Where Heat Goes

Plan a test of thermal energy transfer

HS-PS3-4 "Plan and carry out an investigation to provide evidence for the Second Law of Thermodynamics. (SEP: 3; DCI: PS3.B, PS3.D; CCC: Systems)"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the two starting temperatures, circle the material changed between the cup pairs, and number the steps used to collect temperature evidence in time order.

Can Heat Move Backward?

1. For a system left alone, thermal energy tends to spread from warmer regions to cooler regions. Transfer in the reverse direction does not happen on its own. This behavior is one expression of the Second Law of Thermodynamics. A refrigerator can move thermal energy from cold food to warmer room air, but its motor needs electrical energy. To test the law, identify the system and track what changes inside it. A single thermometer reading cannot show a direction of transfer. Two temperature readings taken repeatedly can reveal how each part of a connected system changes over time.

2. Build two pairs of covered cups. Each pair has 100 mL of water at 50°C in one cup and 100 mL at 20°C in the other. Keep the cups separate so water cannot mix. In the test pair, a metal strip touches the water in both cups. In the comparison pair, use a plastic strip of the same shape. Put each pair in its own insulated box, and place a thermometer at the same depth in every cup. Record temperatures at the start and once each minute for ten minutes. Keep room conditions and cup sizes the same.

3. Metal carries thermal energy through the strip more readily than plastic does. The insulated boxes reduce, but do not eliminate, exchange with room air. A drop in only the hot cup's temperature would not reveal where its energy went. Look at the two cups together, compare the two pairs, and repeat the trial to check whether the pattern persists. Even a clear pattern would support the law under these conditions, not prove that every possible process behaves the same way. The useful question is whether the connected system changes in the direction expected without a motor or other external work.

2 ANSWER WITH EVIDENCE

Use the passage

1. Which cup pair should give stronger evidence of transfer through its strip? What temperature change would you look for in each cup?

2. Why is a falling temperature in the hot cup alone not enough evidence that energy reached the cool cup?

3. Suppose both cool cups warm at nearly the same rate. What parts of the setup would you check before concluding that the metal strip caused the warming?

4. In a well-insulated pair with no added work, what changes in the two cups would challenge the expected direction of thermal energy transfer?

3 YOUR TURN

Your own words

Design a different investigation using a sealed jar of warm water and a cool water bath. In 4 to 5 sentences, identify the system, say what you would measure and when, describe a comparison or controlled condition, predict evidence for the Second Law, and name one limitation.

ANSWER KEY

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HIGH SCHOOL · HS-PS3-4

PART 1 · READ AND MARK

Underline the two starting temperatures, circle the material changed between the cup pairs, and number the steps used to collect temperature evidence in time order. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Which cup pair should give stronger evidence of transfer through its strip? What temperature change would you look for in each cup?	**The metal-strip pair. Its hot cup should cool while its cool cup warms.**
2	Why is a falling temperature in the hot cup alone not enough evidence that energy reached the cool cup?	**Some energy could have escaped to room air. A rise in the cool cup's temperature would help show where energy went.**
3	Suppose both cool cups warm at nearly the same rate. What parts of the setup would you check before concluding that the metal strip caused the warming?	**Check that the starting temperatures, water amounts, cup sizes, room conditions, and insulation matched, and that water did not mix.**
4	In a well-insulated pair with no added work, what changes in the two cups would challenge the expected direction of thermal energy transfer?	**The cool cup getting colder while the hot cup gets warmer would challenge the expected hot-to-cold direction.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would place a sealed jar of 45°C water in a covered, insulated container of 20°C water, so the two amounts of water could not mix. I would measure both water temperatures at the start and every minute for ten minutes. For a comparison, I would repeat the trial with the jar held above the bath inside the container, keeping the water amounts and starting temperatures the same. If the submerged jar cooled while the bath warmed more than in the comparison, the result would support transfer from warm to cool water. Energy leaking to the room could still affect the measurements.

Accept predictions that track both parts of the system and distinguish transfer between them from energy lost to the surroundings. An investigation provides evidence consistent with the Second Law, not proof from a single trial.