16–18 years

Measuring enthalpy changes

ROYAL SOCIETY OF CHEMISTRY

Education
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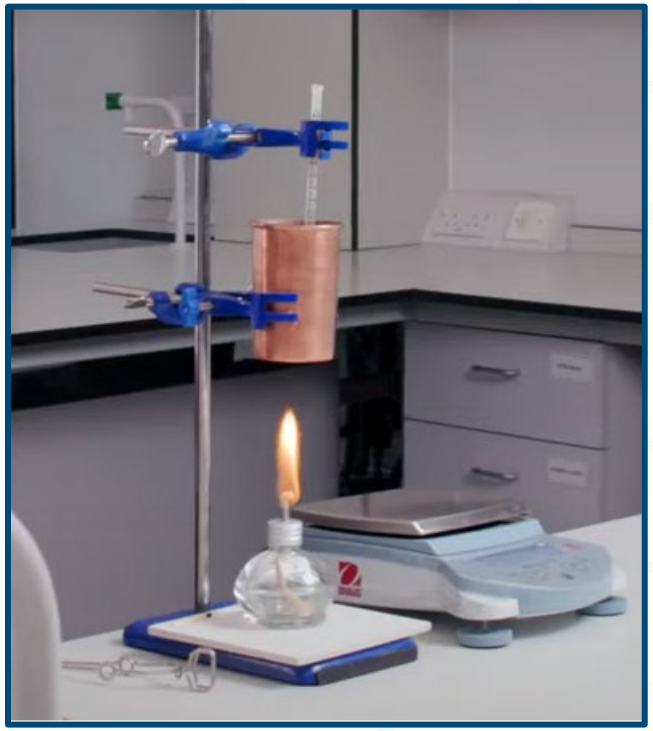
Some enthalpy changes are easy to measure.

For example, enthalpy changes of combustion can be measured by burning a known amount of the substance in oxygen and measuring the amount of energy produced.



Others are difficult, because chemists cannot easily control the bond–breaking, bond–making processes.

Can you think of an example?

What happens when water is added to anhydrous copper(II) sulfate?

Activity

Method

Wear eye protection.

1. Use a spatula to put a small amount (thumbnail covering) of anhydrous copper(II) sulfate into a test tube.
2. Add water drop by drop.
3. Carefully touch the outside of the test tube.

What do you notice?

What happens to the copper(II) sulfate?

Equipment

- Safety glasses
- Test tube
- Test tube rack
- Spatula
- Pipette
- Small beaker containing water
- Anhydrous copper(II) sulfate powder (DANGER: corrosive, irritant, environmental hazard)

Questions

1. Is the enthalpy change for this reaction exothermic or endothermic?
2. What sign should the enthalpy change have?
3. What is the equation for this reaction?
4. What bonds are being broken and formed in this reaction?
5. Why is it difficult to measure this enthalpy change directly?
6. What is this enthalpy change called?

Learning objectives

1. Recognise that some enthalpy changes can't be measured directly.
2. Know that Hess's law shows that whichever route is taken to a product, the overall enthalpy change is the same.

Key points

- It is difficult to measure the enthalpy change of hydration accurately in a direct way because the hydration process can't be controlled directly.
- Instead, you can dissolve anhydrous and hydrated copper(II) sulfate in water.
- You can measure these enthalpy changes easily.
- Each 'route' produces a solution of hydrated copper(II) sulfate.
- Hydrated copper(II) sulfate has some water in the structure already. By dissolving the two salts and determining the enthalpy changes, we can work out the enthalpy change of hydration.

Hess's law

Hess's law says that the enthalpy change for a reaction will be the same regardless of the route taken.

Imagine a chemical journey from A → B, the enthalpy change will be the same even if you were to get there going through C, D and/or E!

An enthalpy change you cannot measure directly

Experiment

Method

Wear eye protection.

1. Calculate the mass of 0.025 moles of anhydrous copper(II) sulfate.
2. Use a spatula to measure out this mass into a weighing boat.
3. Stand the cup in the beaker. Measure out 50 cm^3 of water into the cup.
4. Record the temperature of the water in the cup.
5. Add the copper(II) sulfate to the water and stir with the thermometer.
6. Record the highest temperature reached.
7. Repeat these steps with hydrated copper(II) sulfate.

Equipment

- Anhydrous copper(II) sulfate powder (DANGER: corrosive, irritant, environmental hazard)
- Hydrated copper(II) sulfate crystals (DANGER: corrosive, irritant, environmental hazard)
- Spatula
- Weighing boat (or similar)
- Insulated cup
- Beaker
- Thermometer reading 0–110°C in 0.1°C increments
- Water
- 50 cm^3 pipette or measuring cylinder
- Access to a mass balance
- Eye protection

Working out the enthalpy changes

1. Calculate the energy released.

Energy (Joules) = 50 x 4.2 x temperature rise

2. Divide the energy figure by the number of moles.
3. Write equations with state symbols for the enthalpy changes you have measured. Write their enthalpy changes alongside them.

Write a summary of the experiment …

Summary

Make sure you explain:

- the name of the enthalpy change you are trying to measure,
- why this enthalpy change can't be measured directly,
- why the two routes have the same enthalpy change,
- what the value of the enthalpy change is from your measurements.