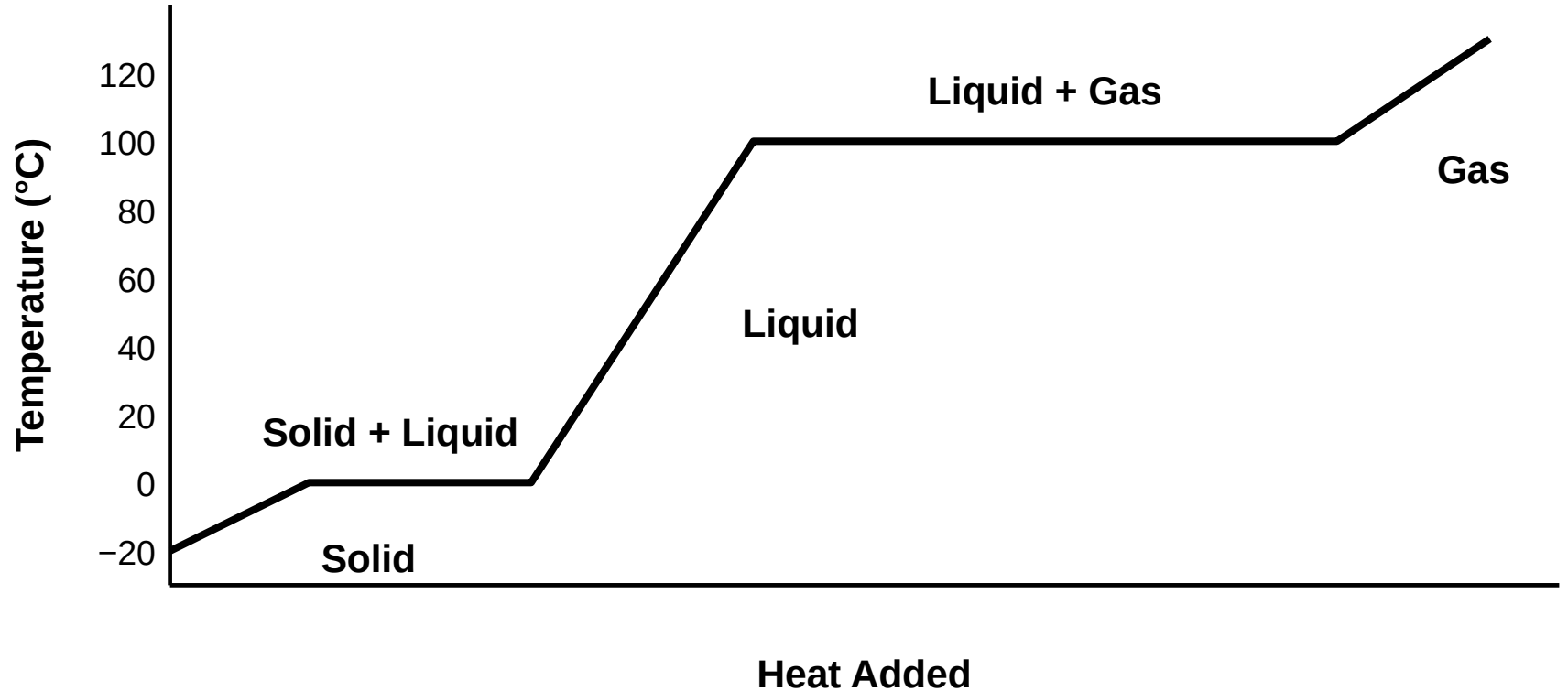


Essential Question

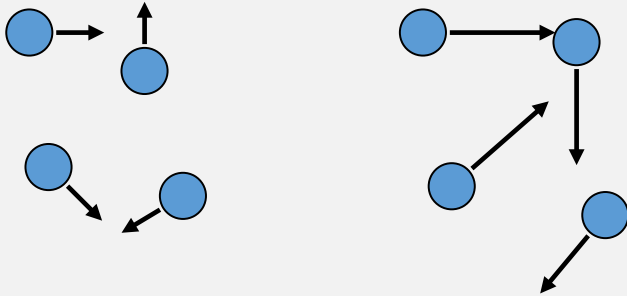
Where does heat go in a phase change?

