

The Bath and the Melting Ice: Where Does the Energy Go?

Investigation question: When a cup of ice sits in a warm bath, energy flows into it the whole time. What happens to the temperature and the particles of the ice while it melts, and after it has melted?

Collaborative systems modeling

Groups of 4

1 session

Setup 8 · Activity 35 · Cleanup 7 min

MS-PS1-4 · assesses

MS-PS3-4 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Ice tender:** Steadies the cup in the bath by its rim, stirs the ice gently and constantly with a plastic spoon, keeps the thermometer bulb in the middle of the ice, and calls out what the cup contains each minute.
- ☐ **Bath tender:** Stirs the bath with the second spoon before each reading and reads the bath thermometer at every call.
- ☐ **Timer and reader:** Calls each minute, reads the cup thermometer at eye level, and notes the exact time the last piece of ice disappears.
- ☐ **Recorder:** Writes both temperatures and the cup observations in the data table, then leads the group graph.

Safety

- Water above about 50 °C can scald. Only the teacher prepares or handles warm water, and students receive water no warmer than 45 °C. Report any water that feels uncomfortably hot.
- Glass thermometers can break and cut. Never stir with a thermometer; rest it on the tray, not at the edge of a table; tell the teacher at once if one breaks and do not pick up the pieces.
- Spilled water and melting ice make floors slippery. Work over the tray and wipe spills right away.
- Ice straight from a freezer can stick to dry skin and cause cold injury with long contact. Move it with a spoon or scoop and hold it only briefly.
- Lab ice and water are not for eating or drinking; cups and spoons used here stay in the lab kit.
- Keep phones, kettles and other electrical devices away from the trays of water.

Procedure

1. Predict before you touch anything. On the recording sheet (q1), each student sketches the graph they expect for the cup's temperature over 25 minutes, with a dashed line for the bath.
2. Map the system. As a group, fill in the system table: the system is the ice and its meltwater in the cup; the surroundings are the bath and the room air; the boundary is the cup wall. Add an arrow showing

which way you expect energy to flow.

3. Set up the bath. Pour 2 L of the teacher's warm water into the tub on the tray. The bath tender stirs it, reads it and records the starting bath temperature in q2.
4. Start the cup. Weigh 150 g of crushed freezer ice into the plastic cup and record the mass. Push the cup thermometer into the middle of the ice, wait 30 seconds, and record the reading as minute 0. Then lower the cup into the bath, hold it upright by the rim, and start the timer.
5. Every minute, the timer calls 'read'. The reader reads the cup thermometer, the bath tender stirs and reads the bath, the ice tender says what is in the cup (all ice, ice and water, slush, a few chunks, all liquid), and the recorder writes all three in the data table. The ice tender stirs the ice gently and constantly between readings, using the spoon, never the thermometer, and keeps the bulb away from the cup wall.
6. Watch for the moment the last piece of ice disappears and write that time in q3. Keep reading every minute until at least 10 minutes after the last ice is gone, or until minute 25.
7. Graph both temperatures against time on the same axes, using one symbol for the cup and another for the bath. Draw a smooth line through each set of points and mark where the ice finished melting.
8. Clean up: pour the water into the sink, dry the thermometers and lay them in their case, and wipe the tray.
9. Complete the three-panel particle drawing and answer the analysis questions individually. Post your group's flat-stretch temperature and length on the class chart.

Record your observations

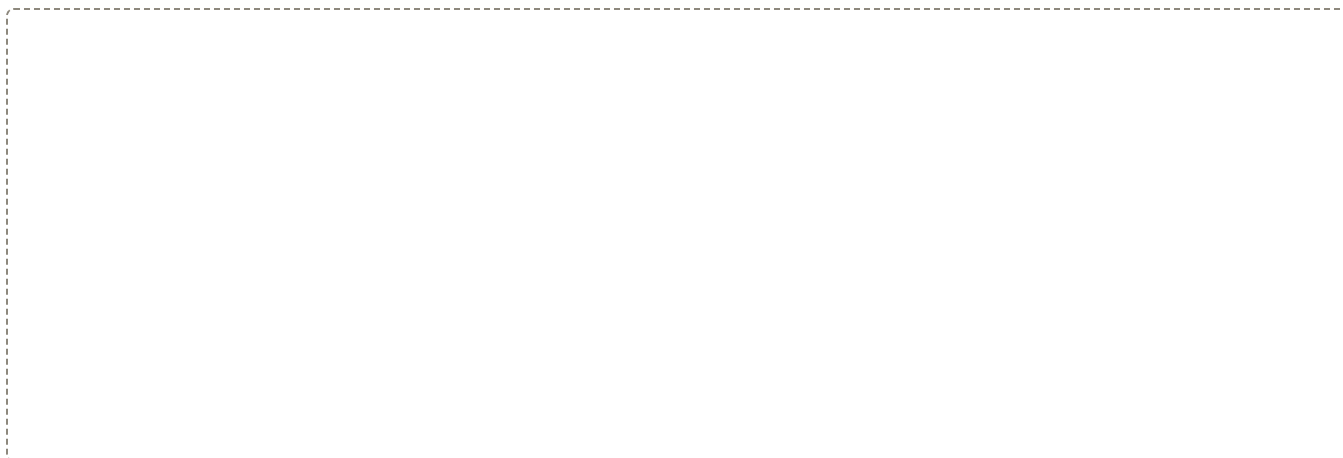
Lab 1 recording sheet: The bath and the melting ice

In this lab the **system** is the ice and its meltwater inside the cup. Everything around it is the **surroundings**. Energy can cross the boundary between them. Your job is to track the temperature of the system and of the bath, and to explain with particles what the energy entering the system is doing.

