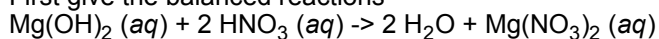


# Acid Base Chemical Reactions Problem Set

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1. Titration/acid base problem. 0.4563 g of  $\text{Mg}(\text{OH})_2$  is weighed out and dissolved in 50.00 mL of  $\text{H}_2\text{O}$ . This is titrated against a solution of  $\text{HNO}_3$ . The initial volume of the burette is 2.35 ml. The final volume of the burette is 47.98 ml. What can you determine?

First give the balanced reactions



Next find the moles of  $\text{NaOH}$

$$\text{Mass}_{\text{MgOH}_2} := 0.4563 \cdot \text{gm}$$

$$\text{MW}_{\text{MgOH}_2} := (24.3050 + 15.9994 \cdot 2 + 1.00794 \cdot 2) \frac{\text{gm}}{\text{mole}}$$

$$\text{Mole}_{\text{MgOH}_2} := \frac{\text{Mass}_{\text{MgOH}_2}}{\text{MW}_{\text{MgOH}_2}} \quad \text{Mole}_{\text{MgOH}_2} = 7.8241 \times 10^{-3} \text{ mol}$$

From the stoichiometry of the balanced reaction this gives

$$\text{Mole}_{\text{HNO}_3} := 2 \text{Mole}_{\text{MgOH}_2} \quad \text{Mole}_{\text{HNO}_3} = 0.016 \text{ mol}$$

The volume of  $\text{HNO}_3$  added is:

$$V_{\text{HNO}_3} := 47.98 \cdot \text{mL} - 2.35 \cdot \text{mL}$$

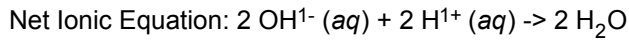
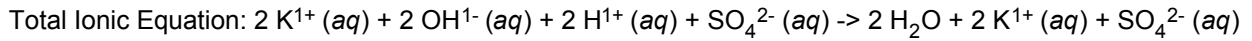
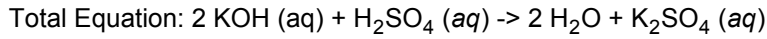
$$V_{\text{HNO}_3} = 45.63 \text{ mL}$$

Therefore the concentration of the nitric acid solution is

$$M := \frac{\text{mole}}{\text{liter}}$$

$$C_{\text{HNO}_3} := \frac{\text{Mole}_{\text{HNO}_3}}{V_{\text{HNO}_3}} \quad C_{\text{HNO}_3} = 0.343 \text{ M}$$

2. A base solution is made by dissolving 4.987 g of Potassium Hydroxide in 500.0 ml of water. 36.84 ml of this base solution is used to titrate 25.00 ml of sulfuric acid. Write the total, total ionic, and net ionic equations for these reactions. What can you calculate from this information? What are your results?



Find the moles of KOH

$$\text{Mass}_{\text{KOH}} := 4.987 \cdot \text{gm}$$

$$\text{MW}_{\text{KOH}} := 56.10564 \cdot \frac{\text{gm}}{\text{mole}}$$

$$\text{Mole}_{\text{KOH}} := \frac{\text{Mass}_{\text{KOH}}}{\text{MW}_{\text{KOH}}}$$

$$\text{Mole}_{\text{KOH}} = 0.089 \text{ mol}$$

$$\text{V}_{\text{KOH}} := 500.0 \cdot \text{mL}$$

$$\text{C}_{\text{KOH}} := \frac{\text{Mole}_{\text{KOH}}}{\text{V}_{\text{KOH}}}$$

$$\text{C}_{\text{KOH}} = 0.178 \text{ M}$$

KOH used in titration

$$\text{V}_{\text{KOH\_used}} := 36.84 \cdot \text{mL}$$

$$\text{Mole}_{\text{KOH\_used}} := \text{C}_{\text{KOH}} \cdot \text{V}_{\text{KOH\_used}}$$

$$\text{Mole}_{\text{KOH\_used}} = 6.549 \times 10^{-3} \text{ mol}$$

From the stoichiometry this gives the  $\text{H}_2\text{SO}_4$  as:

