Specific heat capacity: water and a solid

Student activity • investigation and reasoning

YEAR 11 / LESSON 71 / PHYSICS ONLY

The question

How well can electrical input and temperature rise estimate specific heat capacity?

Observe two staff-operated low-voltage calorimetry setups and compare estimates while accounting for energy transferred to apparatus and surroundings.

Equipment

- Staff water calorimeter with rated immersion heater and separate stirrer
- Purpose-made metal block with compatible heater and probe holes
- Two isolated supplies, joulemeters and temperature probes; balance and timer

Staff operate both heaters and check manufacturer immersion/insertion requirements. Never energise a heater in air or remove it while powered. Keep terminals and supplies dry and guarded, use suitable insulated leads and heat-resistant trays, and stop sample heating at 45 °C. Heater surfaces can be hotter than the measured sample; leave everything in place to cool before handling. No mains immersion heater is used.

Course coverage: Physics only: 5.2P, 5.13P, 5.14P. Electrical investigation of water and a solid.

Plan, model or apparatus sketch

Draw the apparatus or model and label the measured quantities and their units.

Method and reasoning

Read the whole sequence before starting

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1. Staff measure the actual mass of about 0.30 kg water in a suitable supported insulated calorimeter and of a purpose-made metal block of about 0.50 kg. Record each mass in kilograms.

2. Staff fit a rated immersion heater and temperature probe to the water apparatus and a compatible cartridge heater and probe to the block. Heaters remain fully immersed or inserted as required by their manuals; pupils do not handle heated equipment.

3. Record initial temperature and zero each electrical joulemeter. Staff use isolated low-voltage supplies at no more than 12 V and measured power no more than 20 W per setup, within all equipment ratings.

4. Record electrical energy input and temperature every 60 s for up to 300 s. Staff gently stir the water with a separate stirrer. Stop a setup earlier if its measured sample temperature reaches 45 °C or if any abnormal heating occurs.

5. After switching off, observe temperature settling without adding more electrical energy. Record the time and value used for the final temperature separately. Calculate cestimate = Eelectrical/(mΔT) for each sample.

6. Compare estimates and explain why heater, container and probe heat capacity and environmental losses matter. Do not call electrical input exactly equal to energy gained by the sample. Discuss sensor lag and the trade-off in waiting for a settled final reading.

Cleanup

• Switch off and isolate supplies. Leave heaters in their rated setups until cool; staff drain and dry the water apparatus and store the block safely.

Record your evidence

Blank spaces are for your own work

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Reference and task data

The calculation is an estimate. A small positive ΔT makes fractional uncertainty large; do not divide by zero or invent a rise. Practice only: 1800 J, 0.20 kg and 10 °C gives 900 J kg^{-1} $°C^{-1}$. Actual material values must come from measurements and justified reference comparisons.

Time / s	Water E / J	Water T / °C	Solid E / J	Solid T / °C
0				
60				
120				
180				
240				
300				

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Why measure actual sample mass?

2. What does the joulemeter measure?

3. Which temperature change is required?

4. Find c for the practice values.

5. Why can the simple method overestimate c?

6. Why record post-switch-off settling separately?