Review #5 – Acids

1. Nicotine is a weak base. If a 5.0×10^{-3} M solution of nicotine has a pH of 9.86, calculate the K_b for nicotine.

2. Describe three ways in which the titration curve of a strong base to a weak acid differs from that of a strong base added to a strong acid.

3. By law, vinegar must contain 4.00% by mass of acetic acid. A 40.0 mL sample of brand X vinegar is titrated with NaOH. It is found that 27.2 mL of 1.00 M NaOH is required for complete reaction. Show by calculation whether or not Brand X meets the legal requirements. Density of the sample is 0.986 g/mL.

4. Calculate the pH of 0.10 M NaOCl. K_a for HOCl is 3.1×10^{-8}.

5. Derive the relationship between [H_3O^+] and K_a of an indicator at the point where the indicator changes colour.

6. The following equation represents an acid-base reaction:

   $HF + ClO^- \leftrightarrow F^- + HClO \quad K_{eq} = 2.3\times10^4$

   Explain which is the stronger acid in the reaction.

7. Calculate the [OH^-] midway through the colour change for the indicator indigo carmine.

8. When the amphiprotic anion HPO_4^{2-} is added to water, does it act as an acid or as a base?

9. Describe the trend in acidic and basic properties of the aqueous hydroxides of the third row elements in the periodic table.

10. An impure sample of caustic soda, NaOH, was titrated with HNO_3 solution, with the following results:

Mass of impure sample	5.0 g
Volume of acid required	75.00 mL
Concentration of acid	1.40 M

Assuming the impurities do not react, calculate the % purity by mass for this sample of caustic soda.

Review #5 Acids and Bases

1. $K_b = \frac{(7.2x10^{-5})^2}{(5.0x10^{-3}-7.2x10^{-5})}$

$K_b = 1.1x10^{-6}$

$pOH = pK_w - pH$

$pOH = 14.00 - 9.86 = 4.14$

$[OH^-] = antilog(-pOH)$

$= antilog(-4.14)$

$= 7.2x10^{-5}$ M

2. Three ways in which the titration curve of strong base-weak acid differs from that of a strong base-strong acid:

   1. For a strong base-strong acid titration, the stoichiometric point is at pH = 7.00, while for a strong base-weak acid titration, the stoichiometric point is at a pH greater than 7.00 (solution is basic at endpoint).

   2. The strong base-weak acid titration has a buffer zone in which the pH rises very gradually; the strong base-strong acid titration does not form a buffer.

   3. The strong base-weak acid curve has a higher initial pH before any base is added; the strong base-strong acid curve has a lower initial pH.

3. moles NaOH= moles OH^- = MV = $(1.00)(27.2x10^{-3}) = 2.72x10^{-2}$

moles H^+ = moles OH^- = $2.72x10^{-2}$

moles CH_3COOH (acetic acid) = moles H^+

moles CH_3COOH x $\frac{60.0 \text{ g}}{1 \text{ mole } CH_3COOH}$

= 1.63 g CH_3COOH

grams of sample = 0.986 g/mL x 40.0 mL = 39.4 g vinegar

% composition = $\frac{1.63}{39.4}$ x 100 = 4.14%

4. $NaOCl \text{ ---> } Na^+ + OCl^-$

$OCl^- + H_2O \text{ <---> } HOCl + OH^-$

$K_b = \frac{[OH^-][HOCl]}{[OCl^-]} = \frac{K_w}{K_a} = \frac{1.00x10^{-14}}{3.1x10^{-8}} = 3.2x10^{-7}$

Let x = $[OH^-]$

then [HOCl] = x

and $[OCl^-]$ = 0.10 M - x (about 0.10 if x is small)

$\frac{X^2}{0.10} = 3.2 \text{ X } 10^{-7}$

x = $[OH^-]$ = $1.8x\ 10^{-4}$ M

pOH = $-log[OH^-]$ = 3.75

pH = 14.00 - 3.75 = 10.

5. $K_a = \frac{[H_3O^+][I_n^-]}{[HI_n]}$ When indicator changes color $[I_n^-] = [HI_n]$ and $K_a = [H_3O^+]$

6. Since K_{eq} is greater than one, the product of the $[F^-]$ and $[HClO]$ must be greater than the product of the $[HF]$ and the $[ClO^-]$. Since product production is favoured, the HF must be the stronger acid and the reaction proceeds to the right.

7. Midway through color change for indigo carmine, pH = 12.2
$pOH = pK_w - pH = 14.0 - 12.2 = 1.8$
$[OH^-] = \text{antilog}(-pOH) = \text{antilog}(-1.8) = 1.6\times10^{-2}$ M

8. HPO_4^{2-} as an acid $K_a = 2.2\times10^{-13}$ HPO_4^{2-} as a base $K_b = 1.6\times10^{-7}$
It acts as a base since $K_b > K_a$.

9. On the lower left, the compounds are basic (eg. NaOH, $Mg(OH)_2$. Compounds in the middle can be amphiprotic (eg. H_3AlO_3 or $Al(OH)_3$). On the upper right, the compounds are acidic (eg. $HClO_4$)

10. moles HNO_3 = moles H^+ = MV = $(1.40)(75.00\times10^{-3})$
$= 1.05\times10^{-1}$ moles
moles H^+ = moles OH^- = moles NaOH = 1.05×10^{-1} moles
$1.05\times10^{-1} \text{ moles NaOH} \times \frac{40.0\text{ g}}{1\text{ mole NaOH}} = 4.2\text{ g NaOH}$

$\% \text{ purity} = \frac{4.2}{5.0} \times 100 = 84\%$