1. A student determined the concentration of a hydrochloric acid solution by titration with 25.0 cm^3 portions of a 0.05 M primary standard solution of anhydrous sodium carbonate. The portions of sodium carbonate solution were measured into a conical flask using a 25 cm^3 pipette. The hydrochloric acid solution was added from a burette. The mean titre was 20.8 cm^3.

The balanced equation for the titration reaction was:

$$\mathbf{2HCl + Na_2CO_3 \longrightarrow 2NaCl + H_2O + CO_2}$$

(*a*) Explain the underlined term. (5)

(*b*) Describe how the student should have prepared 500 cm^3 of the 0.05 M primary standard solution from a known mass of pure anhydrous sodium carbonate, supplied on a clock glass. (12)

Calculate the exact mass of anhydrous sodium carbonate ($\mathbf{Na_2CO_3}$) required to prepare this solution. (6)

(*c*) (*i*) Describe how the liquid level in the burette was adjusted to the zero mark.

(*ii*) Why was a pipette filler used to fill the pipette with 25.0 cm^3 of the sodium carbonate solution? (6)

(*d*) Name a suitable indicator for this titration.

State the colour change observed at the end point. (9)

(*e*) Calculate, correct to two decimal places, the concentration of the hydrochloric acid solution in

(*i*) moles per litre,

(*ii*) grams per litre. (12)

To determine the concentration of ethanoic acid in a sample of vinegar, 25.0 cm^3 of the vinegar were diluted to 250 cm^3 and then the diluted vinegar was titrated with a previously standardised solution which contained 1.20 g of sodium hydroxide in 500 cm^3 of solution. On average, 18.75 cm^3 of the diluted vinegar were required to neutralise 25.0 cm^3 of this sodium hydroxide solution.

The equation for the titration reaction is:

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

(*a*) Describe in detail the procedures involved in measuring a 25.0 cm^3 sample of the vinegar and diluting it using deionised water to exactly 250 cm^3. (15)

(*b*) Name a suitable indicator for this titration.

What colour change is observed at the end point? (9)

(*c*) Calculate

(*i*) the number of moles of sodium hydroxide in each 25.0 cm^3 portion,

(*ii*) the number of moles of ethanoic acid per cm^3 of *diluted* vinegar. (12)

(*d*) Find the concentration of ethanoic acid in the *original* vinegar

(*i*) in terms of moles per litre,

(*ii*) as a percentage (w/v). (9)

(*e*) Starting with a primary standard solution made from anhydrous sodium carbonate, what two titrations are required to standardise a sodium hydroxide solution? (5)

A batch of washing soda crystals (hydrated sodium carbonate, $\mathbf{Na_2CO_3.}x\mathbf{H_2O}$) had lost some of its water of crystallisation by a process called efflorescence. A chemist was required to determine the percentage water of crystallisation in the crystals and the value of x, the average number of water molecules in the formula.

A sample of the crystals was accurately weighed and found to have a mass of 2.50 g. The sample was dissolved in deionised water and made up to 250 cm^3 of solution. A number of 25.0 cm^3 portions of this solution were titrated with a previously standardised 0.10 M hydrochloric acid (**HCl**) solution. The mean volume of the hydrochloric acid solution required to reach the end point was 21.6 cm^3.

The balanced equation for the titration reaction is:

$$\mathbf{2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2}$$

(*a*) Explain the underlined term. (5)

(*b*) Describe in detail how the chemist should have dissolved the weighed sample of washing soda crystals and made the solution up to exactly 250 cm^3. (12)

(*c*) State **one** precaution that should have been taken as the end point of the titration was approached. Explain how this precaution would have contributed to the accuracy of the titration result. (6)

(*d*) Name a suitable indicator for this titration. State the colour change in the titration flask at the end point. (9)

(*e*) From the mean volume of the hydrochloric acid solution, calculate the concentration of sodium carbonate ($\mathbf{Na_2CO_3}$) in the original solution in (*i*) moles per litre, (*ii*) grams per litre. (9)

(*f*) Calculate the percentage water of crystallisation in the crystals and the value of x, the average number of water molecules in the formula $\mathbf{Na_2CO_3.}x\mathbf{H_2O}$. (9)

An experiment was carried out to determine the percentage water of crystallisation and the degree of water of crystallisation, **x**, in a sample of hydrated sodium carbonate crystals (**$Na_2CO_3.xH_2O$**). An 8.20 g sample of the crystals was weighed accurately on a clock glass and then made up to 500 cm^3 of solution in a volumetric flask. A pipette was used to transfer 25.0 cm^3 portions of this solution to a conical flask. A previously standardised 0.11 M hydrochloric acid (**HCl**) solution was used to titrate each sample. A number of accurate titrations were carried out. The average volume of hydrochloric acid solution required in these titrations was 26.05 cm^3.

The titration reaction is described by the equation:

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$

(*a*) Identify a primary standard reagent which could have been used to standardise the hydrochloric acid solution. (5)

(*b*) Name a suitable indicator for the titration and state the colour change observed in the conical flask at the end point. Explain why not more than 1 – 2 drops of indicator should be used. (12)

(*c*) (*i*) Describe the correct procedure for rinsing the burette before filling it with the solution it is to deliver.

(*ii*) Why is it important to fill the part below the tap of the burette? (12)

(*d*) From the titration figures, calculate the concentration of sodium carbonate (**Na_2CO_3**) in the solution in

(*i*) moles per litre,

(*ii*) grams per litre. (9)

(*e*) Calculate the percentage water of crystallisation present in the crystals and the value of **x**, the degree of hydration of the crystals. (12)

To determine the concentration of ethanoic acid, **CH_3COOH**, in a sample of vinegar, the vinegar was first diluted and then titrated against 25.0 cm^3 portions of a previously standardised 0.10 M solution of sodium hydroxide, **NaOH**. One rough and two accurate titrations were carried out.

The three titration figures recorded were 22.9, 22.6 and 22.7 cm^3, respectively.

(*a*) Why was the vinegar diluted? (5)

(*b*) Describe the correct procedures for measuring exactly 25.0 cm^3 of vinegar and diluting it to exactly 250 cm^3 using deionised water. (15)

(*c*) The equation for the titration reaction is:

$$\mathbf{CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O}$$

Name an indicator suitable for this titration. Justify your choice of indicator.
State the colour change at the end point. (12)

(*d*) Calculate the concentration of the diluted solution of ethanoic acid in

(*i*) moles per litre, (*ii*) grams per litre.

State the concentration of ethanoic acid in the original vinegar sample in grams per litre.

Express this concentration in terms of % (w/v). (15)

(*e*) Ethanoic acid is a carboxylic acid. Identify the carboxylic acid which occurs in nettles and stinging ants. (3)