Indicators and Titrations Practice

1.) If an indicator HIn is yellow in acids and blue in bases, what would the colour of the anion (In^-) be?

Answer – the anion is blue as the indicator will be in its conjugate base form in the presence of a base.

2.) Thymol blue is an indicator that changes colour from $8.0 - 9.6$ on the pH scale. Its equivalence point is at a pH of 8.8. What is an estimate of the K_a value?

Answer – $pH = pK_a$ $K_a = antilog[-pH]$ $K_a = antilog[-8.8]$ $K_a = 1.6 \times 10^{-9}$

3.) If you mix thymol blue and alizarin yellow with a solution of $1.0 \times 10^{-4}\ M\ NaOH$ what colour would the solution be? (Hint – use your acid-base indicators chart)

Answer – $pOH = -\log[OH^-]$ $pOH = 4$ $pH = 14 - pOH$ $pH = 10$

Thymol is blue at 10 and alizarin is yellow at 10. So, at a pH of 10 we have blue and yellow = green.

4.) You found the following results (below) when a solution was tested against three indicators. What is the pH range of the solution?

Indicator	Colour
Methyl red	yellow
Phenol red	red
Phenolphthalein	colourless

Answer – methyl red is yellow at 6.0 and above, phenol red is red at 8.0 and above, and phenolphthalein is colourless at 8.2 and below. This lends a result range from 8.0 to 8.2.

5.) If the following acids and bases are titrated against each other, will the resulting solution be acidic, neutral, or basic? Which indicators would be a good choice for testing for the equivalence point?

a.) HF + NaOH Basic – Phenolphthalein b.) LiOH + HBr Neutral – Bromthymol blue

d.) C_6H_5COOH + $Ca(OH)_2$ Basic – Phenolphthalein e.) HNO_3 + KOH Neutral – Bromthymol blue

6.) When titrating benzoic acid (C_6H_5COOH) it requires $28.4\ mL\ of\ 0.125\ M\ NaOH$. The initial pH of the acid was 2.628 and the pH at the halfway point is 4.191.

a.) What is K_a for benzoic acid?

Answer - $K_a = [H_3O^+]_{1/2}$ where $[H_3O^+]_{\frac{1}{2}}$ is from $pH_{1/2}$ $pH_{1/2} = 4.191$

$K_a = antilog[-pH_{\frac{1}{2}}]$ $K_a = 6.44169 \times 10^{-5}$ $K_a = 6.44 \times 10^{-5}$

b.) What is the starting concentration of the acid?

Answer - $[HA]_{equ} = \frac{[H_3O^+]^2}{K_a}$ where $[H_3O^+]$ is from pH_{init} $pH_{init} = 2.628$

$[H_3O^+] = antilog[-pH_{init}]$ $[HA] = \frac{[2.355\times10^{-3}]^2}{6.44169\times10^{-5}}$ $[HA]_{equ} = 0.086099\ M$

$0.086099 + 2.355 \times 10^{-3} = 0.0885\ M$

7.) A solution of $25.0\ mL$ $C_3H_4N_2$ (imidazole) has a pH of 10.104. This solution is titrated with $36.8\ mL\ of\ 0.0986\ M\ HCl$. The pH at halfway to the equivalence point is 7.047.

a.) What is the K_b of the imidazole?

Answer - $K_b = [OH^-]_{1/2}$ where $[OH^-]_{1/2}$ is from $pOH_{1/2}$ $14 - 7.047 = 6.953$ $pOH_{1/2} = 6.953$

$K_b = antilog[-pOH_{1/2}]$ $K_b = 1.11 \times 10^{-7}$

b.) What is the [imidazole] when calculated from the [HCl] and the volumes of HCl and imidazole?

Answer - $\frac{0.0986\ mol\ HCl}{1\ mol\ HCl} \times \frac{1\ mol\ imidazole}{1\ mol\ HCl} \times 0.0368\ L = 0.00362848\ mol\ imidazole$

$\frac{0.00362848\ mol\ imidazole}{0.025\ L} = 0.1451392\ M\ imidazole$ $[imidazole] = 0.145\ M$

c.) What is the [imidazole] when calculated from the K_b and the initial pH?

Answer - $[A^-]_{equ} = \frac{[OH^-]^2}{K_b}$ where $[OH^-]$ is from pOH_{init} $pOH_{init} = 3.896$

$[OH^-] = antilog[-pOH_{init}]$ $[A^-] = \frac{[1.27057\times10^{-4}]^2}{1.11\times10^{-7}}$ $[A^-]_{equ} = 0.1448762492\ M$

$0.1448762 + 1.27 \times 10^{-4} = 0.145\ M$