www.thinkib.net/chemistry

SL HL Paper 3 Section A Experimental work (2) with worked answers

The following experiment was used to determine the number of moles of water of crystallisation in washing soda crystals, $Na_2CO_3.xH_2O$.

5.35 g of washing soda crystals were placed in a conical flask and exactly 50.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid solution was added. A cotton wool plug was placed in the mouth of the flask and left in place until the reaction was completely finished. All the contents of the flask were then transferred to a 100 cm^3 volumetric flask with washings and the total volume made up to the graduated mark with distilled water. A 10.0 cm^3 sample of this new solution was pipetted into a new conical flask and titrated with 0.100 mol dm^{-3} sodium hydroxide solution using phenolphthalein as the indicator. 12.60 cm^3 of the 0.100 mol dm^{-3} sodium hydroxide solution was required to reach the end point.

(a) State the equation for the reaction of sodium carbonate with hydrochloric acid. ***[1]***

$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$ or $CO_3^{2-}(s) + 2H^{+}(aq) \rightarrow CO_2(g) + H_2O(l)$ ***[1]***

(b) Explain why a piece of cotton wool was placed in the mouth of the conical flask while the reaction was taking place. ***[1]***

The carbon dioxide gas evolved causes effervescence so the cotton wool prevents any of the liquid escaping from the flask. ***[1]***

(c) Describe how you can determine practically that the end point of the titration has been reached. ***[1]***

The end point occurs when the addition of one drop of the sodium hydroxide solution causes a faint pink colour to remain.***[1]***

(Note that the colour changes for common indicators are given in Section 22 of the data booklet.)

(d) Calculate the amount (in mol) of hydrochloric acid remaining after the reaction with the washing soda crystals. ***[1]***

Amount of NaOH in 12.60 cm^3 of 0.100 mol dm^{-3} NaOH = $(12.60 \times 0.100) \div 1000 = 1.26 \times 10^{-3}$ mol
Since 1 mol of NaOH reacts with 1 mol of HCl
Amount of HCl in 10.0 cm^3 sample = 1.26×10^{-3} mol
Amount of HCl in 100 cm^3 volumetric flask = the amount remaining after the reaction = $10 \times 1.26 \times 10^{-3} = 1.26 \times 10^{-2}$ mol ***[1]***

(e) Calculate the amount (in mol) of washing soda crystals initially placed in the conical flask. ***[1]***

Initial amount of hydrochloric acid added = 50.0 x 1.00 ÷ 1000 = 0.0500 mol
Amount that reacted with the washing soda crystals = 0.0500 – 0.0126 = 0.0374 mol
Since 2 mol of HCl react with 1 mol of washing soda crystals
Amount of washing soda crystals placed in flask = ½ x 0.0374 = 0.0187 mol ***[1]***

(f) Determine the number of moles of water of crystallisation (*x*) in washing soda crystals. ***[1]***

0.0187 mol of washing soda crystals has a mass of 5.35 g
1 mol of washing soda crystals has a mass of 5.35 ÷ 0.0187 = 286.1 g
$M(Na_2CO_3.xH_2O)$ = (2 x 22.99) + 12.01 + (3 x 16.0) + x(18.02) = 105.99 + 18.02*x*
Number of moles of water of crystallisation = *x* = (286.1 – 105.99) ÷ 18.02 = 10.0 ***[1]***