

Which Cup Holds More Thermal Energy? The Four-Cup Ice Mystery

Investigation question: Four covered cups of water look identical from the outside. Which one can melt the most ice, which one holds the most thermal energy, and are those the same question?

Evidence-based mystery

Groups of 4

1 session

Setup 7 · Activity 38 · Cleanup 7 min

MS-PS3-4 · supports

MS-PS1-4 · practice

Name _____

Group _____

Date _____

Your role today

- ☐ **Weigher:** Tares the scale, weighs every cup and collection cup, and calls each mass aloud for the recorder.
- ☐ **Thermometer reader:** Reads each cup's temperature through the lid hole after the reading settles, wipes the thermometer between cups, and reads the final liquid temperatures.
- ☐ **Recorder:** Fills the evidence and results tables, subtracts to find each mass, and posts the group's results on the class chart.
- ☐ **Timekeeper and skeptic:** Runs the six-minute timer, checks that all four cups are treated the same way, and asks 'how do we know?' before the group commits to its prediction.

Safety

- Water above about 50 °C can scald. The teacher prepares all warm water, and no cup is warmer than 45 °C. Report a cup that feels hot.
- Spilled water and ice make floors slippery. Keep all pouring over the tray and wipe up at once.
- Keep the scale dry; water can damage it and cause a shock hazard with plug-in models. Use battery scales and set cups on a paper towel on the pan.
- Glass thermometers can break and cut. Do not stir with them; report any break to the teacher.
- Lab water and ice are not for drinking or eating; collection cups and spoons stay in the lab.

Procedure

1. Read the case card: four cups labeled W, X, Y and Z, lids on. Your job is to predict which cup can melt the most ice, using only the evidence you can gather without looking inside. Do not open any lid until step 5.
2. Gather evidence. The weigher weighs each cup with its lid and subtracts the empty mass written on the bottom to find the mass of water. The thermometer reader slides the thermometer through the lid hole, waits until the reading settles, and calls it out. The recorder fills the evidence table.
3. Predict. As a group, rank the cups from most ice melted to least (q1) and write the rule you used (q2). The skeptic checks that every member can explain the ranking. Show the teacher your prediction before

you continue.

4. Prepare the ice. Drain ice from the class cooler in the strainer for about one minute, then weigh four portions of 150 g each into the small bowls. Work quickly so the portions do not sit and melt.
5. Test. Each member takes one cup and one ice portion. On the timekeeper's 'go', everyone removes their lid, tips in the ice and starts stirring gently and steadily with a spoon. Keep stirring for six minutes.
6. At exactly 6:00, everyone pours their cup's liquid into its matching collection cup at the same time, holding the ice back with the spoon. Tip the cup until no more liquid comes out, but do not squeeze or shake the ice.
7. The reader measures the temperature of each collected liquid. The weigher weighs each collection cup and subtracts its empty mass. The recorder finds the ice melted: liquid collected minus starting water.
8. Post your four 'ice melted' values on the class chart, then copy the class results into your table. The teacher reveals what was put in each cup.
9. Empty all ice and water into the sink, dry the cups and spoons, and answer the analysis questions individually.

Record your observations

Lab 2 recording sheet: The four-cup ice mystery

The cups hide different water. You may weigh them and take their temperature, but you may not look inside until the test. Every gram of ice that melts needs energy, and in this lab all of that energy comes from the water in the cup.

Evidence before testing

Cup	Cup + lid + water (g)	Empty cup + lid (g)	Water (g)	Temperature (°C)
W				
X				
Y				
Z				

1. Prediction: rank the cups from the one that will melt the most ice to the one that will melt the least.

2. What rule did you use to make your ranking? If two pieces of evidence pointed in different directions for a pair of cups, say how you decided.

Test results (150 g of ice per cup, 6 minutes)

Cup	Starting water (g)	Liquid collected (g)	Ice melted (g)	Final temperature (°C)
W				
X				
Y				
Z				

Class results: grams of ice melted

Group	W	X	Y	Z
1				
2				
3				
4				
5				
6				
7				
8				
Class middle value (median)				

3. Was your prediction right? Which result surprised your group most, and why?

Analysis questions

4. Make a claim: rank the cups by how much ice they melted, using your results and the class medians as evidence. Did the hottest cup melt the most? Explain why or why not.

5. Cup W's water molecules were more energetic on average than cup Y's. Use particles and energy transfer to explain why cup Y still melted more ice.

6. Cup Z melted almost no ice. Does that mean the water in cup Z had no thermal energy? Explain.

7. Which statement is best supported by the class data?

- ☐ A. The hotter the water, the more ice it melts, whatever the amount.
- ☐ B. The more water, the more ice it melts, whatever the temperature.
- ☐ C. Both the amount of water and how much warmer it is than the ice matter, and water melts ice only while it is warmer than the ice.
- ☐ D. Ice melts only in water that is warmer than room temperature.

8. Every cup that still had ice in it ended close to 0 °C. Explain why the temperature stopped there instead of continuing to fall.

9. Now rank the cups by total thermal energy, not by ice melted. Hint: water at 1 °C is not 'empty' of energy; its molecules still move almost as energetically, on average, as at 45 °C, because the coldest possible temperature is -273 °C. Which two cups trade places between the two rankings, and what does that tell you about the difference between thermal energy and heat?

- 10.** Name two sources of error in measuring 'ice melted', and explain how cup Z's result can help you judge the size of one of them.

- 11.** A team must melt as much ice as possible to fill a cooler with cold water. They can pour on either 1 liter of 25 °C tap water or 100 mL of 60 °C water from a coffee maker. Which should they choose? Explain without calculating energy.
