Fundamentals of Analytical Chemistry, CHC014011L

Acid-base titrations

are usually used to find the amount of a known acidic or basic substance through acid base reactions. The analyte is the solution with an unknown molarity. The reagent (titrant) is the solution with a known molarity that will react with the analyte.

Exercise 1:
standardization of a hydrochloric acid solution by anhydrous sodium carbonate

Objective:
to determine the concentration of hydrochloric acid by anhydrous sodium carbonate as the primary standard in volumetric analysis, using the acid-base titration method

CAUTION
Hydrochloric acid is corrosive. Wear goggles, gloves, and protective clothing at all times.

Equations:

$$Na_2CO_3 + HCl \rightarrow NaHCO_3 + NaCl$$
$$NaHCO_3 + HCl \rightarrow NaCl + CO_2\uparrow + H_2O$$

Colour change:
from yellow to reddish orange

Before titration:
Burette reagent: approximately 0.100 M hydrochloric acid.
Before use rinse a burette with water (remember to clamp it vertically) and then several times with small portions of the HCl solution - discard solution through the tip into a waste beaker. Fill the burette with HCl solution above the zero mark. Fill the burette tip by momentarily opening the stopcock to permit air bubbles in the tip. Make sure that there is no air in the tip and the whole burette. Read the initial volume. *It's not important that the initial reading be exactly 0.00 cm^3, but it is important to know the initial reading as closely as possible.* Remember to record the lower level of the meniscus at eye level.
After use drain and rinse the burette several times with distilled water.

Procedure:
Accurately weight approx. 0.1 g (record all the digits) of the anhydrous sodium carbonate powder into clean 250 cm^3 conical (Erlenmeyer) flask.
Add about 40 cm^3 of distilled water to the flask and swirl gently to dissolve the salt. After dissolving the salt add 2 drops of methyl orange indicator and titrate solution with the HCl solution to a persistent endpoint. The endpoint of this titration is when the solution just changes colour form yellow to reddish orange. Record the final burette reading.
Repeat the determination 2-3 times. Calculate the average concentration of hydrochloric acid.

Expression of results – data for each trial:

sample no.	mass of Na_2CO_3 in sample flask [g]	initial burette reading [cm^3]	final burette reading [cm^3]	titration - volume of HCl required to neutralize Na_2CO_3 [cm^3]

Calculations:
1. molarity of HCl for each trial
2. average HCl concentration (in mol/dm^3)

Exercise 2:
determination of sodium hydroxide concentration

Objective:
to determine the concentration of sodium hydroxide using hydrochloric acid as the titrant using methyl orange and phenolphthalein as the indicator.

Equations:

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Colour change:
1. methyl orange from yellow to reddish orange
2. phenolphthalein from pink to almost colorless

Procedure:
a) Pipette aliquot of sodium hydroxide solution into 250 cm^3 Erlenmeyer flask. Add about 50 cm^3 of distilled water. Next add 1-2 drops of methyl orange indicator. Swirl gently to mix. Titrate with hydrochloric acid solution till the first colour change. Record the final burette reading.
Repeat the titration 2-3 times until you get consistent readings – i.e. till two consecutive titrations agree to within 0.20 cm^3. Calculate the average concentration of sodium hydroxide.
b) Repeat the whole titration procedure (a) using phenolphthalein as an indicator.

Expression of results – data for each trial:

HCl concentration [mol/dm^3]:

tiration no.	indicator	initial burette reading [cm^3]	final burette reading [cm^3]	titration - volume of HCl required to neutralize NaOH [cm^3]

Calculations:

1. average NaOH concentration determined using methyl orange indicator (in mol/dm^3)
2. average NaOH concentration determined using phenolphthalein as an indicator (in mol/dm^3)
3. **explain the difference between results.**

Write up a report for the exercises. Your report should include:

a. the underlying chemical principle of your method,
b. procedures,
c. tables summarizing titration results,
d. treatment of data involving calculations,
e. a conclusion of the investigation and
f. comment on the results obtained.

Tasks for pre-lab quiz:

1. Theory of acid-base titrations; titration of a weak acid with a strong base, weak base with strong acid, strong base with strong acid and strong acid with strong base; pH titration curves;
2. What is a primary standard? What is an Indicator? Primary standards for HCl and NaOH solutions; an explanation how to perform the standardization; the equations for the reactions involved in the standardization titration; calculation steps based on equation stoichiometry;
3. Preparation and storing constancy of standard NaOH solution;
4. Standardisation of NaOH solution using HCl and $C_2H_2O_4$ (procedure, indicators, reactions);
5. Standardisation of HCl solution using Na_2CO_3 and $Na_2B_4O_7{\cdot}10H_2O$ (sodium tetraborate decahydrate) (procedure, indicators, reactions);
6. Calculation related to acid-base titrations;
7. Good Laboratory Practice in analytical chemistry.

http://www.zcha.pwr.wroc.pl/dydaktyka/Fundamentals of analytical chemistry