

Which Way Did the Energy Go? An Evidence Sort for Pack Designers

Learning target: I can work with a group to sort evidence cards by the direction of energy flow, justify each placement with the right kind of evidence, and choose which processes could power a warming pack or a cooling pack.

Collaborative investigation

About 50 min

Small group

MS-PS1-6 · practice

MS-ETS1-2 · practice

collaboration

discussion

data analysis

Name _____

Date _____

Period _____

Directions

Work in groups of three or four. Step 1 (5 minutes): deal the eleven evidence cards out so every member holds two or three; read your cards aloud to the group. Step 2 (15 minutes): as a group, sort every card into one of three piles: energy left the system (exothermic), energy entered the system (endothermic), or no chemical process happened. Every placement needs a reason that names the evidence. Step 3 (15 minutes): complete the decision table and answer the group questions. Step 4 (15 minutes): answer Part C alone. All card data are a teaching scenario invented to be realistic; they were not measured in a lab.

You will need: Eleven cards per group, cut from the card sheet, Group record table, Pencils, Three pile labels per group

Eleven evidence cards (teaching data, room at 21 °C unless stated)

1 Card 1: Calcium chloride in water

8 g of white calcium chloride granules stirred into 50 mL of water in a foam cup. The thermometer in the water rose from 21 °C to 45 °C in 3 minutes. No bubbles. The granules disappeared. The cup was warm for about 20 minutes.

2 Card 2: Citric acid and baking soda in water

10 g of citric acid and 10 g of baking soda stirred into 50 mL of water. Fizzed strongly for about a minute. The thermometer fell from 21 °C to 14 °C in 2 minutes, then slowly climbed back toward 21 °C.

3 Card 3: Hydrogen peroxide and yeast

A spoonful of dry yeast stirred into 50 mL of 3 percent hydrogen peroxide. Thick foam rose up the cup. The thermometer rose from 21 °C to 34 °C in 4 minutes.

4 Card 4: Ammonium chloride in water

15 g of white ammonium chloride crystals stirred into 50 mL of water. No bubbles. The crystals disappeared. The thermometer fell from 21 °C to 9 °C in 2 minutes; droplets formed on the outside of the cup.

5 Card 5: Steel wool after a vinegar rinse

A pad of fine steel wool was dipped in vinegar, squeezed out and placed in a jar with a thermometer, lid loosely on. Over 10 minutes the air in the jar warmed from 21 °C to 27 °C. The wool darkened to red-brown.

6 Card 6: Sugar in water

15 g of table sugar stirred into 50 mL of water. The sugar disappeared. The thermometer read 21 °C before and 20.5 °C after; the half-degree drop was barely readable.

7 Card 7: A snapped light stick

A plastic light stick was bent until the inner glass tube broke and shaken. It glowed bright green for hours. A thermometer taped to it read 21 °C before and 21.5 °C after 10 minutes.

8 Card 8: Baking soda and vinegar

10 g of baking soda added to 50 mL of vinegar. Fizzed over the rim of the cup. The thermometer fell from 21 °C to 17 °C in 1 minute.

9 Card 9: A gel pack from the freezer

A sealed gel pack taken from a freezer. A thermometer pressed to it read –8 °C, rising to 5 °C after 30 minutes on the bench. Nothing was mixed, opened or broken; the gel was the same before and after.

10 Card 10: Magnesium ribbon in a flame (teacher demo)

A 3 cm strip of magnesium held in a burner flame with tongs. It caught and burned with a brilliant white light that students could not look at directly, leaving a white powder. The air half a meter away felt warm for a moment.

11 Card 11: A struck match

A wooden match would not burn until it was scraped on the box. After the scrape, it burned on its own for about 20 seconds with a yellow flame and a wisp of smoke; a thermometer 5 cm above the flame rose from 21 °C to 58 °C.

Part A: Sort (group)

1. Lay out three labeled areas: ENERGY LEFT THE SYSTEM, ENERGY ENTERED THE SYSTEM, NO CHEMICAL PROCESS.
2. For each card, find the evidence that shows the direction: a thermometer in the surroundings going up or down, or light and sound leaving the system. Fizzing, foaming, glowing color and needing a start are not direction evidence by themselves.
3. Place the card and say the reason aloud. If the group disagrees, the card goes face-down until the whole group can state the evidence.
4. Fill in the group record table: card number, pile, and the one piece of evidence that decided it.

Group record (fill in)

Card	Pile	The evidence that decided it
1		

Card	Pile	The evidence that decided it
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

- Group answer: Which card caused the most disagreement, and what evidence finally settled it?

Part B: Decide (group)

A camping-supply company wants one process for a single-use warming pack and one for a single-use cooling pack. Their criteria: (1) the process must move energy in the right direction; (2) it must change the temperature of 50 mL of water by at least 12 °C within 3 minutes; (3) it must be safe to hold against skin inside a sealed plastic pouch, so no flame, no gas that could burst the pouch, and nothing that could burn skin or eyes.

- Group answer: Judge each exothermic card against the three criteria for the warming pack. Write yes or no in each cell and circle the group's choice.

Right direction for a warming pack?	Change ≥ 12 °C in 3 min?	Safe in a sealed pouch?	Choose it?
Card 1			
Card 3			
Card 5			
Card 10			
Card 11			

3. Group answer: Which process did you choose for the cooling pack, and which endothermic card did you reject even though it moved energy the right way? Give the criterion that eliminated it.

Part C: Individual accountability (complete alone)

4. Card 7's thermometer barely moved, yet the card belongs in the energy-left-the-system pile. Explain what evidence shows energy leaving and why a thermometer can miss it.

5. A classmate argues that card 8 is exothermic 'because it fizzed harder than anything else on the table.' Write the reply you would give, naming the evidence that decides.

6. Card 9 made your hand cold just as card 4 did. Explain why card 9 is in a different pile from card 4, and what the words system and surroundings mean for a gel pack.

7. Card 11 needed a scrape to start. Explain why it still belongs in the energy-left pile, using the thermometer reading and the idea of net energy transfer.

8. Write the process on card 1 as an equation with the energy term on the correct side, given that calcium chloride separates into calcium ions (Ca^{2+}) and chloride ions (Cl^-) in water: $\text{CaCl}_2 \rightarrow$ _____

One question per card

For every card ask only this: did a thermometer in the surroundings go up, go down, or barely move, and did light or sound leave? Up or light leaving means energy left the system. Down means energy entered. Barely moved with nothing leaving means little or no net transfer. Then ask a second question only for the barely-moved and the no-mixing cards: did any new substance form? If nothing was mixed, broken or changed, there was no chemical process to classify, even if the object felt hot or cold.

Design the twelfth card

Write a twelfth evidence card that would be hard to sort: a change where the thermometer in the surroundings rises, but the rise comes from something other than a chemical process (for example, a pouch warmed by rubbing, or a cup warmed by a lamp). Then explain what extra observation a group would need, beyond the thermometer, to keep it out of the exothermic pile. Finish with one sentence on why engineers testing a hand warmer sealed it in nitrogen before opening it to the air.