An acid is neutralized by a base. If the concentration and volume of the base are accurately known, the concentration or the molar mass of an acid can be determined. The concentration of an unknown acid is equal to the moles of acid per liter of acid. The molar mass of an acid is the grams of acid per mole of acid.

**Examples**

When 1.04 g of a monoprotic unknown acid (HA) is titrated with 0.300 M NaOH it takes 75.21 mL of base to neutralize the acid. Determine the molar mass of the unknown acid.

\[
\text{HA} + \text{NaOH} \rightarrow \text{NaA} + \text{H}_2\text{O}
\]

- begin with units of L on the bottom: (liters will be converted to moles, which are on the bottom of molar mass)

\[
\frac{1}{0.07521 \text{ L NaOH}} \times \frac{1 \text{ mol NaOH}}{0.300 \text{ mol NaOH}} \times \frac{1 \text{ mol NA}}{1 \text{ mol HA}} \times \frac{1.04 \text{ g HA}}{1} = 46.1 \text{ grams HA mol HA}^{-1}
\]

An unknown diprotic acid (H₂A) with a volume of 10.0 mL is titrated with 165 mL of 0.15 M KOH. Find the concentration of the acid in mol/L.

\[
\text{H}_2\text{A} + \text{KOH} \rightarrow \text{K}_2\text{A} + 2 \text{H}_2\text{O}
\]

- begin with units of L on the top: (liters will be converted to moles, which are on the top of the molarity units)

\[
\frac{0.165 \text{ L KOH}}{1} \times \frac{0.15 \text{ mol KOH}}{1 \text{ mol KOH}} \times \frac{1 \text{ mol H}_2\text{A}}{2 \text{ mol KOH}} \times \frac{1 \text{ mol H}_2\text{A}}{0.0100 \text{ L H}_2\text{A}} = 1.2 \text{ mol H}_2\text{A L H}_2\text{A}^{-1}
\]

**Answer the following questions. Show all work and report answers with units.**

1. Lactic acid, a chemical responsible for muscle fatigue, is a monoprotic acid. When 0.578 g of lactic acid is titrated with 0.206 M NaOH, a volume of 31.11 mL of NaOH is used. What is the molar mass of lactic acid?

   \[
   \text{HA} + \text{NaOH} \rightarrow \text{NaA} + \text{H}_2\text{O}
   \]

2. A volume of 25.0 mL of nitric acid, HNO₃ is titrated with 0.12 M NaOH. To completely neutralize the acid 10 mL of NaOH must be added. Find the concentration (mol/L) of the nitric acid.

   \[
   \text{HNO}_3 + \text{NaOH} \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}
   \]

3. Malonic acid is a diprotic acid used in the production of pharmaceuticals. A 0.965 g sample of malonic acid requires 45.91 mL of 0.404 M LiOH to be neutralized. Determine the molar mass (g/mol) for malonic acid.

   \[
   \text{H}_2\text{A} + 2 \text{LiOH} \rightarrow \text{Li}_2\text{A} + 2 \text{H}_2\text{O}
   \]

4. To find the molarity of sulfuric acid, H₂SO₄ it is titrated with 0.75 M KOH. It requires 328.4 mL of KOH to neutralize a 40.00 mL sample of sulfuric acid. Calculate the concentration (mol/L) of the sulfuric acid.

   \[
   \text{H}_2\text{SO}_4 + 2 \text{ KOH} \rightarrow \text{K}_2\text{SO}_4 + 2 \text{ H}_2\text{O}
   \]

5. Boric acid is a triprotic acid that is used as an ant and roach killer. A 1.42-g sample of boric acid is neutralized by 157 mL of 0.4388 M NaOH. Determine the molar mass (g/mol) for boric acid.

   \[
   \text{H}_3\text{A} + 3 \text{NaOH} \rightarrow \text{Na}_3\text{A} + 3 \text{H}_2\text{O}
   \]

6. Tartaric acid, H₂C₄H₄O₆ is neutralized with 0.100 M NaOH. A sample of 3.0 g of tartaric acid reacts with 45 mL of base. How concentrated is the base?

   \[
   \text{H}_2\text{C}_4\text{H}_4\text{O}_6 + 2 \text{NaOH} \rightarrow \text{Na}_3\text{C}_4\text{H}_6\text{O}_6 + 2 \text{H}_2\text{O}
   \]

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