1. You are provided with:
   (i) Two stoppered containers containing solid C 2.5g of $NaHCO_3$
   (ii) Solution $D_1$ containing HCl
   (iii) Solution A containing 4.8g of Borax salt ($Na_2B_4O_7.10H_2O$) in 250cm$^3$ solution.

   You are required to determine;
   (i) The molar heat of solution of $NaHCO_3$
   (ii) The molarity of HCl

***Procedure I***

Place 30cm$^3$ of distilled water into 100ml beaker. Add 2.5g of $NaHCO_3$ to the water stir the mixture thoroughly and retain the resulting $NaHCO_{3(aq)}$ for use in ***procedure II.***

***Procedure II***

Measure 30cm$^3$ of solution $D_1$ HCl using 100ml measuring cylinder, measure the initial temperature of solution $D_1$.

Add the 30cm$^3$ HCl to the $NaHCO_3$ solution prepared in ***procedure I*** in a 100ml plastic beaker ,stir the mixture thoroughly with a thermometer and record the final temperature of the mixture in table 2 below.

a) **Table 2**

| | |
|---|---|
| Final temperature (°C) | |
| Initial temperature (°C) | |

b) Determine the change in temperature $\Delta T_1$

c) Calculate;
   (i) The heat change of reaction (C = 4.2J/g/k, Density of solution = 1g/cm$^3$)

   (ii) Moles of $NaHCO_3$ used (Na = 23, H = 1, C = 12, O = 16)

   (iii) Molar heat of reaction $\Delta H_2$ between $NaHCO_{3(aq)}$ and HCl



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***Procedure III***

(i) Place $30cm^3$ of $D_1$ HCl into 100ml plastic beaker and measure the initial temperature of solution.

(ii) Place the remaining 2.5g of solid C ($NaHCO_3$) to the HCl stir the mixture with a thermometer and record the final temperature of the mixture in **table 3**

**RETAIN THE MIXTURE FOR USE IN PROCEDURE IV**

**a) Table 3**

| | |
|---|---|
| Final temperature (°C) | |
| Initial temperature (°C) | |

b) Determine the change in temperature $\Delta T_2$

c) Calculate'

(i) Molar heat change of reaction $\Delta H_3$ between $HCl_{(aq)}$ and solid C ($NaHCO_3$) (C = 4.2J/g/k, D = $1g/cm^3$)

(ii) Given that; (2 marks)

$\Delta H_2$ : $NaHCO_{3(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

$\Delta H_3$ : $NaHCO_{3(s)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

Calculate $\Delta H_1$ for the reaction below;

$\Delta H_1$ : $NaHCO_{3(S)} \xrightarrow{H_2O} NaHCO_{3(aq)}$

***Procedure IV***

- Transfer all the content of 100ml beaker obtained in ***procedure III*** into 250ml volumetric flask. Add distilled water upto the mark and label it as **solution D.**
- Fill the burette with **solution A** upto 0.0 mark.
- Pipette $25cm^3$ of solution **D** into a clean 250ml conical flask add 3 drops of methyl orange indicator and titrate against solution A until permanent yellow colour is formed.
- Record your value in **table 4** below. Repeat the titration two more times and complete **table 4.**



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**Table 4**

| | I | II | III |
|---|---|---|---|
| Final reading ($cm^3$) | | | |
| Initial reading ($cm^3$) | | | |
| Volume of A used ($cm^3$) | | | |

a) Calculate:

i) The average volume of solution A used.

ii) The molarity of solution A in moles per litre (Molar mass of Borax salt is 381)

iii) The number of moles of solution A used in titration.

b) Solution A reacts with Hydrochloric in ratio **1:2** according to the equation below:

$Na_2B_4O_7.10H_2O_{(aq)} + 2HCl_{(aq)} \longrightarrow 4H_3BO_{3(aq)} + 2NaCl_{(aq)} + 5H_2O_{(l)}$

Calculate the number of moles of HCl:

(i) In the Average volume solution D used.

(ii) $250cm^3$ of solution D

(iii) That reacted with solid C $NaHCO_3$ (in **procedure III**)

(iv) Total moles of HCl in $30cm^3$ of **Original** solution $D_1$

c) Calculate the molarity of HCl in moles per litre of solution $D_1$



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2. You are provided with **solution N** which is a **mixture of two salts** use it to answer questions that follow.

a) i) To the 1st portion containing about $2cm^3$ of solution N, add $NH_{3(aq)}$ solution dropwise.

| Observation | Inference |
|---|---|
| | |

ii) To the 2nd portion containing $2cm^3$ of solution add $NaOH_{(aq)}$ dropwise until in excess.

| Observation | Inference |
|---|---|
| | |

iii) To the 3rd portion of about $2cm^3$ of solution N add 3 drops of $Ba(NO_3)_2$

| Observation | Inference |
|---|---|
| | |

iv) To the 4th portion containing $2cm^3$ of solution N add 5 drops of Nitric (v) acid, test any gases produced using a burning splint.

| Observation | Inference |
|---|---|
| | |



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v) To the 5th portion containing $2cm^3$ of solution N, **dip** red litmus paper.

| Observation | Inference |
|---|---|
| | |

b) To the remaining solution N in a boiling tube, add piece of Aluminium foil provided followed by 5 drops of $NaOH_{(aq)}$ shake and warm the mixture. Test any gases produced using **moist** red litmus paper.

| Observation | Inference |
|---|---|
| | |

3. You are provided with **organic solid G** use it to answer questions that follow.

a) Scoop a third of solid G and ignite on non-luminous flame.

| Observation | Inference |
|---|---|
| | |

b) Transfer half of the remaining solid G into a boiling tube and about $8cm^3$ of water. Place $2cm^3$ of solution formed into 3 test tubes.

(i) To the 1st portion add 3 drops of Bromine water.

| Observation | Inference |
|---|---|
| | |



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(ii) To the 2nd portion add 3 drops of acidified potassium dichromate VI.

| Observation | Inference |
|---|---|
| | |

(iii) To the 3rd portion add all $Na_2CO_3$ provided.

| Observation | Inference |
|---|---|
| | |

c) To the remaining solid G add $3cm^3$ of $NaOH_{(aq)}$ and shake the mixture thoroughly.

| Observation | Inference |
|---|---|
| | |

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