System map

Part of the model	In our setup
System	
Surroundings	
Boundary energy crosses	
Direction energy flows (from → to)	

1. Prediction: sketch the graph you expect for the cup's temperature over 25 minutes, starting from ice straight out of the freezer. Add a dashed line for the bath. Write one sentence explaining your prediction.



2. Starting readings: mass of ice ____ g; cup temperature at minute 0 ____ °C; bath temperature at minute 0 ____ °C.

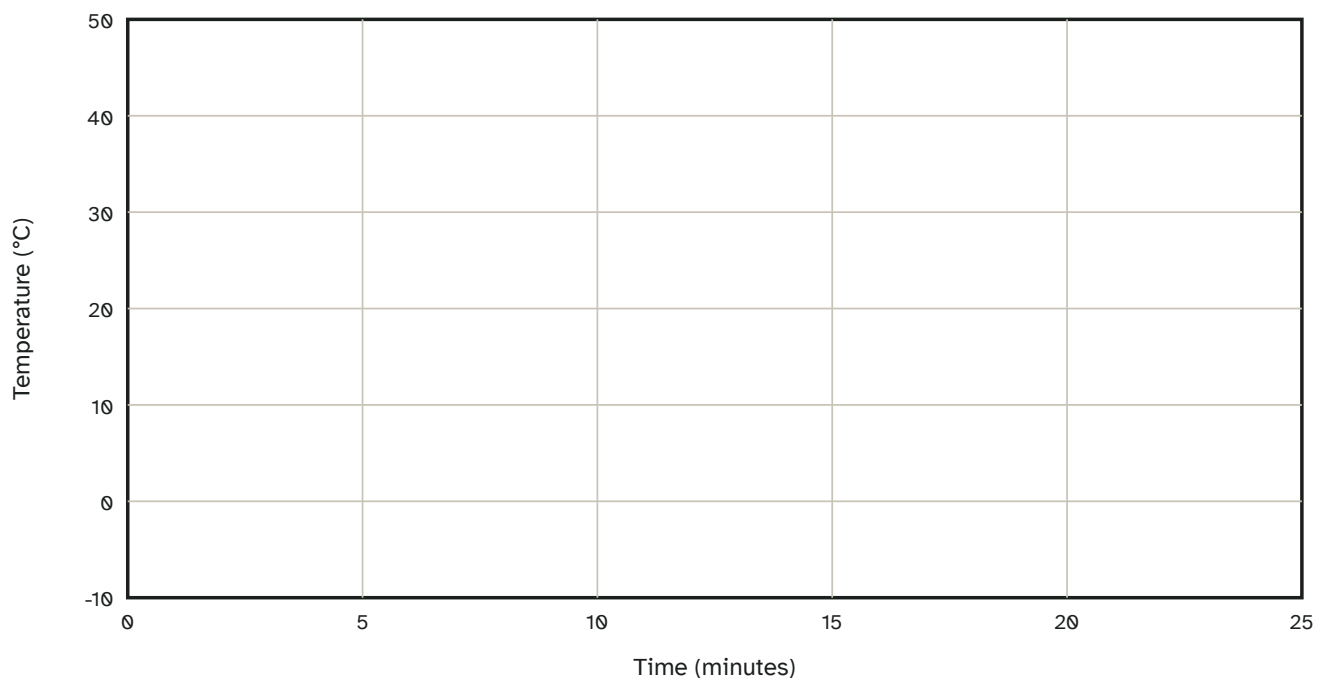
Data table

Time (min)	Cup (°C)	Bath (°C)	What is in the cup
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Time (min)	Cup (°C)	Bath (°C)	What is in the cup
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

3. The last piece of ice disappeared at minute _____. The cup's temperature at that moment was _____ °C.

Temperature of the cup and the bath over time



-  Three-panel particle model of the water in the cup: (a) at minute 0, before the reading reached 0 °C; (b) halfway through the flat stretch; (c) five minutes after the last ice disappeared. Draw particles as dots with short motion lines, and an arrow for energy entering from the bath. Under each panel write one sentence saying what the incoming energy is doing to the particles.

Analysis questions

4. Describe your cup's curve in three stretches. For each stretch give the minutes it covered, what the temperature did, and what was in the cup.

5. During the flat stretch, was energy entering the cup? Use your bath readings as evidence, and explain why energy flows that way.

6. Explain with particles what the energy entering the cup did during the flat stretch, and what it did after the last ice disappeared. Why did the thermometer behave so differently in the two stretches?

7. Another group used 300 g of ice with the same 2 L bath. Which prediction is best?

- ☐ **A.** The flat stretch would sit at a lower temperature, about -5°C , for the same length of time.
- ☐ **B.** The flat stretch would sit at 0°C and last about twice as long, or a little longer.
- ☐ **C.** There would be no flat stretch, because the extra ice keeps the cup too cold to melt.
- ☐ **D.** The flat stretch would sit at 0°C but be shorter, because more ice means more surface for the bath to touch.

8. Compare your flat-stretch temperature with the class chart. If one group's flat stretch read 1°C and another's read -1°C , give two reasons that have to do with the measurement rather than with the science of melting.

9. Predict the opposite experiment: a cup of 20°C water is placed in a -18°C freezer and read every few minutes for two hours. Describe or sketch the curve and explain its flat stretch using energy leaving the water.

10. Suppose the teacher kept heating the meltwater on a stove at sea level. At what temperature would the next flat stretch appear, and what would be happening to the particles during it?

11. Name two ways our setup differs from the idealized heating curve on slide 17, and one thing your particle drawing cannot show about real water.
