

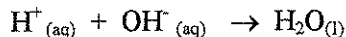
ACID-BASE TITRATIONS

Objective: To determine the molarity of solutions of unknown concentration using acid-base titrations and indicators.

Introduction: When two solutions, one containing strong acid (e.g., HCl) and the other containing strong base (e.g., NaOH), are mixed, a neutralization reaction occurs that is represented by the following overall balanced equation:



And the net ionic equation:



The reaction can be considered to proceed completely to the right, with all of the limiting reactant used up (neutralized), leaving the solution either acidic or basic depending on whether acid or base is present in excess. If exactly equivalent amounts of acid or base are used so that neither reactant is present in excess, the mixture is called "stoichiometric" and the solution is said to be at the "equivalence point." If we consider only monoprotic acids and bases (those that furnish or react with one H^+ per molecule), then at the equivalence point the number of moles of acid must equal the number of moles of base (moles acid = moles base) because the monoprotic acid and NaOH react in a 1:1 mole ratio.

An acid-base "titration" is a procedure used to compare the amount (moles) of acid in one sample with the amount (moles) of base in another. In this laboratory exercise you will carry out such a titration to "standardize" (determine the exact concentration of) an acid solution by measuring accurately how many milliliters of standard base are required to exactly neutralize a known volume of acid. A "buret" filled with the "titrant" (NaOH solution) is used to measure the volume of NaOH solution added to the known amount of acid in a flask. A tiny amount of an indicator (a chemical substance that exhibits different colors in acidic and basic solution) is added to signal when addition of titrant should be stopped, the "endpoint", i.e., when all the acid has been neutralized and the solution composition changes suddenly from excess acid to excess base and the indicator color changes. The endpoint and the equivalence points are the same only if an indicator is used which has a visually detectable color change at the pH the solution will have at the end of the acid-base reaction (the stoichiometric point in the titration).

The exact molarity of the titrant (NaOH) has been determined by titration with a solid acid using phenolphthalein indicator. Check the bottle and record its concentration carefully in your notebook. Once you have determined the endpoint volume of the base, the number of moles of base required to neutralize the acid present is calculated by multiplying molarity of base x volume of base in liters. Where the stoichiometry in the balanced chemical reaction indicates a one-to-one mole relationship between acid and base present, the number of moles of base is equal to the number of moles of acid present.

$$\text{moles NaOH required} = \text{moles acid used}$$

If all measured quantities are known to four significant figures (the volume of NaOH solution will be known to four significant figures if buret readings are estimated to within 0.02 mL, then the molarity can be specified to four significant figures, e.g., 0.1234 M).

An accurately measured 10.00 mL portion of the unknown HCl solution is pipetted into the flask and titrated with the standard NaOH solution.

$$\text{moles NaOH required} = \text{moles HCl used}$$

$$(\text{L NaOH}) (\underline{\text{M NaOH}}) = (\text{L HCl}) (\underline{\text{M HCl}})$$

$$\underline{M.HCl} = \frac{(\text{LitersNaOH})(\underline{M.NaOH})}{(\text{LitersHCl})}$$

Titration of two or more separate portions of the HCl solution will improve the reliability of the value reported for the molarity of the HCl solution.

Procedure

Part I: Standardization of NaOH.

- 1) Prepare 200. mL of 0.100 M NaOH solution. Obtain the solid NaOH from the front table.
- 2) Due to the fact that NaOH can absorb $\text{CO}_2(\text{g})$ from the air, your calculations are approximate. We need to know the exact pH of your base solution. We will find this using the CBL pH sensors.

Part II: Titration of H_2SO_4 against NaOH.

1. Place 10.00 mL of the unknown molarity of H_2SO_4 solution into the titration flask, add 4 or 5 drops of phenolphthalein indicator, and titrate with standard NaOH. You should try to achieve 5 good results.

Calculate the molarity of the H_2SO_4 solution. Remember to write and balance the equation for the acid-base reaction involved. Be careful in doing the stoichiometric calculations and record qualitative observations about the quality of your endpoints.

ACID-BASE TITRATIONS

NAME _____ PERIOD _____

Prelab

1. A 50.00mL sample of sulfuric acid required 35.00mL of NaOH for titration to the phenolphthalein endpoint. The molarity of the NaOH had been standardized and determined to be 0.4965M. What is the molarity of the sulfuric acid solution? (4 significant figures)

2. A 25.00mL sample of an unstandardized HCl solution is titrated with 0.1567 M NaOH solution. If 32.55mL of NaOH solution is required to reach the endpoint, what is the molarity of the HCl solution? (4 significant figures)
3. How accurately can you estimate the buret reading on a 50-mL buret, which has calibration markings every 0.1 mL?
(a) ± 1 mL (b) ± 0.1 mL (c) ± 0.01 mL (d) ± 0.001 mL
4. If 1.5000g of NaOH is dissolved in water and diluted to 50.00mL and 25.00 mL of this solution is titrated with 0.1500 M HCl, how many mL of acid would be required to neutralize the base solution?

