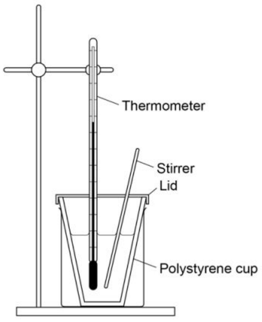
CAIE Chemistry A-Level

Practicals for Papers 3 and 5

Enthalpy Change & Measuring Temperature

Measuring Temperature

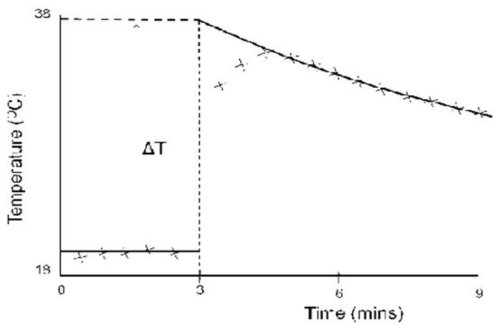


In an enthalpy change practical, the temperature change needs to be accurately measured. This is done by **minimising heat loss** or heat gain from the surroundings. A **polystyrene cup** and **lid** is used to insulate the reaction mixture from surroundings. The stirrer is used to ensure thermal energy is spread evenly in the reaction mixture. The **bottom of the thermometer must be in the reaction mixture**. An **electronic temperature sensor** and data logging software could be used to plot the graph accurately. If not, ensure you read the scale carefully.

A flame calorimeter could be used to improve accuracy:

- Spiral chimney is made of copper
- Flame is enclosed
- Fuel burns in pure oxygen rather than air

Example temperature change graph



These graphs are constructed to eliminate the error that is due to heat loss to the surroundings. This gets a **more precise temperature change** from the cooling curve (for an exothermic reaction). The horizontal reflection in of the diagram on the left is the heating curve that occurs in an endothermic reaction. The same principle applies.

Enthalpy Change

Note that you make the following **assumptions**:

- All solutions have the heat capacity of water.
- Neglect the specific heat capacity of the calorimeter, any heat absorbed by the apparatus is ignored.
- Reaction or dissolving isn't incomplete or slow.
- Density of solution is taken to be the same as water.
- None of the water could have evaporated.
- Room temperature is unchanged.
- No incomplete combustion if using a fuel.

Due to these assumptions, the value you calculate (whilst being accurate) **may vary** from the data book value for enthalpy.

Before the practical begins, use the method for **measuring mass**, to calculate a **mass of solid** used. Then calculate the moles from ($n = M_r \text{ X } m$). The energy change is from $Q=mc\Delta T$) where: Q is **energy** in J (divide by 1000 to convert to kJ), m is **mass of water** in grams, c is specific heat capacity (4.186 for water) and ΔT is temperature change (from graph). To work out enthalpy change divides the energy (kJ) by moles. If exothermic add a minus, if endothermic add a plus. Standard units are kJ mol^{-1}.

Method (example: enthalpy change of hydration of $CuSO_4$)

Method	Accuracy	Explanation
1. Weigh out between 3.90-4.10 g of anhydrous copper (II) sulfate in a dry, stoppered weighing bottle. Keep the stock of solid in a closed container during weighing. The precise mass should be recorded.	• Wash the containers with the solution to be used. • Dry the cup after washing.	
2. Construct a suitable table of results to allow you to record temperatures at minute intervals up to 15 minutes.		
3. Using a measuring cylinder, place 25 cm^3 of deionised (or distilled) water into a polystyrene cup and record its initial temperature (t=0). Start the timer and then continue to record the temperature each minute, for three minutes.	• Allow the water to stand for some time. • Stir the liquid continuously. • Place the polystyrene cup in a beaker for extra insulation and support. • Clamp thermometer into place ensuring that the bulb is immersed in liquid. (see diagram) • If the two reactants are solutions then the temperature of both solutions need to be measured before addition and an average temperature is used.	This ensures they all reach room temperature, allowing a better average temperature to be obtained. Polystyrene beakers make good calorimeters because they are good insulators and have high specific heat capacities.
4. At the fourth minute, add the powdered anhydrous copper (II) sulfate to the water in the polystyrene cup and but **do not** record the temperature. At the fifth minute continue the temperature readings at minute intervals, up to fifteen minutes. Stir the solution in the polystyrene cup as this is done.	• Add the powdered anhydrous copper (II) sulfate rapidly. • Using a lid on the polystyrene cup can help to minimise heat loss and maximise change in temperature.	
5. Plot a graph of temperature (on the y-axis) against time. Draw two separate best fit lines; one, which joins the points before the addition, and one, which joins the points after the addition. Extrapolate both lines to the fourth minute. (see diagram)	• Use a large scale on the graph.	
6. Use your graph to determine the temperature change at the fourth minute, which theoretically should have occurred immediately on addition of the solid.		See example temperature change graph above.