

Heat in and out of reactions

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lab

Name: _____ Date: _____ Class: _____

Some salts make the water hot when they dissolve and others make it cold, which is why cold packs and hand warmers can be built from them. You measure the temperature change for three salts, classify each dissolving process and turn the thermometer readings into an energy change per mole.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-4

Aim

To find which of three salts dissolves exothermically and which endothermically, and to calculate the energy change per mole of salt dissolved.

Equipment

- Polystyrene cup with lid and a beaker to support it
- Thermometer (-10 to 110 °C) and a stirrer
- Measuring cylinder (25 cm^3), balance reading to 0.1 g , stopwatch
- Ammonium nitrate (5.0 g), anhydrous calcium chloride (2.0 g), sodium chloride (5.0 g)
- Distilled water, spatula, paper towel

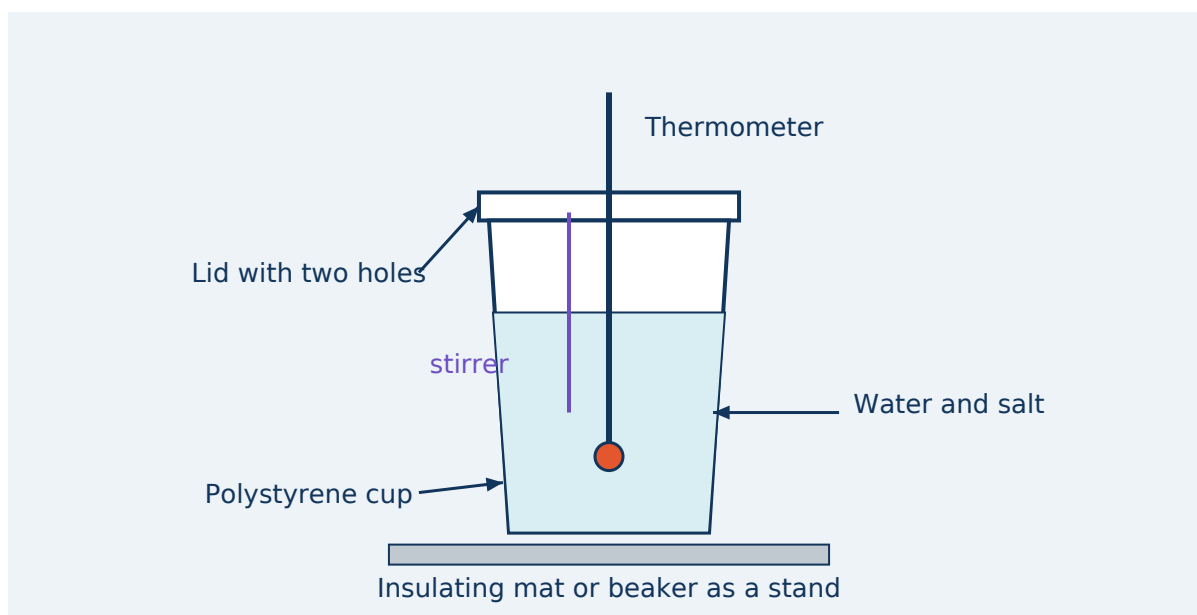
Safety

Safety

Wear safety goggles. Calcium chloride is an irritant and gets hot, so add it slowly. Ammonium nitrate must be kept away from fuels and heat. Wash hands afterwards and do not eat or drink in the lab.

Method

1. Place the cup in the beaker and add 25 cm^3 of water (25 g). Record the temperature after one minute of stirring.
2. Weigh the first salt and add it all at once. Replace the lid immediately.
3. Stir gently and record the lowest or highest temperature reached.
4. Empty and rinse the cup, then repeat with each of the other salts using fresh water at room temperature.



A lidded polystyrene cup reduces energy loss to the room.

Results

Sample results with 25 g of water each time:

Salt	Mass / g	Start / °C	End / °C
Ammonium nitrate	5.0	21.0	9.0
Calcium chloride	2.0	21.0	34.5
Sodium chloride	5.0	21.0	19.5

Analysis questions

Question 1 Temperature changes

Calculate the temperature change for each salt and classify each dissolving process as exothermic or endothermic.

Question 2 Energy transferred

Use $q = m \times c \times \Delta T$ with $m = 25$ g of water and $c = 4.2$ J/g/°C. Calculate q in kJ for each salt, ignoring the sign.

Question 3 Moles of salt

Calculate the moles of each salt used (Ar: N = 14, H = 1, O = 16, Ca = 40, Cl = 35.5, Na = 23).

Question 4 Energy change per mole

Calculate ΔH in kJ/mol for each salt, including the correct sign.

Question 5 Comparing with accepted values

The accepted value for ammonium nitrate is about +26 kJ/mol.

1. Calculate the percentage difference between your value and the accepted one.
2. Suggest why the experimental value is smaller in size.

Question 6 Sources of error

Explain why a lid and a polystyrene cup are used and give one further source of error.

Question 7 Conclusion and use

State which salt is best for a cold pack and which for a hand warmer, and suggest one improvement to the method.