The Heating Curve of Water



Kinetic vs. Potential Energy

Kinetic Energy = motion

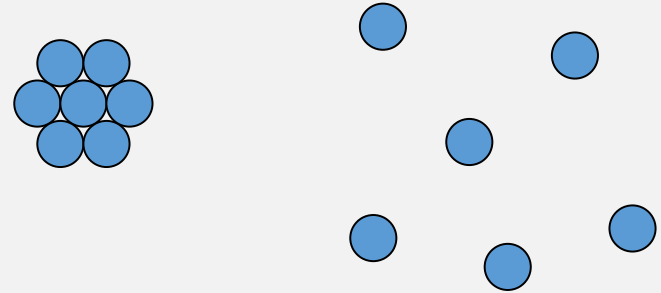


Slow

Fast

Temperature measures KE

Potential Energy = spacing



Close: low PE

Far apart: high PE

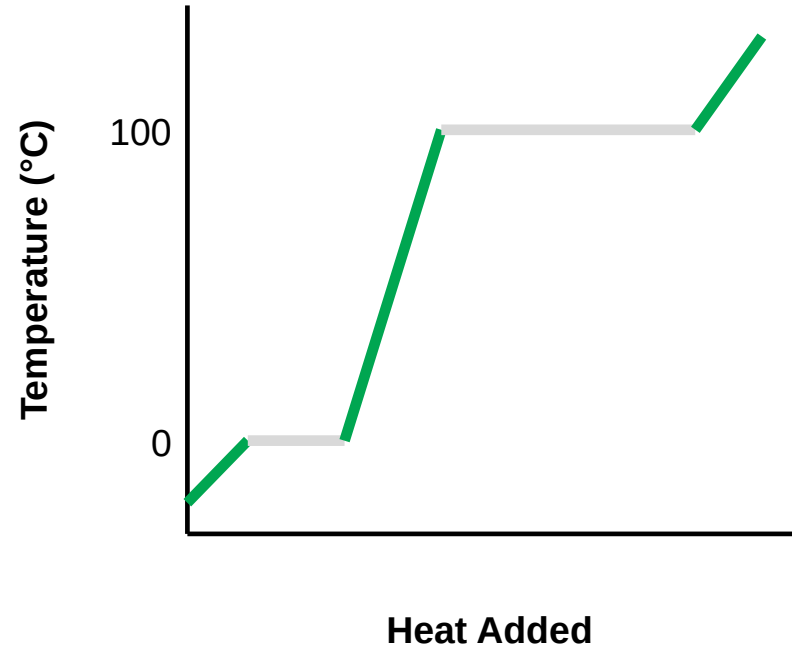
Phase changes change PE

Sloped Segments: Temperature Changes

- Temperature goes **up**
- Particles speed up: **KE** increases

$$q = mc\Delta T$$

Use **c** for that phase



Flat Segments: Phase Changes

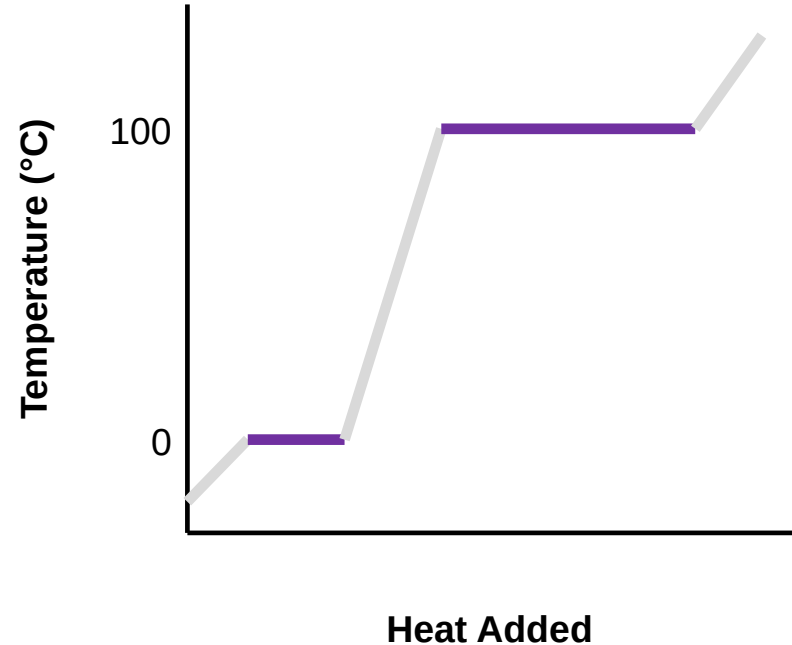
- Temperature stays **constant**
- Particles pull apart: **PE** increases

