AS Chemistry Coursework – To Determine the Concentration of a Limewater Solution

Aim

To determine the concentration of a limewater solution using hydrochloric acid with a known concentration of 2.00 $moldm^{-3}$.

Introduction

The initial idea of how to carry out this task is with a titration, however before this can be achieved other tasks have to be carried out. We know the limewater has a concentration of approx 1g dm^{-3} and the HCl has a concentration of 2.00 $moldm^{-3}$ so the concentration of HCl has to be reduced.

The second issue with the titration is which indicator to use. The indicator will be used to show the point where the solution becomes neutral when all of the base has been reacted. From Understanding Chemistry, for the indicator it is important that:

- The indicators colour change is sharp so one drop of acid will cause the colour to change instantly rather than it changing gradually as more acid is added.
- The colour change happens at the equivalence point which is the point where the amount of hydroxide ions equals the amount of hydrogen ions.
- The colour change is distinct which would make it easier to see when the solution has been neutralised; a good example of this is phenolphthalein.

Preparation

Before the titration can take place, the correct concentration of HCl must be found and prepared. Using certain equations, this can be achieved.

Reaction

$Ca(OH)_{2(aq)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + 2H_2O_{(l)}$

1 mole of Calcium Hydroxide reacts with 1 mole of Hydrochloric Acid.

Concentration of Limewater ($Ca(OH)_{2(aq)}$):

Conc. approx = 1g dm-3

$Mr(Ca(OH)_2) = 40 + 2(16 + 1) = 74$

Moles = Mass / Mr

Moles = 1 / 74

Conc. approx = $^{1}/_{74}$ $moldm^{-3}$ = 0.0135 $moldm^{-3}$

Concentration of Hydrochloric Acid ($HCl_{(aq)}$):

Original Conc. = 2.00 $moldm^{-3}$

To get about 25 cm^3 of Limewater to react with 25cm^3 of HCl, the concentration of HCl needs to be double the limewater. A concentration of 0.02 $moldm^{-3}$ will be used.

Dilution factor = x100

New Conc. = 0.02 $moldm^{-3}$

Safety

Before any of the experiments are carried out, these safety points must be read.

- Must wear safety goggles when near any chemicals.
- HCl is in a high concentration so gloves must be worn when using it.
- Keep the work area safe and tidy; when equipment is no longer required, move it aside or clear it away.
- Do avoid spillage; ensure the burette tap is closed before filling and use a funnel.
- Remove the funnel from the burette when not in use, this could cause a hazard and any chemicals dripping off the funnel into the burette will cause inaccurate results.
- Wash out all equipment before and after use to remove all traces of chemicals which could cause errors in the experiment.

Method

Method to dilute HCl:

It would be impractical to dilute by x100 so it must be diluted by x10 twice. The following equipment, chemicals and amounts are required:

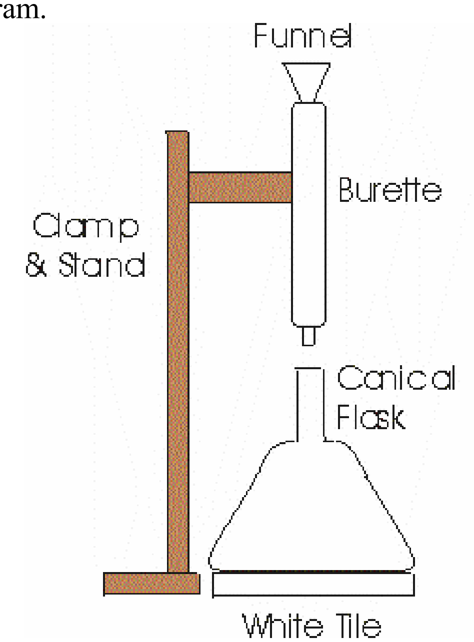
- Graduated Pipette ($25cm^3$ or $50cm^3$ capacity) & Pipette pump
- Standard Flask ($500cm^3$ capacity)
- Beaker ($500cm^3$ capacity)
- $50cm^3$ of HCl solution of concentration 2.00mol dm^{-3}
- $900cm^3$ of de-ionised water

