Some Relatively Challenging Acid/Base Problems for Students who Like to Think!

1. 20.0 ml of .400 M acetic acid are mixed with 40.0 ml of .300 M potassium hydroxide. What is the pH?
2. 40.0 ml of .300 M sulfuric acid are mixed with 40.0 ml of .600 M sodium hydroxide. What are the equilibrium concentrations of all species?
3. 20.0 ml of .200 M hydrochloric acid are mixed with 20.0 ml of .300 M ammonium hydroxide.What is the pH?
4. What is the pH of a mixture of .4 M nitrous acid and .2 M lithium nitrite?
5. What is the percent ionization of a solution of .2 M acid HA with a pH of 3.3?

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EXPLANATIONS!!

1. You have .008 moles of acetic acid reacting with .012 moles of KOH. The stoichiometric ratios are all 1:1:1:1, so KOH is in excess by .004 moles. The total volume of solution is .06 liters, so the concentration of the EXCESS KOH is .067 M.
Since KOH is a strong base, there is no equilibrium shift due to the common ion in the salt and the pH is determined solely by the concentration of the hydroxide. The pOH is 1.17 and the pH is 12.83.

2. You have .012 moles of sulfuric acid and .024 moles of sodium hydroxide. There is no excess reactant because of the 2:1 reactant ratio. .012 moles of sodium sulfate are produced, when will be divided by .08 liters to get a molarity of .15. Since there is no excess reactant, the only thing in the solution at the end will be the sodium sulfate, which **dissociates into two sodium ions and one sulfate ion** so the concentration of the sodium will be .3 M and the sulfate will be .15 M (if time permits on Monday, we will delve into the ionization of the sulfate ion.)

3. The excess reactant is ammonium hydroxide. The concentration of the excess ammonium hydroxide is .05 M. Since this is a weak base, it must be "iced."
When icing, the concentration of the ammonium ion must include the concentration from the salt that is produced. The ammonium chloride salt has a concentration of .004/.04 or .1 M.

The final "iced" set up is $1.74 \times 10^{-5} = (x)\ (x + .1)\ /\ (.05 - x)$
Since the power differences between Kb and the concentration exponents are both 3 or more, you can ignore the "-x." The value of x is $8.7 \times 10.^{-6}$ pH is 8.94.

4. Nitrous acid is a weak acid and lithium nitrite is a soluble salt. When they are in the same solution the concentrations of all substances at equilibrium are as follows:

Nitrous acid ----- .4 M - x
Nitrite ion ----- x (from the ionization of the weak acid) + .2 (from the concentration of the soluble salt.)
Hydronium ion ---- x

The value of x is .0008 M and the pH is 3.1. (I used .0004 for Ka of nitrous acid—from the text).

5. Since the pH is 3.3, the hydronium ion concentration is .000501 M. This is the amount that reacted, so divide this number by the original concentration and multiply by 100 to find the % ionization.
The answer is .25 %.