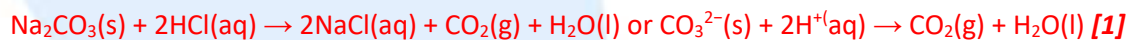


**SL HL** Paper 3 Section A Experimental work (2) **with worked answers**

The following experiment was used to determine the number of moles of water of crystallisation in washing soda crystals,  $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$ .

5.35 g of washing soda crystals were placed in a conical flask and exactly  $50.0 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  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  $100 \text{ cm}^3$  volumetric flask with washings and the total volume made up to the graduated mark with distilled water. A  $10.0 \text{ cm}^3$  sample of this new solution was pipetted into a new conical flask and titrated with  $0.100 \text{ mol dm}^{-3}$  sodium hydroxide solution using phenolphthalein as the indicator.  $12.60 \text{ cm}^3$  of the  $0.100 \text{ mol dm}^{-3}$  sodium hydroxide solution was required to reach the end point.

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



**(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  $12.60 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  NaOH =  $(12.60 \times 0.100) \div 1000 = 1.26 \times 10^{-3} \text{ mol}$

Since 1 mol of NaOH reacts with 1 mol of HCl

Amount of HCl in  $10.0 \text{ cm}^3$  sample =  $1.26 \times 10^{-3} \text{ mol}$

Amount of HCl in  $100 \text{ cm}^3$  volumetric flask = the amount remaining after the reaction =  $10 \times 1.26 \times 10^{-3} = 1.26 \times 10^{-2} \text{ mol}$  **[1]**

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

Initial amount of hydrochloric acid added =  $50.0 \times 1.00 \div 1000 = 0.0500$  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 =  $\frac{1}{2} \times 0.0374 = 0.0187$  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  $5.35 \div 0.0187 = 286.1$  g

$M(\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}) = (2 \times 22.99) + 12.01 + (3 \times 16.0) + x(18.02) = 105.99 + 18.02x$

Number of moles of water of crystallisation =  $x = (286.1 - 105.99) \div 18.02 = 10.0$  **[1]**