Calculate the pH in 100.0 mL of 0.400 M H_3BO_3

Answer:

pH = 4.77

Acid - Base Titrations

- titrations are used to determine the concentration of a solution by adding the titrant until the equivalence point is reached

> **titration** = quantitative chemical analysis used to determine the unknown concentration of a known reactant

equivalence point = mole ratio in the reaction exactly equals the mole ratio required by the stoichiometry of the reaction

$$aA + bB \rightarrow cC + dD$$

$$\frac{\text{mole A}}{\text{moles B}} = \frac{a}{b}$$

- all titration problems involve at least five parameters:
  - concentration of acid
  - volume of acid
  - concentration of base
  - volume of base
  - acid/base mole ratio

- when the reaction equation is given, the acid/ base ratio is read directly from the balance equation

- there are three parts to the calculation:
  1. use M = mol/L to calculate moles of first substance
  2. use acid/base ratio to calculate moles of second substance
  3. use M = mol/L to calculate either concentration or volume of second substance

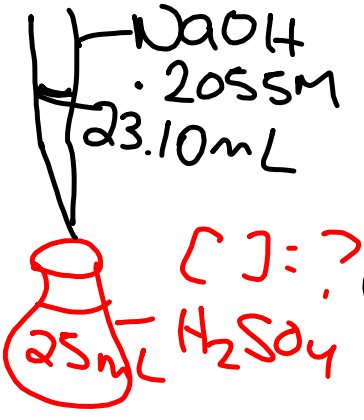
NOTE:

- several trials are necessary to check the accuracy of titrations
  - > volumes should agree within ± 0.02 mL
  - > volumes that exceed this are discarded when calculating the average

ex. In the reaction

$$1\,H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

23.10 mL of 0.2055 M NaOH is needed to titrate a 25.00 mL sample of H_2SO_4 to its equivalence point. What is the $[H_2SO_4]$?



① moles NaOH $= \left(0.2055 \frac{mol}{L}\right)(.0231L)$

$= 4.747 \times 10^{-3}$ mol NaOH

② mol H_2SO_4 $= (4.747 \times 10^{-3}\ mol\ NaOH)\left(\frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH}\right)$

$= 2.3735 \times 10^{-3}$ mol H_2SO_4

③ $[H_2SO_4] \frac{mol}{L} = \frac{2.37 \times 10^{-3}\ mol}{0.025L}$

$= 9.494 \times 10^{-2} M$

- Titrations can also be used to determine the molar mass of an acid.

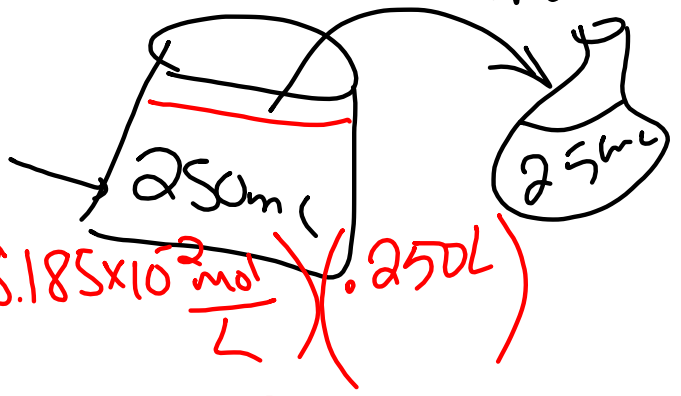
ex. A 3.2357 g sample of unknown monoprotic (HA) acid is diluted to 250.0 mL. A 25.00 mL sample of the acid solution is titrated with 16.94 mL of 0.1208 M KOH. What is the molar mass of the acid?

$HA + KOH \rightarrow H_2O + KA$

① $\text{mol}_{KOH} = \left(.1208 \frac{\text{mol}}{L}\right)(.01694\,L) = 2.046 \times 10^{-3}\ \text{mol}$

② $\text{mol}_{HA} = 2.046 \times 10^{-3}\ \text{mol}$

③ $\frac{\text{mol}}{L}_{HA} = \frac{2.046 \times 10^{-3}\ \text{mol}}{.025\,L} = 8.185 \times 10^{-2}\ M$ of 25mL



④ moles in 25mL $\left(\frac{g}{\text{mol}}\right)$ = ?

$\left(8.185 \times 10^{-2} \frac{\text{mol}}{L}\right)(.250\,L)$

$= 2.046 \times 10^{-2}\ \text{mol}$

$\frac{g}{\text{mol}} = \frac{3.2357\,g}{2.046 \times 10^{-2}\ \text{mol}} = 1.581 \times 10^{2}\ \frac{g}{\text{mol}}$

$= 158.1\ \frac{g}{\text{mol}}$

ex. A solution of HCl of unknown [ ] is titrated with 0.150 M $Ba(OH)_2$. The equivalence point is reached when 14.83 mL of $Ba(OH)_2$ is added to 50.00 mL of HCl. Find [HCl] in original sample.

answer:

$[HCl] = 8.90 \times 10^{-2} M$