$$q = m\Delta H_{\text{fus}}$$

melting

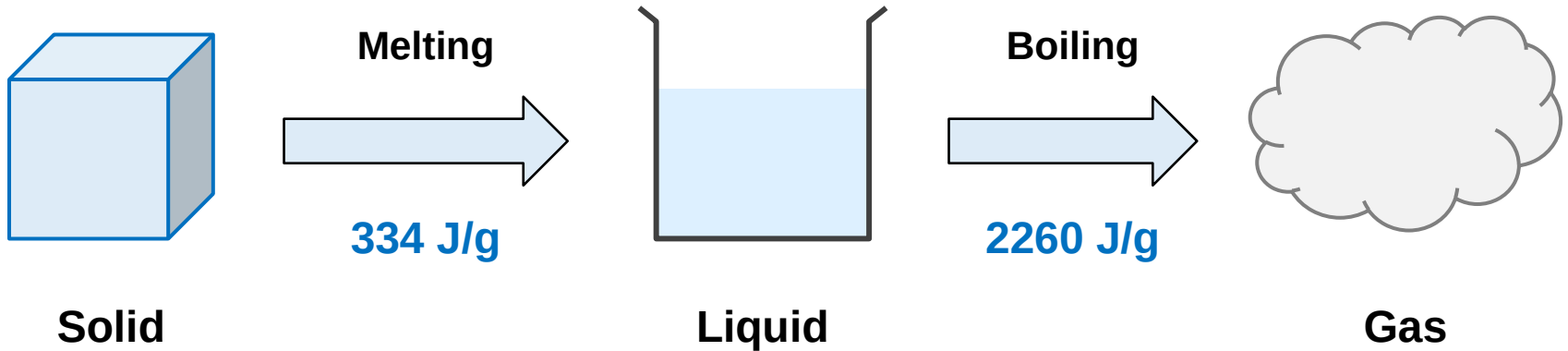
$$q = m\Delta H_{\text{vap}}$$

boiling

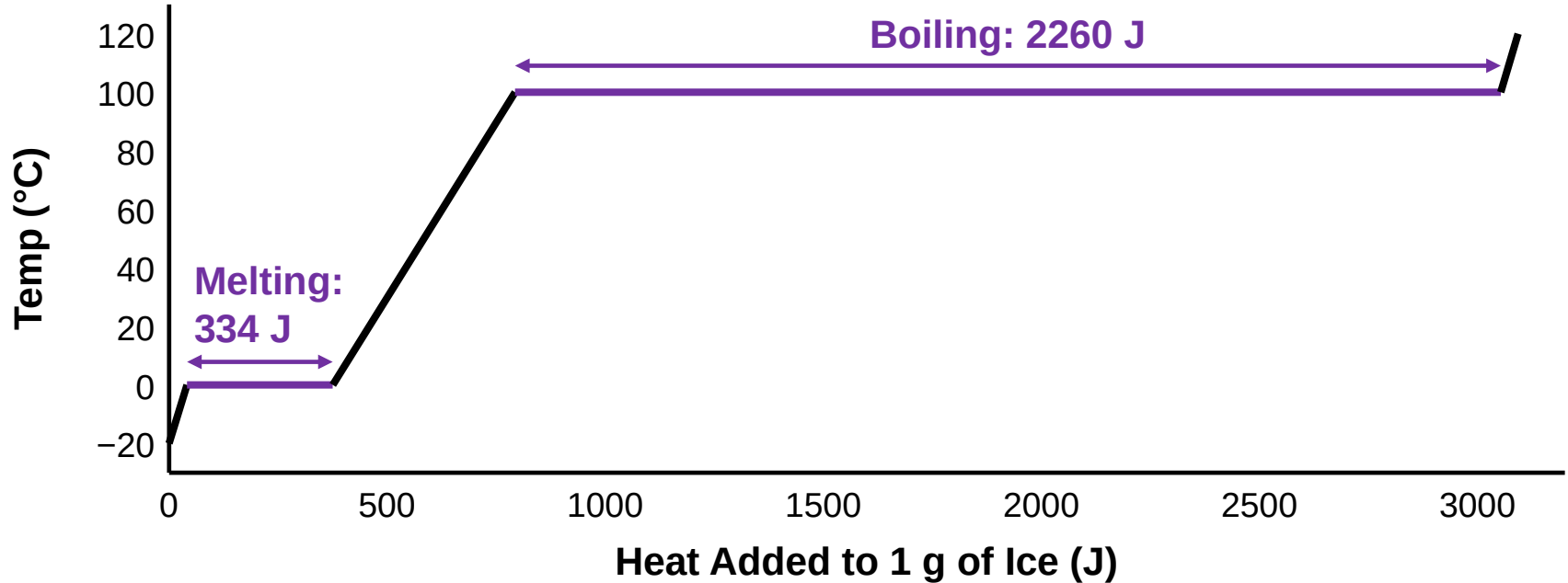


Heat of Fusion & Vaporization

- Heat of fusion (ΔH_{fus}): heat to melt 1 g
- Heat of vaporization (ΔH_{vap}): heat to boil 1 g

