

Ion-exchange lab

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Chemistry 330 - QUANTITATIVE ANALYSIS

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# Abstract:

The amount of copper ion in aqueous solution was determined using ion exchange resin and titrations. After exchanging the copper ions for hydronium in the resin, an acid-base titration was performed with phenolphthalein indicator. The amount of copper in the sample was found to be .184% (wt/wt).

# Introduction:

Sometimes, it is desirable to know what amount of material you have in a solution. There are many methods of calculating this. Sometimes it is possible to perform a titration. This is when you add a solution with known amount of material (the titrant) that reacts with the unknown amount of material in a reaction vessel (the analyte). In titrations, there must be a way of determining when there is equal amounts of molecules of titrant and analyte, thus we can imply the amount of analyte in solution. In our case, we exchange all the copper ions in a solution with 2 protons then we titrate those protons with hydroxide. This reaction is fast, has an extremely clear endpoint and indicators that work in solution, making it a good titration, theoretically.

Ion-exchange resins are porous microbead polymers that trap some ions and release others. They are typically made out of polystyrene sulfonate. Acidifying the sulfonate groups results in sulfonic acid groups which are good for cation exchange[1]. This resin is used in our experiment to exchange the copper in solution with a stoichiometrically constant ratio, or a precise ratio of molecules exchanged.

# Reagents:

All reagents are manufactured by Sigma Aldrich unless specified otherwise:

2g of ion-exchange resin

12.1M hydrochloric acid

Sodium hydroxide pellets

Potassium hydrogen phthalate (KHP)

Phenolphthalein indicator solution

# Procedure:

A copper solution was received into a 25mL volumetric flask. DI water was used to dilute the unknown up to the mark. This is the unknown. Around 50mL of water was added to a 250 mL beaker. 8.3mL of 12.1M HCl was added to the beaker and the acid was diluted to produce 100mL of 1M HCl. 2g of ion-exchange resin was added to this beaker then the solution was stirred with a glass rod. The solution was decanted so the resin solution fit into a 50mL burette with glass wool inserted into the bottom. The solution was drained dropwise and 1cm of acid was left covering the resin. Approximately 25mL of DI water was added to the burette and likewise drained dropwise remaining 1cm of liquid above the resin. This washing was repeated two more times. 4.00mL of unknown solution and 25mL of DI was poured in and left to react with the resin. This solution was dropwise drained into a 500mL Erlenmeyer flask remaining 1cm of liquid above the resin. This step was repeated twice for a total of 3 trials.

A standardized solution of NaOH was prepared. A precise amount of KHP, around 1.5 grams, was measured out and placed into 3 Erlenmeyer flasks with ~50mL of DI water and 4 drops of phenolphthalein. A 0.1M NaOH solution was prepared by weighing out 2g of sodium hydroxide pellets. The pellets were placed into a screw-top bottle and 500mL of DI water was added and shaken. The NaOH solution was added to a clean burette and the KHP solutions were titrated to the pink endpoint. The precise molarity of the NaOH solution was calculated. 4 drops of phenolphthalein were added to the three Erlenmeyer flasks with the solution that passed through the resin. Each solution was titrated with NaOH to the pink endpoint[2].

# Data:

Titration of KHP to determine molarity of sodium hydroxide:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Trial 1 | Trial 2 | Trial 3 |
| KHP | .3994g | .4067g | .3830g |
| NaOH | 0.01824L | 0.01800L | 0.01826L |
| M(NaOH) | 0.1072M | 0.1106M | .1027M |
| Average M ± s.d. | (0.108 ± 0.004)M | | |

Calculation for trial one is found in eqn. 1:

eqn. 1

Titration of solution passed through resin to determine percent copper in unknown:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Trial 1 | Trial 2 | Trial 3 |
| Volume of copper unknown | 4.00mL | 4.00mL | 4.00mL |
| mL(NaOH) to reach endpoint | 2.20mL | 2.20mL | 2.21mL |
| %Cu in sample | 0.187% | 0.187% | 0.178% |
| Average %Cu±s.d. | (.184±.005)% | | |

Calculation for trial 1 is found in eqn. 2.

eqn. 2

# Results & Discussion:

We calculated the percent coper in the unknown 25mL solution to be (.184±.005)%. Our results are realistic and are similar to those found in other groups. The method we used is still prone to error however. It is important that the ion exchange resin is left to react. Since the blue color in the solution is due to the copper, the solution coming out of the resin should be perfectly clear, all blue color transmitted to the resin. Our solution was not perfectly clear. Perhaps we could have left our solution to react longer or drip slower. Our rate was much faster than dropwise, hence less reaction taking place. Although this will affect our results, we are still confident our results approximate the real amount. To fix this, the solution could have been left longer or drained dropwise.

This method is one way of determining concentration of colored solutions, another way might be through standard additions and spectrophotometry. Since the solution is colored, the beer lambert law applies and we might be able to take known amounts of copper solution, add it to the unknown, and measure the absorbance. Constants needed would include the molar absorptivity of copper ion and concentration of the unknown added. The concentration of unknown can then be extrapolated from the data. This method might be better due to less reagents necessary. No strong chemicals are used and the procedure is simpler.

# Conclusion:

Although our group successfully measured the amount of copper in the unknown solution, there are likely better, safer methods that are more rapid. Our sample was found to have (.184±.005)% Cu2+(wt/wt) although we could have had more

# References:

[1] Ion Exchangers. *Ullmann’s Encyclopedia of Industrial Chemistry*, 5th ed; VCH: Weinheim, Germany, 2008; Vol. A14, pp 393-461

[2] Dahl, D. CHEM 330 *Lab on Gas Chromatography.* Western Kentucky University, March 31, 2022.