Essential Question

How do we measure the heat of a reaction?

ZornScience | zornscience.org | CC BY-NC-SA 4.0

System vs. Surroundings

- System: the reacting chemicals
- Surroundings: everything else, usually the water
- The thermometer sits in the surroundings

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Heat Lost = Heat Gained

- Law of conservation of energy: never made or destroyed
- Thermodynamics: the study of energy and how it moves
- Energy moves as heat or as work
- $q_{rxn} = -q_{soln}$

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Three Ways Energy Changes

- Heating or cooling
- Phase changes
- Chemical reactions
- Heat lost = heat gained works for all three

ZornScience | zornscience.org | CC BY-NC-SA 4.0

The Coffee-Cup Calorimeter

- Two foam cups: insulation that traps heat
- Lid and stirrer: keep heat in and mix
- Thermometer: starting and final temperatures
- Almost no work is done, so energy moves as heat

ZornScience | zornscience.org | CC BY-NC-SA 4.0

What ΔT Tells You

- The thermometer reads the water, not the reaction

Water temperature	Reaction	q_{rxn}
rises	exothermic	negative (−)
drops	endothermic	positive (+)

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Treat the Solution Like Water

- c = 4.18 J/g·°C
- 1.00 g/mL, so 1 mL → 1 g
- Use the total mass in the cup

ZornScience | zornscience.org | CC BY-NC-SA 4.0

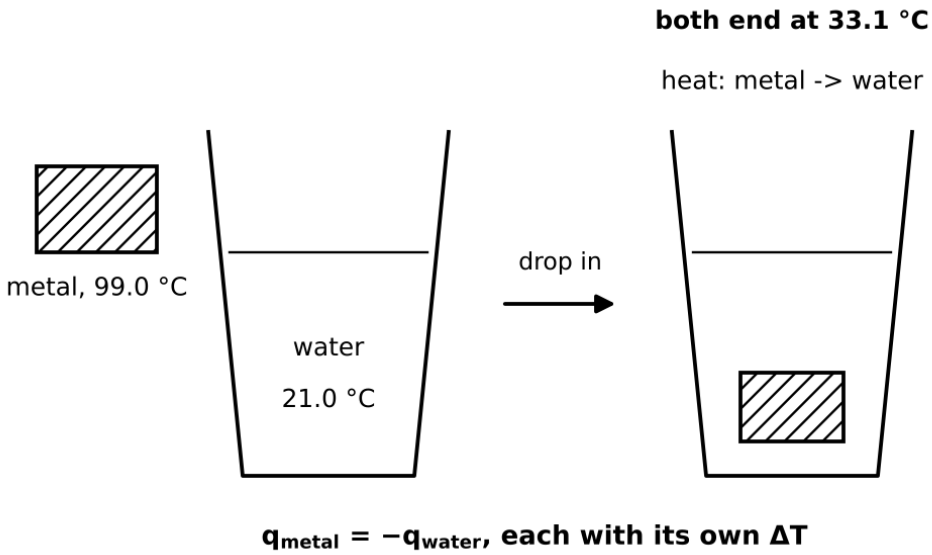
Calorimetry Steps

- 1. $q_{soln} = mc\Delta T$
- 2. $q_{rxn} = -q_{soln}$
- 3. $\Delta H = q_{rxn} \div$ mol, in kJ/mol (only if asked)

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Hot Metal in Water

- The metal loses heat; the water gains it
- Both end at the same temperature
- Each has its own ΔT
- $c_{metal} = q \div (m\Delta T)$



ZornScience | zornscience.org | CC BY-NC-SA 4.0

Example: System or Surroundings?

A hand warmer packet gets hot when you open it. (a) What is the system? What are the surroundings? (b) Is q for the system positive or negative? (c) Is the process exothermic or endothermic?

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Example: Mixing Water

100. g of water at 80.0 °C is mixed with 200. g of water at 20.0 °C in a calorimeter. Find the final temperature. Use c = 4.18 J/g·°C.

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Example: Dissolving a Salt

10.0 g of NH_4Cl is dissolved in 50.0 g of water at 23.0 °C in a coffee-cup calorimeter. The final temperature is 12.0 °C. Find q_{rxn}. Is dissolving endothermic or exothermic?

ZornScience | zornscience.org | CC BY-NC-SA 4.0

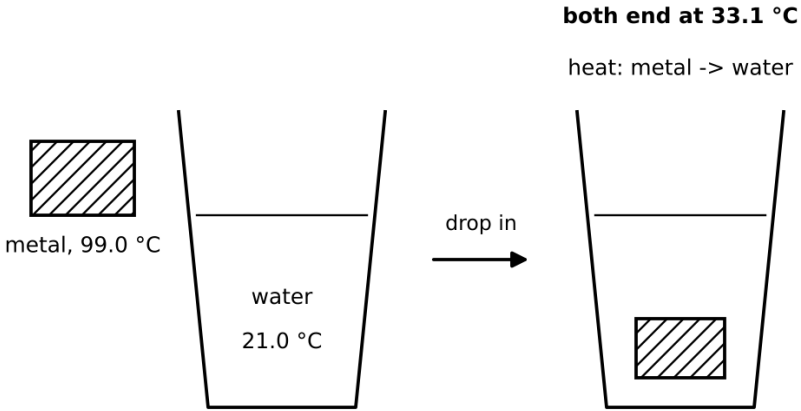
Example: Neutralization

50.0 mL of 1.0 M HCl and 50.0 mL of 1.0 M NaOH, both at 21.0 °C, are mixed in a calorimeter. The temperature rises to 27.7 °C. Find ΔH in kJ per mole of water formed (0.050 mol H_2O forms).

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Example: Identifying a Metal

A 100.0 g metal sample at 99.0 °C is dropped into 50.0 g of water at 21.0 °C. Both end at 33.1 °C. Find the specific heat of the metal and identify it (Al 0.897, Fe 0.449, Cu 0.385 J/g·°C).



$q_{metal} = -q_{water}$, each with its own ΔT

ZornScience | zornscience.org | CC BY-NC-SA 4.0

Calorimetry

Big Ideas

- Heat lost = heat gained: $q_{rxn} = -q_{soln}$
- Find q_{soln} with $q = mc\Delta T$, then flip the sign
- T up: exothermic. T down: endothermic.
- $\Delta H = q_{rxn} \div$ mol, in kJ/mol
- Hot metal in water: $q_{metal} = -q_{water}$, then $c = q \div (m\Delta T)$

ZornScience | zornscience.org | CC BY-NC-SA 4.0