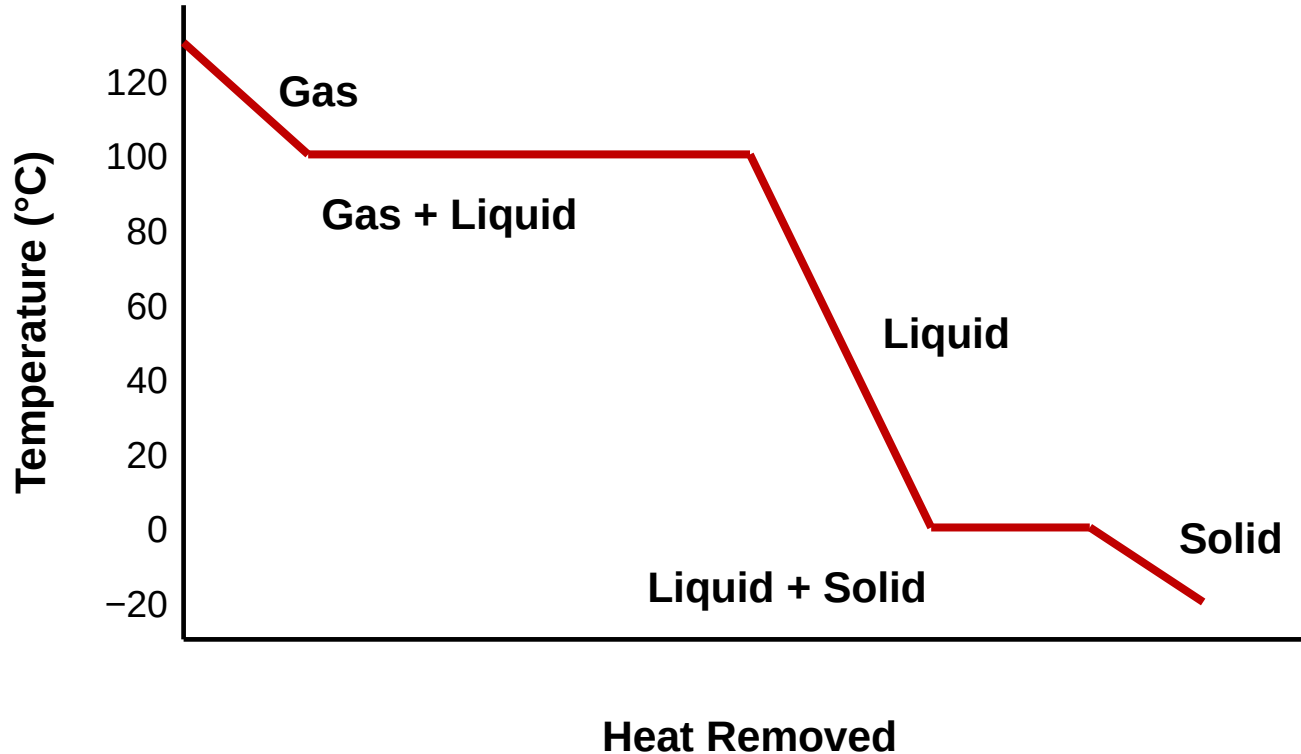


Why the Boiling Plateau Is Longer



Boiling takes about **7 times** more heat than melting

The Cooling Curve



Heat released
 q is negative

Heating & Cooling Curves

Water Data

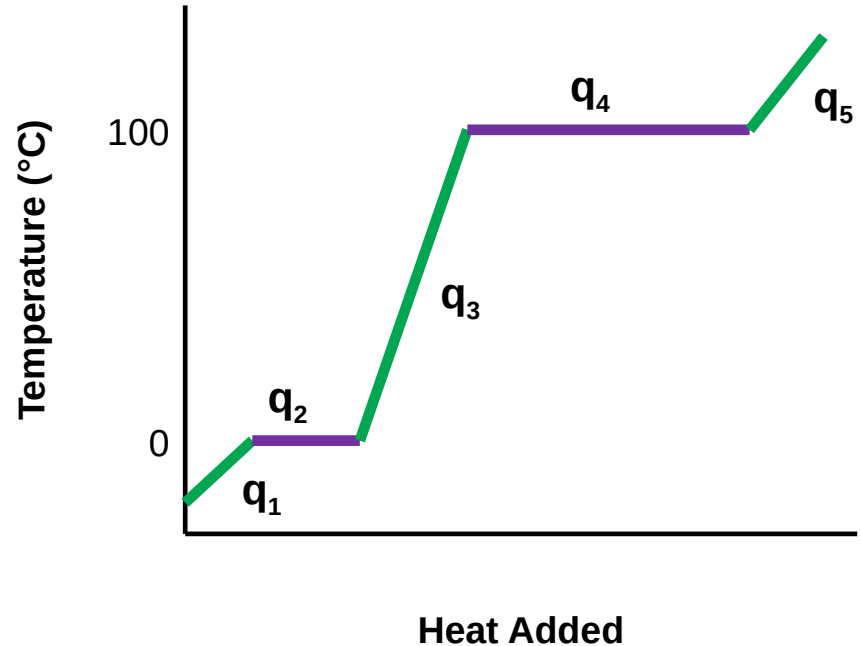
Quantity	Value	Segment
Specific heat of ice, c_{ice}	2.06 J/g·°C	Sloped
Specific heat of water, c_{water}	4.18 J/g·°C	Sloped
Specific heat of steam, c_{steam}	1.99 J/g·°C	Sloped
Heat of fusion, ΔH_{fus}	334 J/g	Flat
Heat of vaporization, ΔH_{vap}	2260 J/g	Flat

