Determining the enthalpy for the thermal decomposition of $KHCO_3$

Transcript

When potassium hydrogen carbonate is heated strongly, it decomposes.

During its decomposition, the water produced can be seen condensing on the inside of the tube.

As the substance requires heating for decomposition, the enthalpy change for this reaction cannot be measured directly.

The enthalpy change can be found indirectly using a Hess's law cycle.

First, potassium hydrogen carbonate is reacted with hydrochloric acid. This is labelled ΔH_1.

Then, anhydrous potassium carbonate is reacted with hydrochloric acid. This is labelled ΔH_2.

The enthalpy of decomposition is then found using the data calculated for ΔH_1 and ΔH_2.

First, ΔH_1 is determined. Hydrochloric acid is added to a clean polystyrene calorimeter.

A thermometer is added, which is supported gently by the clamp. This prevents the reaction mixture from tipping over.

The initial temperature of the hydrochloric acid is recorded.

Potassium hydrogen carbonate is accurately weighed out and should be between 3.25 and 3.75 g.

The accurate mass is recorded.

The solid mass is added carefully to the calorimeter producing lots of effervescence.

The lid is placed loosely on top. The lid should have a hole for the thermometer. The hole should be wide enough for the thermometer, and to allow for the gas produced to escape.

The thermometer is carefully guided through the calorimeter lid.

The temperature of the reaction mixture decreases and the temperature at its lowest point is recorded.

The experiment is now repeated using anhydrous potassium carbonate. The same volume and concentration of acid is used.

As before, the initial temperature of the hydrochloric acid is recorded.

Anhydrous potassium carbonate is accurately weighed out and should be between 3.25 and 3.75 g.

The accurate mass is recorded.

The solid is added carefully to the calorimeter, effervescence is observed and the lid fixed on.

The thermometer is carefully guided through the calorimeter lid.

The temperature of the reaction mixture increases and the temperature at the highest point is recorded.

The experimental data can be used to calculate ΔH_1 and ΔH_2.

Once these values have been calculated, the enthalpy for the decomposition of potassium hydrogen carbonate can be determined.

The first step is to calculate the amount of energy released or absorbed in each reaction according to the amount of substance.

This is calculated using the equation $Q = mc\Delta T$.

Q is the heat energy lost or gained in the experiment.

m, represents mass.

The mass used for the calculation equals the volume of the acid added. Therefore, m is 20 g.

c represents the specific heat capacity. To simplify the calculations, we neglect the specific heat capacity of both the calorimeter and the reagents.

The value used is the same as that for water, 4.18 J g^{-1} K^{-1}.

And finally, ΔT is the difference between the initial and final temperatures.

Here are the values for ΔH_1.

The units for temperature in this calculation is kelvin.

The resulting enthalpy change is 1087 J.

As the temperature for this reaction decreased it is endothermic.

By convention, a plus sign is added to show that energy is absorbed in the reaction.

This value represents the heat absorbed in this reaction. Enthalpy values are always quoted as molar enthalpy values, so it is necessary to calculate the molar enthalpy change.

To do this, the number of moles of potassium hydrogen carbonate used in this experiment are calculated.

To find the molar enthalpy change, the heat energy calculated earlier for ΔH_1 is divided by the number of moles for potassium hydrogen carbonate.

Enthalpies are expressed in kJ mol^{-1}.

The number of J mol^{-1} is therefore divided by 1000 giving the answer in kJ mol^{-1}.

ΔH_2 is calculated following the same procedure.

The heat energy is calculated first. As the temperature of the reaction increased, the reaction is exothermic. Therefore, a negative sign is added to the front of the value.

The number of moles of potassium carbonated are calculated and is used to convert the heat energy into a molar quantity giving the J mol^{-1}, which is then divided by 1000 to give the answer in kJ mol^{-1}.

The values for ΔH_1 and ΔH_2 can now be added to the Hess' Law cycle.

$\Delta H_{\text{decomposition}}$ is calculated using the values for ΔH_1 and ΔH_2. Note that the value for ΔH_1 is multiplied by 2 because 2 moles of potassium hydrogen carbonate are reacting.

The calculated value is 92.2 kJ mol^{-1}. The overall process is endothermic because bonds have to be broken for decomposition to occur.

Hess's law states that the total enthalpy change in a chemical reaction is independent of the route by which the chemical reaction takes place as long as the initial and final conditions are the same.