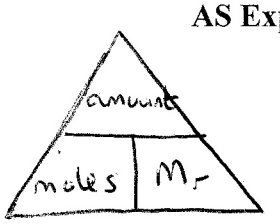
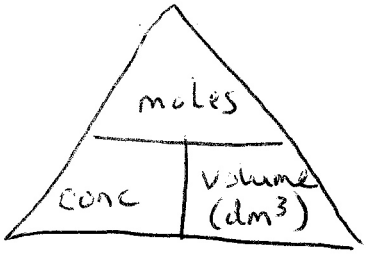
AS Experiment 10.2(3)



FINDING THE FORMULA OF WASHING SODA

(An Experiment in Volumetric Analysis)



INTRODUCTION

Volumetric analysis involves finding the volumes of solutions which react exactly with each other. Accurate volumetric glassware is used to measure out the volumes and the process involved is called titration.

- ***A standard volumetric flask*** is used to make up a solution accurately. There are various sizes available. The most common one you will use is $250cm^3$.
- ***A graduated pipette*** is used to measure out one of the solutions into a conical flask for titration. Again, various sizes are available and you will commonly use a $20cm^3$ one. These are usually used with a safety filler. The portion of solution measured out using the pipette is called the ***aliquot***.
- ***A burette*** holds $50cm^3$ of liquid and is used to run the other solution into the conical flask in controlled amounts so that the reacting volume can be found to an accuracy of $0.1cm^3$. The volume measured from the burette is called the ***titre***.

AIMS

- To learn how to make up a standard solution accurately in a volumetric flask.
- To use titration technique to find the accurate concentration of the solution.
- To use the results of the titration to determine the formula of sodium carbonate crystals.

MAKING THE SOLUTION

Sodium carbonate forms hydrated crystals, commonly known as "washing soda". When the crystals are fresh the formula is $Na_2CO_3 \cdot 10H_2O$. The crystals gradually lose water of crystallisation to the air (a process called efflorescence) and they start to become white and crumbly in texture. The number of moles of water in the formula for the crystals is < 10.

1) You are going to make up $250cm^3$ of sodium carbonate solution of concentration approximately 0.05 $mol.dm^{-3}$. Work out how many moles of sodium carbonate you need.

moles = ... conc x volume = 0.05 x 0.25 = 0.0125 .....

2) Assuming that the formula of the crystals is $Na_2CO_3 \cdot 10H_2O$, work out the mass of crystals you will need. (A_r values are Na = 23.0 ; C = 12.0 : O = 16.0 ; H = 1.0)

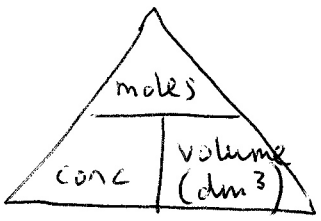
mass = ... (2 x 23) + (12) + (3 x 16) + (10 x 18) = 286 g .....

amount = moles x Mr
= 286 x 0.0125
= 3.575

3) Weigh out accurately in a $250cm^3$ beaker the mass you have calculated above, plus or minus about 0.5 gram. (If the crystals are large you may need to crush them first.)

actual mass weighed out = ... 3.58 g .....

4) Add about $100cm^3$ of distilled water to the beaker and stir to dissolve the crystals. Your teacher will show you how to transfer this solution quantitatively to the volumetric flask and make it up to the graduation mark. You now have $250cm^3$ of approximately 0.05M sodium carbonate solution.



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USING THE RESULTS

1) Use your concordant results to work out an average titre.

Average titre = 25cm³ (0.025 dm³)

HCl = 0.1 mol/dm³

2) Work out the number of moles of HCl contained in this volume of solution.

Moles of HCl = 0.1 x 0.025 = 0.0025

3) The equation for the reaction between sodium carbonate and hydrochloric acid is:-

$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

Look at the balancing numbers. You will see that moles of sodium carbonate reacted is **half** the moles of acid used. Use your answer to Qu. 2 to work out how many moles of sodium carbonate there were in the 20cm³ portions of solution used in the titration.

Moles Na_2CO_3 = 0.0025/2 = 0.00125

1 : 2 ratio

4) Now calculate the concentration of the sodium carbonate solution you made up.

Concentration of Na_2CO_3 solution = conc = $\frac{0.00125}{0.025}$ = 0.05 mol/dm³

Each sample was 25cm³

5) Now you know the concentration of the solution you made up, you can calculate how many moles of Na_2CO_3 there were in the original 250cm³ flask.

Moles of Na_2CO_3 in flask = moles = conc x volume = 0.05 x 0.25 = 0.0125

6) Calculate the mass of Na_2CO_3 in the flask, using your answer to Qu. 5.

Mr of Na_2CO_3 = 106

Mass of Na_2CO_3 in flask = 0.0125 x 106 = 1.325g.

amount = moles x Mr

7) Subtract this from the total mass of the crystals you weighed out to find out the mass of water which must have been in the crystals.

Mass of water in crystals = 3.575 - 1.325 = 2.25g

8) Convert the mass of water into moles.

Moles of water in crystals = $Na_2CO_3 = \frac{1.325}{106}$: $H_2O = \frac{2.25}{1.8}$

Ratio = 0.0125 : 0.125

9) Finally, divide the moles of water (Qu. 8) by moles of Na_2CO_3 (Qu. 5) to find out the number of moles of water of crystallisation in the formula for the crystals. (Remember that fresh crystals have a value of 10, so your number should be less than this.)

Ratio of moles = 0.0125 : 0.125 so formula = $Na_2CO_3 . 10H_2O$

1 : 10