4 A student is required to determine the concentration of hydrochloric acid using a solution of sodium carbonate of concentration 0.105 mol dm^{-3}.

Outline procedure

Step **1** Fill a clean burette with the hydrochloric acid.

Step **2** Pipette 25.0 cm^3 of the sodium carbonate solution into a conical flask and add a few drops of methyl orange indicator.

Step **3** Carry out a rough titration.

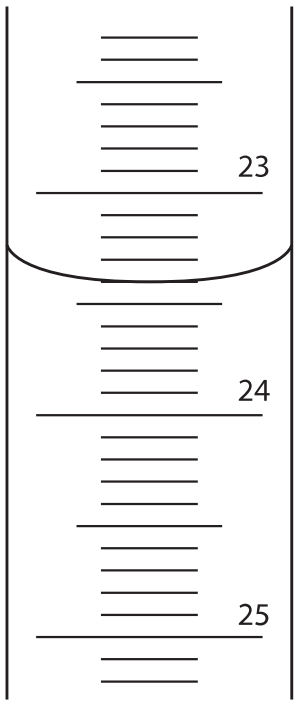
Step **4** Carry out accurate titrations until concordant results are obtained.

(a) State the colour change of the indicator at the end-point of the titration.

(2)

From ..... to .....

(b) The diagram shows the burette at the end-point of the rough titration.



Give the burette reading for this rough titration.

(1)

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(c) The student refilled the burette and prepared a second conical flask by adding sodium carbonate solution and methyl orange indicator.

Describe how an accurate titration should then be carried out.

(3)

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(d) The mean titre from two accurate titrations was 22.65 cm^3.

Calculate the concentration of the hydrochloric acid, in mol dm^{-3}.
The equation for the reaction is shown.

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

(3)

(Total for Question 4 = 9 marks)

TOTAL FOR PAPER = 50 MARKS

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