs Free Energy for the combustion of ethanol is less than zero. Sketch a reaction-coordinate Gibbs Free Energy plot for this reaction. Clearly label all parts.

    c. Compare the activation energy of the forward reaction with the activation energy of the reverse reaction. Clearly support your answer.

    d. The activation energy for the combustion of ethanol has recently been reported to be 57.6 kJ / mol. For a temperature of 500°C, calculation the fraction of molecular collisions with kinetic energy greater than this activation energy.

    e. Determine how many times faster the ethanol combustion reaction (with a 57.6 kJ/mol activation energy) would occur at a temperature of 600°C than it does at a temperature of 500°C.

7. Outline and draw diagrams clearly showing four different interactions that hold together parts of a protein molecule that are far apart in the amino acid sequence.