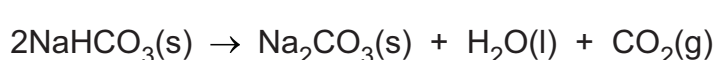
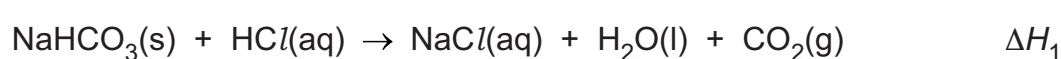


1 Sodium carbonate can be manufactured using a two-step process. The first step involves making sodium hydrogencarbonate, NaHCO_3 , which is then converted into sodium carbonate, Na_2CO_3 , in the second step of the process by the following reaction.



In this experiment you will determine the enthalpy change, ΔH_r , for this reaction. You will do this by calculating the enthalpy changes when separate samples of sodium hydrogencarbonate and sodium carbonate are added to excess hydrochloric acid, $\text{HCl}(\text{aq})$. You will then combine these values using Hess's law.



FB 1 is 2.0 mol dm^{-3} hydrochloric acid, HCl .

FB 2 is sodium hydrogencarbonate, NaHCO_3 .

FB 3 is sodium carbonate, Na_2CO_3 .

(a) Method

Experiment 1

- Support a cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 20.0 cm^3 of **FB 1** into the cup.
- Weigh the container with **FB 2**. Record the mass.
- Measure the temperature of the acid in the cup. Record this temperature.
- Carefully add all of the **FB 2**, in small portions to avoid acid spray. Stir to dissolve. Record the lowest temperature.
- Reweigh the container with any residual **FB 2**. Record the mass.
- Calculate and record the mass of **FB 2** used.
- Calculate and record the decrease in temperature.

Experiment 2

- Support the second cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 20.0 cm^3 of **FB 1** into the second cup.
- Weigh the container with **FB 3**. Record the mass.
- Measure the temperature of the acid in the cup. Record this temperature.
- Carefully add all of the **FB 3**, in small portions to avoid acid spray. Stir to dissolve. Record the highest temperature.
- Reweigh the container with any residual **FB 3**. Record the mass.
- Calculate and record the mass of **FB 3** used.
- Calculate and record the increase in temperature.

Keep FB 1 for use in Question 3.

Results

I	
II	
III	
IV	

[4]

(b) Calculations

- (i) Calculate the amount, in mol, of **FB 2** that reacts with **FB 1** and the amount, in mol, of **FB 3** that reacts with **FB 1**.

Experiment 1	Experiment 2
amount of FB 2 = mol	amount of FB 3 = mol

[2]

- (ii) Calculate the energy changes, in J, for each reaction.

Experiment 1	Experiment 2
energy change = J	energy change = J

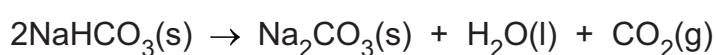
[1]

- (iii) Calculate the enthalpy change, ΔH , in kJ mol^{-1} for each reaction.

Experiment 1	Experiment 2
$\Delta H_1 = \dots\dots\dots \text{kJ mol}^{-1}$ <i>sign</i> <i>value</i>	$\Delta H_2 = \dots\dots\dots \text{kJ mol}^{-1}$ <i>sign</i> <i>value</i>

[2]

- (iv) Construct an enthalpy cycle and use Hess's law to determine the enthalpy change, ΔH_r , for the reaction shown. Show your working.



(If you were unable to calculate values in (b)(iii) then assume that ΔH_1 is $+27.3 \text{ kJ mol}^{-1}$ and that ΔH_2 is $-24.9 \text{ kJ mol}^{-1}$. These may **not** be the correct values.)

$$\Delta H_r = \dots\dots\dots \text{kJ mol}^{-1}$$

sign *value*

[2]

[Total: 11]