

EduTrend Contents

W4C · CHEMISTRY · HIGH SCHOOL

Design a Hand Warmer

Use energy changes in reactions to solve a design brief.

Ages 15–18 | Level: Advanced | 75 minutes | Pairs · up to 24 | Activity 05

Inside: activity at a glance · step-by-step session plan · facilitator notes · 3 student worksheets · assessment checklist

ACTIVITY 05 · AT A GLANCE

Design a Hand Warmer

Students investigate energy changes when substances dissolve or react. They measure the temperature change for several salts and a neutralisation reaction, calculate the energy transferred and then choose a system for a hand warmer or a sports cold pack that meets a design specification. The activity connects measurement, calculation and applied chemistry.

Learning outcomes

By the end of the session students can:

- distinguish exothermic and endothermic processes from temperature data;
- calculate energy transferred using Q = m × c × temperature change;
- evaluate the accuracy of calorimetry measurements;
- justify a design choice using data and safety considerations.

KEY WORDS

exothermic · endothermic · enthalpy change · calorimetry · specific heat capacity · specification

CURRICULUM LINKS

Chemistry: energy changes, enthalpy, calorimetry. Physics: specific heat capacity. Design & technology: specification and evaluation.

1	2	3	4	5	6
QUESTION	**PREDICT**	**PLAN**	**TEST**	**OBSERVE**	**EXPLAIN**
What do we want to know?	What will happen?	Keep it fair	Try it safely	Record results	Why did it happen?

Materials (per pair)

- Polystyrene cup calorimeter with lid and thermometer (0.1 °C if available)
- Anhydrous calcium chloride, ammonium chloride (or urea), sodium carbonate
- Citric acid and sodium hydrogencarbonate
- Balance, spatulas, 25 ml measuring cylinder
- Distilled or tap water
- Worksheets 1, 2 and 3

Before the session

- Weigh out 2.0 g samples in labelled tubes if time is short.
- Check CLEAPSS or local guidance for the salts used.
- Prepare a class results table on the board.
- Test the calcium chloride run yourself.

SAFETY

Goggles on. Calcium chloride can cause eye irritation and heats up quickly: add slowly. Ammonium chloride is harmful if swallowed. Follow your school risk assessment. Wash hands afterwards.

ACTIVITY 05 · SESSION PLAN

Step by step

Timings are for a 75-minute lesson. For a 60-minute lesson, give pairs pre-weighed samples and set the design write-up as homework.

Time	What happens	Say or ask
0–10 min Hook	Crack a commercial hand warmer or cold pack. Ask how a packet can make heat without a flame.	*"Where does the energy come from?"*
10–20 min Method	Demonstrate the cup calorimeter: 25 ml water, record starting temperature, add 2.0 g solid, stir, record the maximum or minimum temperature.	*"Why use a lid and a polystyrene cup?"*
20–45 min Measure	Pairs test three solids and the citric acid plus hydrogencarbonate reaction, recording temperature change for each.	*"How will you decide when to take the final reading?"*
45–55 min Calculate	Pairs calculate Q = m × c × temperature change for each (m = mass of water, c = 4.18 J per g per °C).	*"Which processes are exothermic? Which are endothermic?"*
55–70 min Design	Pairs choose a system for a hand warmer (raise 25 ml water by at least 15 °C) or a cold pack (lower by at least 8 °C) and justify it on Worksheet 3.	*"What else matters besides temperature change?"*
70–75 min Review	Pairs share designs and identify the largest source of error.	

CHALLENGE CARD (print or copy onto the board)

Specification: a single-use hand warmer must raise the temperature of 25 ml of water by at least 15 °C using no more than 5 g of solid, and be safe to handle. Choose your system, calculate the energy released and justify your choice.

ACTIVITY 05 · FACILITATOR NOTES

The chemistry in brief

When a solid dissolves, bonds between its ions break (which takes in energy) and new attractions form between ions and water molecules (which releases energy). If more energy is released than taken in, the process is exothermic and the water warms up, as with calcium chloride. If more is taken in, it is endothermic and the water cools, as with ammonium chloride. The reaction between citric acid and sodium hydrogencarbonate is also endothermic.

The energy transferred to or from the water is estimated with Q = m × c × temperature change. Because the polystyrene cup is not perfectly insulated and some energy heats the cup and thermometer, measured values are usually smaller than true values. Commercial hand warmers often use the oxidation of iron powder or the crystallisation of sodium ethanoate, while instant cold packs use the dissolving of ammonium nitrate or urea.

Common ideas to listen for

- “Cold is added to the water.” Energy is taken from the water, so it cools.
- “A bigger temperature change always means more energy.” Energy also depends on the mass of water.
- “Dissolving is not a chemical process.” Dissolving involves real energy changes in bonds and attractions.

Adapting the activity

Support

Provide a worked example of Q = m × c × temperature change and a results table with formulas prompts.

Stretch

Convert results to kJ per mole of solid and compare with data-book values; discuss the reasons for the difference.

WORKSHEET 1

Calorimetry results

Name: _____ Class: _____ Date: _____

Use 25 ml water and 2.0 g of solid each time.

Results

Substance	Start (°C)	End (°C)	Change (°C)	Exo or endo?
Calcium chloride				
Ammonium chloride				
Sodium carbonate				
Citric acid + NaHCO3				

Sources of error

WORKSHEET 2

Energy calculations

Q = m × c × temperature change, where m = mass of water (g), c = 4.18 J per g per °C.

Calculations

Substance	m (g)	Change (°C)	Q (J)
1			
2			
3			
4			

Which system transfers the most energy per gram? Show working.

WORKSHEET 3

Design brief

Choose: hand warmer or cold pack.

My design

Sketch the packet: compartments, how it is activated, materials.

Justification (data, safety, cost, reuse)

FOR THE TEACHER

Assessment checklist

Use during the session. One sheet covers up to eight students; copy as needed.

Student	Measures accurately	Calculates energy correctly	Justifies design with data

Suggested codes: W = working towards · E = expected · G = greater depth

ABOUT THIS ACTIVITY

Design a Hand Warmer is a sample activity from the EduTrend Contents W4C Chemistry programme (high school, level: advanced). Every activity in the programme follows the same format: a practical challenge, a clear session plan, facilitator notes and ready-to-print worksheets, so that teachers, club leaders and parents can run it without extra preparation.

Full 15-, 20- and 32-week programmes are available from EduStore at edutrend.org.

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