Volumetric Analysis I: NaOH Standardization I

$H_2C_2O_4(aq) + 2NaOH(aq) \rightarrow 2H_2O + Na_2C_2O_4(aq)$ $H_2C_2O_4 \cdot 2H_2O = 126.0$ g/mol

Suppose that you weight out a 1.218 g sample of $H_2C_2O_4 \cdot 2H_2O$

[1.218 g] / [126.0 g/mol] = 9.667 X 10^{-3} mol of $H_2C_2O_4 \cdot 2H_2O$

Oxalic acid dehydrate ionizes to yield **2** protons, the two waters just go into the solution

$H_2C_2O_4 \cdot 2H_2O \rightarrow 2H_2O + C_2O_4^{2-} + 2H^+$

what yields **2 X [9.667 X 10^{-3} mol of H^+**]. Notice the Acid:Base mole ratio is 1:2

If the NaOH solution was 0.0995 mol/L in concentration, then the volume of this solution required to neutralize the acid would be

[1.933 X 10^{-2} mol of H^+] / [0.0995 mol/L] = 194.3 X 10^{-3} L of NaOH

which equals 194.3 mL, a volume much larger than our buret's capacity.

The best way to do this is to place the 1.218 g of $H_2C_2O_4 \cdot 2H_2O$ in a 100.0 mL volumetric flask and take aliquots. For a 17.01 mL aliquot, the amount of $H_2C_2O_4$ being withdrawn is 17.01 % of the total…

9.667 X 10^{-3} mol of $H_2C_2O_4$ X [17.01 mL/100.0 mL] = 1.643 X 10^{-3} mol of $H_2C_2O_4$

Suppose the volume of NaOH solution required to neutralize the acid is 34.41 X 10^{-3} L, then the molarity of the NaOH solution is

[2 X 1.643 X 10^{-3} mol of $H_2C_2O_4$] / 34.41 X 10^{-3} L = 0.0995 mol/L

Trial	Example	I	II	III	IV
Acid Vol [L X 10^{-3}]	17.01	______	______	______	______
Mol of Acid X 10^{-3}	1.643	______	______	______	______
Mol eq of Base X 10^{-3}	3.286	______	______	______	______
Buret $Read_1$ [L X 10^{-3}]	10.97	______	______	______	______
Buret $Read_2$ [L X 10^{-3}]	45.38	______	______	______	______
$Read_2$ - $Read_1$ [L X 10^{-3}]	34.41	______	______	______	______
M of NaOH [mol/L]	0.0995	______	______	______	______

Average Molarity of NaOH:________________ [mol / L]

Volumetric Analysis II: NaOH Standardization II

$KHC_8H_4O_4$ (aq) + NaOH(aq) → H_2O + $KNaC_8H_4O_4$ (aq) $KHC_8H_4O_4$ = 204.0 g/mol

Again we use the same solution as last time. Suppose you weight out a 0.456 g sample of $KHC_8H_4O_4$.

[0.456 g] / [204.0 g/mol] = 2.235 X 10^{-3} mol of $KHC_8H_4O_4$

Potassium hydrogen phthalate ionizes to yield **1** proton

$KHC_8H_4O_4 \rightarrow KC_8H_4O_4^- + H^+$

what yields **2.235 X 10^{-3}** mol of H^+.

If the sample requires 22.47 mL of NaOH to reach the equivalence point, then the molarity of the NaOH solution is

[2.235 X 10^{-3} mol of H^+] / [22.47 X 10^{-3} L] = 0.0995 mol/L

Trial	Example	I	II	III	IV
Acid Mass [grams]	0.456	________	________	________	________
Mol of Acid X 10^{-3}	2.235	________	________	________	________
Mol eq of Base X 10^{-3}	2.235	________	________	________	________
Buret $Read_1$ [L X 10^{-3}]	10.02	________	________	________	________
Buret $Read_2$ [L X 10^{-3}]	32.49	________	________	________	________
$Read_2$ - $Read_1$ [L X 10^{-3}]	22.47	________	________	________	________
M of NaOH [mol / L]	0.0995	________	________	________	________

Average Molarity of NaOH:________________ [mol / L]

Volumetric Analysis III: Percent purity of a $KHC_8H_4O_4$ sample

$KHC_8H_4O_4$ (aq) + NaOH(aq) → H_2O + $KNaC_8H_4O_4$ (aq) $KHC_8H_4O_4$ = 204.0 g/mol

Now we make use of the standardized NaOH solution to determine the percent purity of a Potassium hydrogen phathalate sample. We use our standard solution, (say 0.0995 M) This time you weight out a 0.8420 g sample of impure $KHC_8H_4O_4$. Again, the potassium hydrogen phthalate ionizes to yield **1** proton, but the impurities do not react with the NaOH

Impurities + $KHC_8H_4O_4$ (aq) + NaOH(aq) → H_2O + $KNaC_8H_4O_4$ (aq) + Impurities

Suppose that 25.44 X 10^{-3} L of the standard NaOH solution were required to neutralize the acid. From stoichiometry we get that the number of moles of acid in the sample is

[25.44 X 10^{-3} L] X [0.0995 mol/L] = 2.531 X 10^{-3} mol of $KHC_8H_4O_4$

Using the molar mass of $KHC_8H_4O_4$ we get the number of grams

[2.531 X 10^{-3} mol of $KHC_8H_4O_4$] X [204.0 g/mol] = 0.5164 g of $KHC_8H_4O_4$

Then we determine the percent purity of the sample

[0.5164 g of $KHC_8H_4O_4$ / 0.8420 g of sample] X [100] = 61.33 % $KHC_8H_4O_4$ by mass

Trial	Example	I	II	III	IV
Sample Mass [grams]	0.842	________	________	________	________
Buret Read$_1$ [L X 10^{-3}]	12.35	________	________	________	________
Buret Read$_2$ [L X 10^{-3}]	37.79	________	________	________	________
Read$_2$ - Read$_1$ [L X 10^{-3}]	25.44	________	________	________	________
Mol of Base X 10^{-3}	2.531	________	________	________	________
Mol eq of Acid X 10^{-3}	2.531	________	________	________	________
Mass of Acid [g]	0.5164	________	________	________	________
% $KHC_8H_4O_4$	61.33	________	________	________	________

Average % $KHC_8H_4O_4$ by mass:________________