Titration 2

Key

1. A solution of hydrochloric acid was standardized by titrating a sample of sodium carbonate. A 0.2786-g sample of the sodium carbonate was added to approximately 25 mL of water in a flask. An addition of 23.78 mL of the HCl solution was required to reach the endpoint. What is the molar concentration of the hydrochloric acid?
(An earlier version of the question was worded differently, but has the same solution.

[HCl] = ?

$2\,HCl + Na_2CO_3 \rightarrow 2\,NaCl_{(aq)} + H_2O_{(l)} + CO_{2\,(g)}$ (From $H_2CO_{3\,(aq)}$)

23.78 mL

mol = ?

0.2786 g

105.99 g/mol

$$0.2786\text{ g } Na_2CO_3 \left| \frac{1\text{ mol}}{105.99\text{ g}} \right| \frac{2\text{ mol HCl}}{1\text{ mol } Na_2CO_3} = 0.0052571\text{ mol HCl}$$

$$[HCl] = \frac{0.0052571\text{ mol HCl}}{0.02378\text{ L}} = \boxed{0.2211\text{ M HCl}}$$

2. In a titration, 27.92 mL of a 0.4500 *M* NaOH solution is required to fully titrate a 15.00 mL sample of a solution that contains the triprotic acid, citric acid: $H_3C_6H_5O_7$. Calculate the molarity of the citric acid in the solution.

$H_3C_6H_5O_7 + 3\,NaOH \rightarrow Na_3C_6H_5O_7 + 3\,H_2O$

15.00 mL

mol = ?

27.92 mL

0.4500 mol/L

$[H_3C_6H_5O_7] = ?$

$$0.02792\text{ L} \left| \frac{0.4500\text{ mol NaOH}}{1\text{ L NaOH soln}} \right| \frac{1\text{ mol } H_3C_6H_5O_7}{3\text{ mol NaOH}} = 0.004188\text{ mol } H_3C_6H_5O_7$$

$$[H_3C_6H_5O_7] = \frac{0.004188\text{ mol}}{0.01500\text{ L}} = \boxed{0.2792\text{ M } H_3C_6H_5O_7}$$

3. A 0.361 g sample of an unknown tetraprotic acid is titrated with a 0.100 *M* solution of KOH and 33.15 mL of the solution is required to fully titrate the acid sample.

$H_4A + 4\,KOH \rightarrow K_4A + 4\,H_2O$

0.361 g

$M_m = \frac{0.361\text{ g}}{?\text{ mol}}$

0.100 mol/L

33.15 mL

$$33.15\text{ mL} \left| \frac{0.100\text{ mol KOH}}{1000\text{ mL}} \right| \frac{1\text{ mol } H_4A}{4\text{ mol KOH}} = 8.2875 \times 10^{-4}\text{ mol } H_4A$$

$$M_m = \frac{0.361\text{ g}}{8.2875 \times 10^{-4}\text{ mol}} = \boxed{436\text{ g/mol}}$$