Measuring the enthalpy change for a reaction experimentally

Calorimetric method

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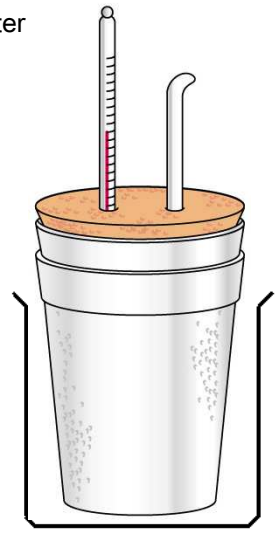
Experimental method

Apparatus: polystyrene cup in a beaker for stability and extra insulation, lid, stirrer, accurate thermometer 0.1°C (clamp this in place). Volumetric pipettes for accurate measurement of volume



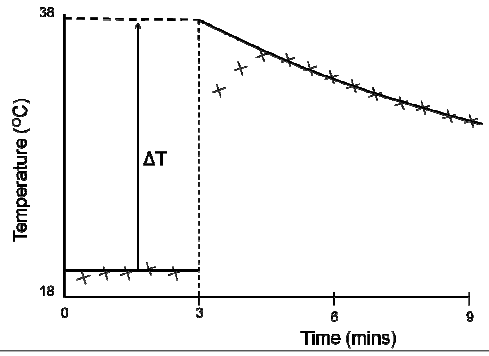
Method

1. washes equipment with solutions
2. dries cup
3. measures initial temperatures of reactants
4. transfers reagents to cup
5. thermometer bulb immersed in liquid
6. stirs mixture
7. records temperature at suitable intervals
8. repeats experiment

Measuring the temperature change

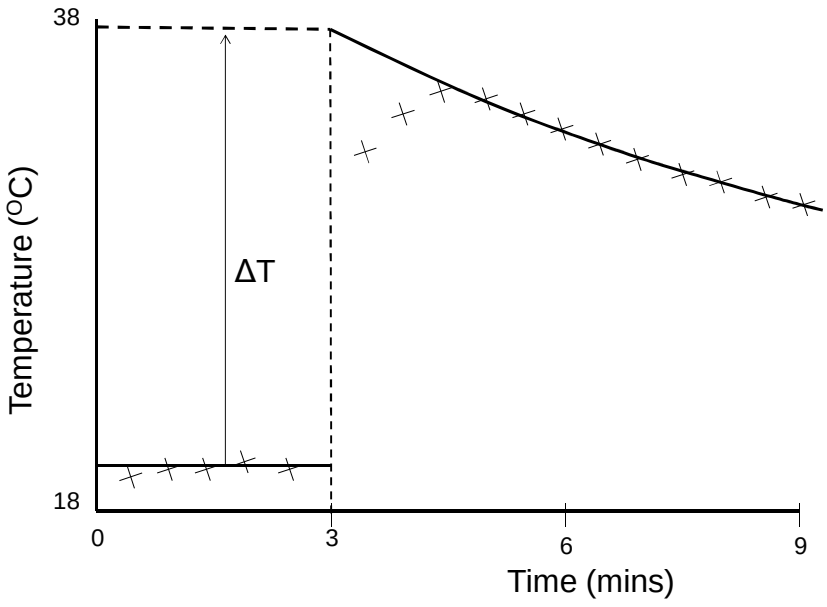
If the reaction is slow then the exact temperature rise can be difficult to obtain as cooling occurs simultaneously with the reaction

To counteract this we take readings at regular time intervals and extrapolate the temperature curve/line back to the time the reactants were added together



We also take the temperature of the reactants for a few minutes before they are added together to get a better average temperature. If the two reactants are solutions then the temperature of both solutions need to be measured before addition and an average temperature is used

Extrapolating curve



Calculating energy change for an experimental reaction

For a reaction in solution we use the following equation

energy change = mass of solution x heat capacity x temperature change

Q (J) m (g) c_p (J $g^{-1}K^{-1}$) ΔT (K)

We often use the unit of Kelvin for temperature. This is the unit used for the absolute temperature scale

absolute 0 K = -273°C

0°C = 273 K

to turn °C into K add 273

However if temperature change is needed we do not need to turn °C into K

The heat capacity of water is 4.18 J $g^{-1}K^{-1}$. In any reaction where the reactants are dissolved in water we assume that the heat capacity is the same as pure water.

We also assume that the solutions have the density of water, which is 1g cm^{-3}. Eg 25cm^3 will weigh 25 g

This equation will only give the energy for the actual quantities used. Normally this value is converted into the energy change per mole of one of the reactants. (The enthalpy change of reaction, ΔH_r)

Calculating the enthalpy change of reaction, ΔH_r from experimental data

Calculate the enthalpy change of reaction for the reaction where 25cm^3 of 0.2 M copper sulphate was reacted with 0.01mol (excess of zinc). The temperature increased 7^{o}C .

This calculation normally occurs in 3 steps. Sometimes each step is a different sub-question on the exam paper.

Step 1: Calculate the energy change for the amount of reactants in the test tube.

$Q = m \times c_p \times \Delta T$

$Q = 25 \times 4.18 \times 7$

$Q = 731.5$ **J**

step 2 : calculate the number of moles of the reactant not in excess.

moles of $CuSO_4$ = conc x vol
= 0.2 x 25/1000
= 0.005 mol

If you are not told what is in excess then you need to work out the moles of both reactants and work out using the balanced equation what is in excess

Step 3 : calculate the energy change per mole which is often called ΔHr (the enthalpy change of reaction)

energy change per mole
ΔHr = Q/ no of moles
= 731.5/0.005
= 146300 **J mol^{-1}**
= 146 **kJ mol^{-1} to 3 sf**

Finally add in the sign to represent the energy change: if temp increases the reaction is exothermic and is given a minus sign eg **–146 kJ mol^{-1}**

Remember in these questions: sign, unit, sig figs.

Question.

25cm^3 of 2M HCl was neutralised by 25cm^3 of 2M NaOH.
The Temperature increased 13.5^{o}C

What was the energy change for the 25cm^3 of HCl used?

What was the energy change per mole of HCl (ΔHr, the enthalpy change of reaction)