1. Use the pipette and pipette pump to transfer $50cm^3$ of HCl solution into the standard flask. Fill the pipette to the fill line indicated; the bottom of the meniscus is the level of the solution. If the capacity of the pipette is only $25cm^3$ then this must be done twice to transfer the full $50cm^3$.
2. Fill the standard flask with 450cm3 of the de-ionised water, the fill line is also indicated, this must be exact, if the level goes over this line, the preparation of the HCl must be started over. Shake the flask with the lid on to ensure the solution is mixed.
3. Empty out the flask into the beaker then wash out the flask.
4. Move $50cm^3$ of the new HCl solution from the beaker into the flask using the same method as in Step 1.
5. Repeat step 2.
6. Empty out the beaker and wash out and then transfer then solution from the flask to the beaker.
7. The 0.02 $moldm^{-3}$ solution of HCl is now prepared. All equipment and chemicals other than in the beaker can now be discarded.

Method of Titration:

The following equipment, chemicals and amounts are required:

- Graduated Pipette (25cm^3 capacity) & Pipette pump
- Burette, Stand w/ clamp & Funnel
- Conical Flask
- Beaker containing 500cm^3 of 0.02moldm^{-3} HCl solution. (Max. of 50cm^3 needed for each titration)
- Beaker containing 250cm3 of Limewater of unknown concentration. (25cm^3 needed for each titration)
- Phenolphthalein Indicator & White Tile



1. Set up the equipment as shown in the diagram.
2. Transfer 25cm3 of the lime water to the conical flask using the pipette and pipette pump.
3. Add a few drops of the indicator into the conical flask.
4. Fill the burette to the max level with the 0.02 moldm^{-3} HCl solution and then remove the funnel.
5. *1st titration*: open the tap on the burette and keep gently shaking the conical flask until it changes from colourless to red. Read the level on the burette and take this result as rough.
   Further titrations: Open the tap on the burette and let out less solution which you got for the rough or previous titrations. Then open and close the tap to let one drop out at a time while gently shaking the conical flask to get an accurate result off the level on the burette.
6. Empty out the flask and wash it out, then repeat steps 1 to 5 until three results which are within 0.10 cm^3 of each other.

Results

Use the following results table to record the results of the titration above. All burette initial readings will be 0.00 using the above method. The Volume Used is the Final minus the initial. Do all results to 2 decimal places and take the average of all the results except for the Rough result.

		Rough	1st	2nd	3rd	4th …
Burette	Final / cm^3					
Readings	Initial / cm^3					
Volume Used / cm^3						
Average Volume Used / cm^3						

Calculations

The average volume used from the results is required and must be in dm^3. To convert from cm^3 to dm^3, divide by 1000. For the calculations ***V*** will be used to represent this volume in dm^3.

Known information:

	HCl	$Ca(OH)_2$
Moles / moles	***?***	***?***
Volume / dm^3	***V***	0.025
Conc. $moldm^{-3}$	0.02	***?***

Moles can be worked out using the equation *Concentration = Moles / Volume*
Moles = Concentration x Volume = 0.02 x ***V***

The reaction shows that two moles of HCl react with one mole of $Ca(OH)_2$ so in the neutralisation there must have been twice as many moles of HCl than $Ca(OH)_2$.
Therefore moles of $Ca(OH)_2$ must be $^{(0.02 \times V)} / _2 = 0.01 \times V$

Again using *Concentration = Moles / Volume* :
Conc. of $Ca(OH)_2 = ^{(0.01 \times V)} / _{0.025} = 0.4 \times V$

The number of moles in dm^3 will be concentration x1 which is 0.4 x ***V*** x 1 = 0.4 x ***V***.
The mass of the Calcium Hydroxide in the solution can now be worked out using
Moles = Mass / Mr → *Mass = Moles x Mr*
$Mr(Ca(OH)_2) = 40 + 2(16 + 1) = 74$
Mass of Calcium Hydroxide in dm^3 = 0.4 x ***V*** x 74

Therefore the concentration of the Limewater in gdm^{-3} will be:

0.4 x ***V*** x 74 = ________ gdm^{-3}

Bibliography

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