Test Project

Chemical Laboratory Technology

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Introduction

In the case where an acid mixture with several different acids is titrated, one would expect a titration curve with so many potential jumps as the number of acids present in the sample solution. This is the case for the acid mixture consisting of hydrochloric acid, acetic acid, and ammonium chloride i.e. HCl:CH_3COOH:NH_4Cl, as given below:

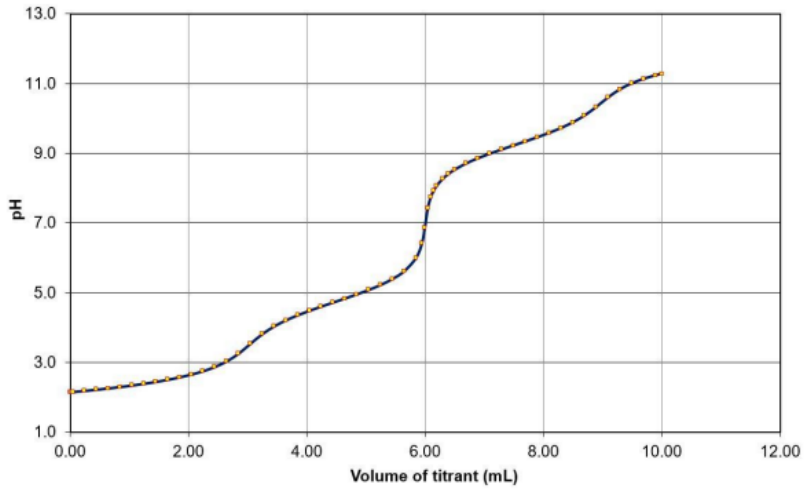


Fig. 1: Simulated titration curve of 3 mL each of 0.1 M HCl (strong acid), 0.1 M CH3COOH (weak acid strength), and 0.1 M NH_4Cl (very weak acid) in water with 0.1 M NaOH (CurTitPot, http://www.iq.usp.br/gutz/Curtipot_.html).

Here, all acids have the same concentration i.e. 0.1 M, and the same sample size. The mixture, diluted with 50 mL deionized water, is titrated with a strong base such as sodium hydroxide having the same concentration i.e. 0.1 M NaOH. The titration curve shows three potential jumps at 3, 6 and 9 mL titrant consumption. In particular, each potential jump indicates the equivalence point (EQP) of the corresponding neutralization reaction. The determined EQP allows for the calculation of the content of each acid.

However, there is still one question that needs to be answered: How do we know which potential jump corresponds to which acid?

The sequence of the three potential jumps in the curve is given by the strength of the acids. In fact, the strongest acid is first neutralized. Subsequently, the neutralization of the weaker acids just occurs once the stronger acid is neutralized. Overall, acids in a mixture are neutralized successively in the order of their acid strength. In the HCl:CH_3COOH:NH_4Cl mixture, the first potential jump corresponds to the strongest acid, HCl, then acetic acid is neutralized leading to the second jump, and the third one corresponds to the weakest acid NH_4Cl:

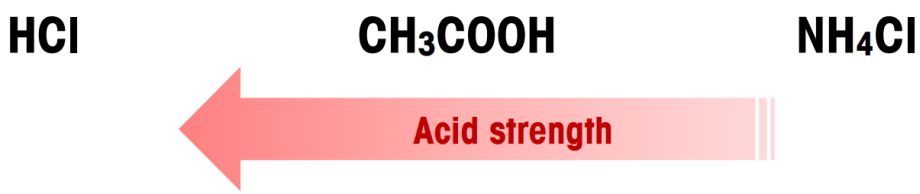


Fig. 2: HCl is the strongest acids compared to acetic acid and ammonium chloride.

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Description of project and tasks

- Planning
- Preparation of solutions.
- Solution standardization.
- Acid Cleaner formulation.
- Acid Cleaner analysis.
- Data processing.
- Conclusion.

Instructions to the Competitor

Planning

In your planning, present:

1. The volumes of solutions to be prepared, and the justifications for such decision.
2. A list or table with all reagents that will be used during the task, their respective principal Globally Harmonized System (GHS) code, and their protective actions**. You must show this list to the Experts before starting the experimental work.**

Preparation of solutions

Sodium Hydroxide Solution 0,1 M: Estimate the consumption of this solution and prepare a sufficient volume. **Show the mass that you calculated to the Experts.**

Phenolphthalein Solution 0.1% (w/v): This solution will be available in the Module B cabinet.

Solution standardization

Use the potassium hydrogen phthalate located in the drybox (desiccator) labeled with your country's code to standardize the 0.1 M NaOH solution.

For each standardization titration, you must use between 10 and 15 mL of titrant.

This standardization must be performed in a triplicate using the automatic titrator.

Acid Cleaner formulation

Use 10% (w/w) standardized solutions of acetic acid, nitric acid, and phosphoric acid to formulate a low-concentration acidic cleaner. Prepare a 1000 g pilot batch according to the table:

ACID	CONCENTRATION (%m/m)
Phosphoric Acid	0,25
Nitric Acid	0,10
Acetic Acid	0,10

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Acid Cleaner analysis

To verify the acid concentrations in your cleaner, titrate 10 ± 0,05 g of the formulated product with 0.1 M NaOH solution.

This analysis must be performed in a triplicate using the automatic titrator, using the Methods >> Method >> Calculation menu and configuring Result, Result unit, Formula, Constant C=, M and Z.

A trial titration must be first performed to set the optimum values for the potential (mV) ranges of each acid. These ranges are identified in the table of measured values and subsequently defined in the calculation formula at the titrator.

Export the table of measured values of the trial titration to the excel spreadsheet (tab. 5. Acid Cleaner Analysis) and use this to identify the ranges.

Call the Experts to photograph the calculation formulas that you configured at the titrator and the results of each titration.

Data processing

The calculations for,

1. Planning
2. Preparation of Solutions
3. Solution standardization
4. Acid cleaner formulation
5. Acid cleaner analysis
6. Calc. to task questions

must be **identified and numbered using exactly these headings** and may be submitted either handwritten or in an Excel spreadsheet. For handwritten work, use the standardized sheets provided by the Experts. For Excel spreadsheets, use a separate tab for each of the six (6) headings and submit the .xlsx file within the allotted task time.

Conclusion

All text (measurement records, discussion, planning justifications, conclusions, answers to the task questions, etc.) must be submitted within the task duration in a text file saved in PDF format. It can be submitted in your native language. **Any other format will not be considered in the assessment.**

Task questions

1. Calculate manually (handwrite or in Excel) the Nitric Acid content (% w/w), the relative error compared to the formulation table, and its respective percentage coefficient of variation.
2. Calculate manually (handwrite or in Excel) the Phosphoric Acid content (% w/w), the relative error compared to the formulation table and its respective percentage coefficient of variation.
3. Calculate manually (handwrite or in Excel) the Acetic Acid content (% w/w), the relative error compared to the formulation table and its respective percentage coefficient of variation.

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Other

List of Appendix:

1. Safety data sheets for all chemical reagents in the Competition, in digital format.
2. Appendix 1 - pKa of Acids **(PDF – at your Flash Drive)**.
3. Basic infrastructure list for this module.

Check if you have received all these annexes and immediately inform the Experts if any are missing.

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