VANCOUVER COMMUNITY COLLEGE

Titration Calculations

Titrations are a quantitative measurement of a neutralization reaction involving an acid and a base. An acid (or base) of unknown concentration is titrated with a base (or acid) of known concentration to produce a salt and water. Given the known concentration and volume of the titrant, and a measured volume of the unknown, we can determine the unknown concentration once we know the stoichiometry of the reaction.

Example 1: A standard solution of 0.500 M sodium hydroxide (NaOH) is prepared. It is poured into the burette. A 25.00 mL sample of hydrochloric acid of unknown concentration is in the Erlenmeyer flask below the burette. It takes 35.00 mL of sodium hydroxide to neutralize the hydrochloric acid. What is the concentration of HCℓ?

Solution: The first step is the write the equation for the reaction if it is not given:

$$HC\ell + NaOH \rightarrow H_2O + NaC\ell$$

This equation tells us that for every one mole of hydrochloric acid in the flask, exactly one mole of NaOH is required to react with it. Now we work towards finding out the concentration of HCℓ. What do we know? We know the volume and concentration of NaOH solution used.

Molarity = moles/volume

We multiply molarity by volume to find the number of moles — remember to convert any volumes to litres for calculations!

Moles NaOH = (0.03500 L NaOH)(0.500 mol/L NaOH) = 0.0175 moles NaOH

Based on the stoichiometry of the equation above, we know if 0.0175 moles of NaOH were used, they must have reacted with 0.0175 moles of HCℓ.

The concentration of HCℓ is then: 0.0175 moles/0.02500 L = 0.700 M

In practice problems though, you will often be asked to apply the concepts of a titration to situations that experimentally wouldn't occur. For instance you might be given the molarity of HCℓ and asked to find how many millilitres were titrated instead. Or you might be given one of the reactants as a mass dissolved in water. The key steps are always to write the reaction equation, find the moles of the compound that is known, and use the reaction stoichiometry to find the moles of the reactant that the question is about. From there, concentration or volume or even mass can be calculated depending on the question.

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EXERCISES

A. 1. Suppose that 36.00 mL of 0.250 M NaOH solution are required to neutralize 40.00 mL of hydrochloric acid solution. What is the molarity of the acid solution?

2. Suppose that 36.00 mL of 0.250 M NaOH solution are required to neutralize 40.00 mL of sulphuric acid solution. What is the molarity of the acid solution?

3. Suppose that 40.00 mL of 0.150 M HCℓ solution are required to neutralize 35.00 mL of lithium hydroxide solution. What is the molarity of the base solution?

4. Suppose that 40.00 mL of 0.150 M HCℓ solution are required to neutralize 35.00 mL of barium hydroxide solution. What is the molarity of the base solution?

B. 1. What volume (mL) of 0.675 M HNO_3 will be required to neutralize 20.45 g $Ca(OH)_2$ according to the reaction below?

$$2\ HNO_{3\ (aq)} + Ca(OH)_{2\ (s)} \rightarrow Ca(NO_3)_{2\ (aq)} + 2\ H_2O_{\ (\ell)}$$

2. How many grams of $Cs(OH)_2$ will be required to neutralize 550 mL of 0.225 M HCℓ according to the following reaction:

$$2\ HC\ell_{\ (aq)} + Cs(OH)_{2\ (s)} \rightarrow CsC\ell_{2\ (aq)} + 2\ H_2O_{\ (\ell)}$$

3. What volume (mL) of 0.150 M KOH is required to neutralize 725 mL of 0.0525 M H_2SO_4?

4. If 21.64 mL of $HC\ell O_4$ is needed to neutralize 3.00 g $A\ell(OH)_3$, what is the concentration of $HC\ell O_4$?

5. A 10.0 mL sample of NaOH was diluted to a volume of 50.00 mL in a volumetric flask. Then 25.00 mL of that diluted solution was transferred to an Erlenmeyer flask and titrated. It required 50.00 mL of 0.600 M HNO_3 to neutralize the NaOH solution in the Erlenmeyer flask. What was the concentration of the original NaOH?

SOLUTIONS

A. (1) 0.225 M (2) 0.113 M (3) 0.171 M (4) 0.0857 M

B. (1) 818 mL (2) 10.3 g (3) 508 mL (4) 5.33 M (5) 6.00 M

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