$$\text{Mole}_{\text{H}_2\text{SO}_4} := 0.5 \cdot \text{Mole}_{\text{KOH\_used}}$$

$$\text{Mole}_{\text{H}_2\text{SO}_4} = 3.27456 \times 10^{-3} \text{ mol}$$

The concentration of the acid is:

$$\text{V}_{\text{H}_2\text{SO}_4} := 25 \cdot \text{mL}$$

$$\text{C}_{\text{H}_2\text{SO}_4} := \frac{\text{Mole}_{\text{H}_2\text{SO}_4}}{\text{V}_{\text{H}_2\text{SO}_4}}$$

$$\text{C}_{\text{H}_2\text{SO}_4} = 0.131 \text{ M}$$

3. A sodium hydroxide solution of unknown concentration is titrated against 0.8765 g KHP (Potassium acid phthalate, a monoprotic acid, MW 204.3 g/mol). 48.6 mL of the sodium hydroxide solution is required to reach the endpoint of the titration. What is the concentration of the unknown sodium hydroxide solution.

Information given in problem

$$\text{mass}_{\text{KHP}} := 0.8765 \cdot \text{gm}$$

$$\text{MW}_{\text{KHP}} := 204.3 \cdot \text{gm} \cdot \text{mole}^{-1}$$

$$V_{\text{NaOH}} := 48.6 \cdot \text{mL}$$

Moles of KHP

$$\text{mole}_{\text{KHP}} := \frac{\text{mass}_{\text{KHP}}}{\text{MW}_{\text{KHP}}}$$

$$\text{mole}_{\text{KHP}} = 4.29 \times 10^{-3} \text{ mol}$$

Moles of NaOH

From the reaction:  $\text{NaOH} + \text{KHP} \rightarrow \text{H}_2\text{O} + \text{Na}^{1+} + \text{K}^{1+} + \text{Ph}^{2-}$

$$\text{mole}_{\text{NaOH}} := \text{mole}_{\text{KHP}}$$

$$\text{mole}_{\text{NaOH}} = 4.29 \times 10^{-3} \text{ mol}$$

Concentration of NaOH

$$M_{\text{NaOH}} := \frac{\text{mole}_{\text{NaOH}}}{V_{\text{NaOH}}}$$

$$M := \frac{\text{mole}}{\text{liter}}$$

$$M_{\text{NaOH}} = 0.088 \text{ M}$$

4. This sodium hydroxide solution is then used to titrate an unknown nitric acid sample. 25.0 mL of the nitric acid solution is titrated. 32.8 mL of the sodium hydroxide solution is required to reach the endpoint. What is the concentration of the nitric acid solution?

Information Given:

$$V_{\text{HNO}_3} := 25.0 \cdot \text{mL}$$

$$V_{\text{NaOH}} := 32.8 \cdot \text{mL}$$

Calculate moles of NaOH used:

$$M_{\text{NaOH}} = 0.088 \text{ M}$$

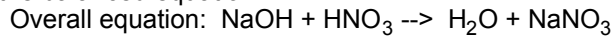
Molarity found in previous question

$$\text{mole}_{\text{NaOH}} := M_{\text{NaOH}} \cdot V_{\text{NaOH}}$$

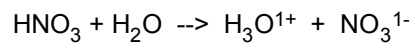
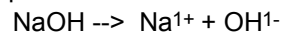
$$\text{mole}_{\text{NaOH}} = 2.895 \times 10^{-3} \text{ mol}$$

Calculate moles of HNO<sub>3</sub> used

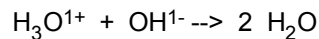
From the balanced equation:



Stepwise:



Net:



$$\text{mole}_{\text{HNO}_3} := \text{mole}_{\text{NaOH}}$$

$$\text{mole}_{\text{HNO}_3} = 2.895 \times 10^{-3} \text{ mol}$$

Concentration of HNO<sub>3</sub>

$$M_{\text{HNO}_3} := \frac{\text{mole}_{\text{HNO}_3}}{V_{\text{HNO}_3}}$$

$$M_{\text{HNO}_3} = 0.116 \text{ M}$$