**Question 28** (8 marks)

The flowchart shown outlines the sequence of steps used to determine the concentration of an unknown hydrochloric acid solution.

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┌─────────────────────────────┐
│   Preparation of      (A)   │
│ 500 mL 0.100 mol L⁻¹ sodium │
│   carbonate standard solution│
└─────────────────────────────┘
              │
          25.0 mL used
              │
              ▼
┌─────────────────────────────┐        ┌──────────────────┐
│      Titration        (B)◄──┼────────│    Unknown       │
└─────────────────────────────┘        │ hydrochloric acid│
              │                         │    solution      │
     Average titration                  └──────────────────┘
     volume of acid 21.4 mL
              │
              ▼
┌─────────────────────────────┐
│   Concentration of    (C)   │
│ hydrochloric acid solution  │
└─────────────────────────────┘
```
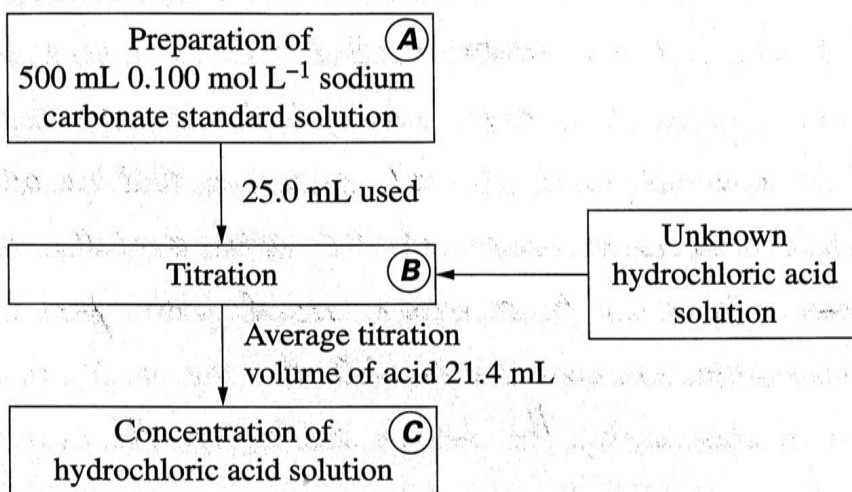
Describe steps **A**, **B** and **C** including correct techniques, equipment and appropriate calculations. Determine the concentration of the hydrochloric acid.

Step A is the process of preparing a standard solution, Step B is the process of Titrating the HCl against the Na_2CO_3; and Step C was the calculation of the HCl concentration.

Step A; involves the process of preparing a standard solution. A standard solution is a solution created with known volume, concentration, and ~~limited structure~~ low reactivity with air. The standard solution in this case is the sodium carbonate solution. Initially, one must weig an amount of $Na_2CO_{3(s)}$ by using an accurately calibrated electronic balance. This predefi mass of Na_2CO_3 is then dissolved in a specific, accurately measured volume of water, and is the ~~kept until~~ by adding the solid powder, ~~and~~ stoppering, and shaking to ensure complete dissolution. In this experiment, the mass of the standard can be calculat

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Question 28 (continued)

$n = cV$ ∴ $n_{(Na_2CO_3)} = 0.1 \times 0.5 = 0.05$ moles

and $n = \frac{m}{M}$

∴ $M(Na_2CO_3) \times n = m$ ∴ $m = 5.2995g$ of $Na_2CO_{3(s)}$ used in preparation of the standard.

Step B: involves titrating an unknown concentration of HCl, against th standard, with an appropriate indicator such as bromothymol blue, until a point where a complete neutralisation is achieved. The standard is pipetted from its beaker into volumetric flask (25ml), and then distilled H_2O is added to fill up to the etched line. Once this is ready, it is kept aside and th titrant is prepared. The titrating beurette is cleaned with th HCl to ensure that no other chemicals could be present which m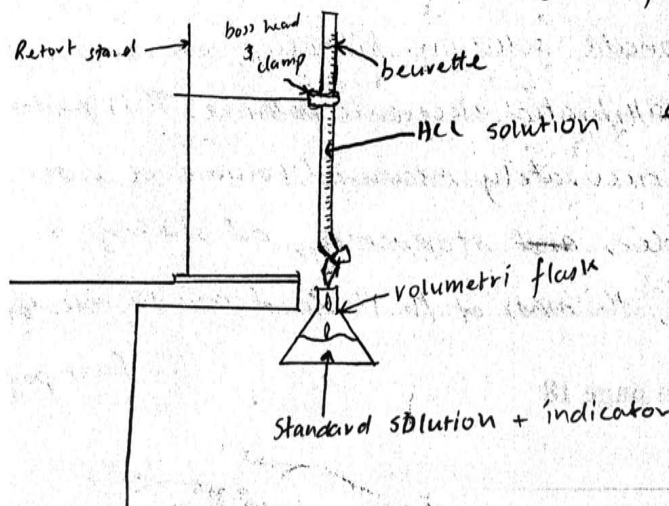ay contaminate th HCl. After carefully rinsing and emptying, it is set up by attaching to a retort stand with boss head and clamps with th centre measurements at eye level. With th tap in th closed position and th volumetric flask underneath, the HCl is added to th beurette to a point below th zero mark, so accurate readings can be made. Once the apparatus is set up as shown in diagram, th titration process can begin by slowly releasing the tap, whilst s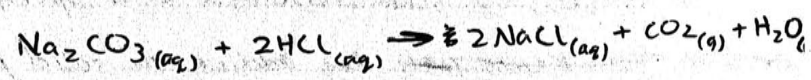wirling th volumetric flask to ensure mixing. When th colour of th solution begins to change, th rate of flow of th HCl should be minimised to ensure prevention of overshooting the mark. Once th titration is complete, a series of five to 10 repetitions should be undertaken to ensure reliability of results, whilst eliminating any extreme outliers.

End of Question 28

Retort stand →

boss head
& clamp

beurette

HCl solution

volumetri flask

Standard solution + indicator

Step C: Mathematically, th concentration of HCl titrated can be determined:

$$Na_2CO_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O$$

$n(HCl) = 2 \times 0.05 = 0.1\,mol$

$C = \frac{n}{V} = \frac{0.1}{0.0214} = 4.67\,mol\,L^{-1}$