Each phase has its **own** specific heat

Multi-Step Problems

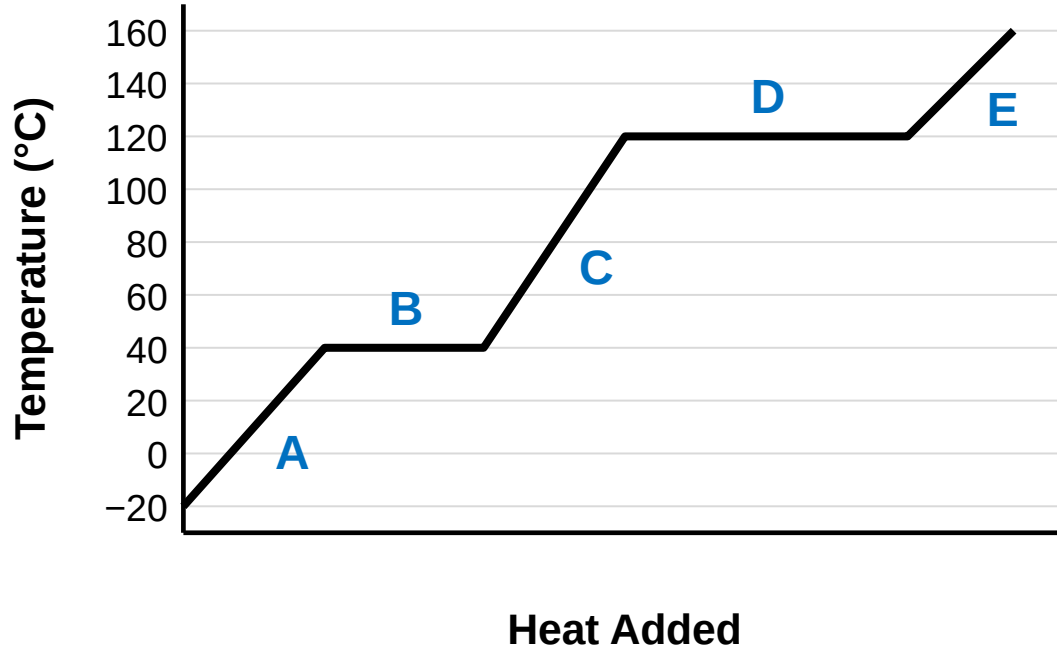
1. Mark the start and end
2. One q for each segment
3. Add all the q values

$$q_{\text{total}} = q_1 + q_2 + q_3 \dots$$



Example 1: Reading a Heating Curve

Use the heating curve of an unknown substance to answer:



- (a) Melting point?
- (b) Boiling point?
- (c) Which segments have two phases present?
- (d) Where does KE stay constant while PE increases?

Example 2: Freezing Water

How much heat is released when 40.0 g of water at 0 °C freezes to ice at 0 °C?

Data

$$\Delta H_{\text{fus}} = 334 \text{ J/g}$$

Example 3: Ice to Warm Water

How much heat is needed to change 15.0 g of ice at $-10.0\text{ }^{\circ}\text{C}$ to liquid water at $40.0\text{ }^{\circ}\text{C}$?

Data

$$c_{\text{ice}} = 2.06 \text{ J/g}\cdot^{\circ}\text{C}$$

$$\Delta H_{\text{fus}} = 334 \text{ J/g}$$

$$c_{\text{water}} = 4.18 \text{ J/g}\cdot^{\circ}\text{C}$$

Example 4: Boiling Water

How much heat is needed to change 50.0 g of water at 80.0 °C into steam at 100 °C?

Data

$$c_{\text{water}} = 4.18 \text{ J/g}\cdot^{\circ}\text{C}$$

$$\Delta H_{\text{vap}} = 2260 \text{ J/g}$$

Big Ideas

- **Sloped:** temperature changes, use $q = mc\Delta T$
- **Flat:** phase change, use $q = m\Delta H$
- Multi-step: one q per segment, then add
- Cooling releases heat, so q is **negative**