Homework, Week 8

1. a) 0.45 moles of hydrofluoric acid are dissolved in 100 mL of water. Determine the concentration of all species at equilibrium.

  b) HCl is added to this solution to a final concentration of [Cl⁻] = 0.03 M. Determine the concentration of all species in this solution at equilibrium.

  c) Is your original solution a good buffer? Why or why not?

2. Prepare a buffer that will maintain the pH of an aqueous solution at 8.3.

3. a) Identify the most acidic hydrogen atom on the following molecules:

ethanoic acid   phenol   propanoic acid

pentyne   imidazole   ethane thiol
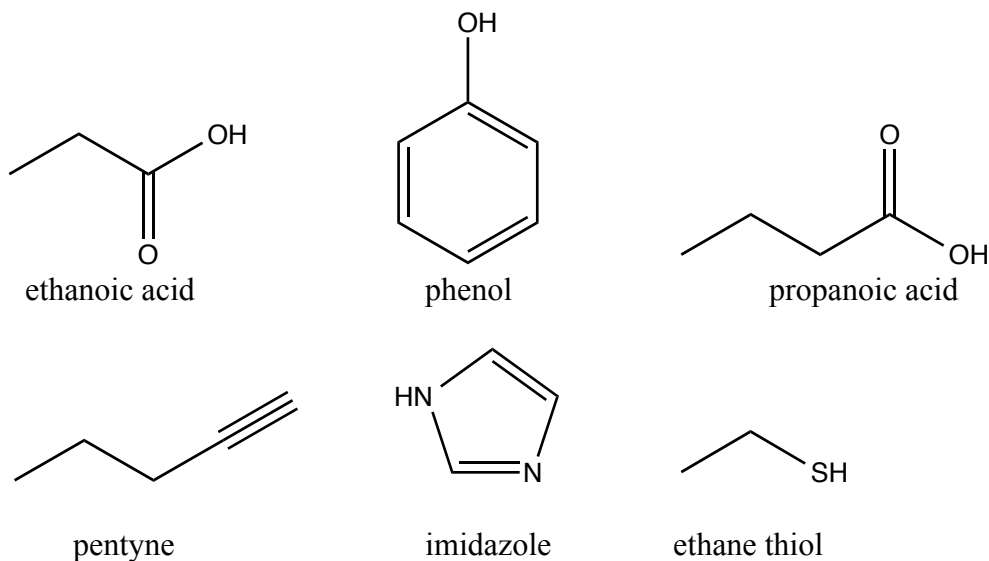
  b) Without looking at any data tables, rank these molecules in order of increasing pK_a and justify your reasoning.

4. Determine whether the following molecules will accept a hydrogen atom (i.e. is a Bronsted-Lowry base). If the answer is "yes," draw the structure of the resulting conjugate acid.

imidazole   1,3-propanediamine (aka cadaverine)   2-amine ethanoic acid
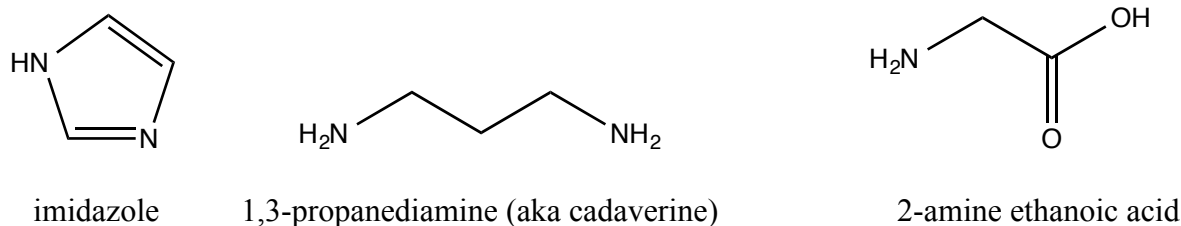
5. You need to titrate a solution of a weak acid to determine its concentration. You make a solution of 0.500 M NaOH(aq) by dissolving an appropriate amount of solid NaOH in water. However, as you attempt to mass out the solid NaOH you discover that this molecule is exceedingly hygroscopic – i.e it easily absorbs water from the air. As you measure out the solid in your weighing boat, you watch it dissolve in atmospheric water before your very eyes. Because of this, it is impossible to know the mass of NaOH that you have dissolved in water to the accuracy necessary for your solution. Describe an experiment that you could run that would resolve this situation. Assume you have an entire laboratory at your disposal, including, for example, a bottle of commercial concentrated HCl, which comes in a solution of 38% (w/w).

6. Cooked fish contains large amounts of organic amines of the formula $R-NH_2$ (e.g. $R = CH_3$, $(CH_3)_2$, $(CH_3)_3$). These molecules have high vapor pressure and very distinct smells that are often associated with the aroma of cooked fish. Using arguments from acid-base chemistry, explain why many people like to squeeze some lemon on their fish before eating.

7. The pH of human blood is maintained by several buffer systems, but one of the most important is based on carbonic acid (H_2CO_3) and its conjugate base bicarbonate (HCO_3^-). The body controls the amount of carbonic acid in the blood through respiration of $CO_2(g)$ produced during metabolism (breathing faster and more deeply decreases the concentration of $CO_2(g)$ dissolved in the blood, which in turn decreases the amount of carbonic acid). The body controls the amount of bicarbonate in the blood by varying its rate of excretion in urine. Any injury or disease which impedes these control mechanisms will very quickly result in death.

What is the ratio of this acid/conjugate base pair that must be maintained in the blood to keep a constant pH level of 7.35-7.45?