

Four Mystery Packets: Which Way Does the Energy Go?

Investigation question: Four unlabeled packets go into water. Which ones release energy to the surroundings, which absorb it, and which do neither, and what evidence tells you?

Evidence-based mystery

Groups of 4

1 session

Setup 7 · Activity 33 · Cleanup 8 min

MS-PS1-6 · practice

MS-ETS1-2 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Safety captain and mixer:** Checks that everyone's goggles are on, pours the measured water, adds the packet on the timer's signal, and stirs gently with the stick. The only person who touches reagents.
- ☐ **Timer and caller:** Starts the stopwatch the instant the packet goes in and calls out 'read' every 30 seconds for three minutes.
- ☐ **Thermometer reader:** Holds the probe in the middle of the liquid without touching the cup bottom and reads the temperature aloud to one decimal place at each call.
- ☐ **Recorder:** Writes every reading and observation in the table, computes the temperature change, and leads the group's spec-sheet matching.

Safety

- Goggles on from the first packet to the last rinse. Citric acid, calcium chloride and hydrogen peroxide are all eye irritants.
- Only the safety captain touches reagents, and with dry hands. Calcium chloride pellets warm when wet and can irritate skin; if any touches skin, rinse with water for a minute.
- 3% hydrogen peroxide can sting cuts and bleach fabric. Keep it in the cup, on the tray. The yeast foam may overflow the cup; that is why the tray is there.
- Never cap or seal any cup. Stations B and D make gas; a sealed container can burst.
- Nothing is tasted, nothing is sniffed up close, and no cup is held near the face. Hands are washed at the end.
- The amounts are chosen so that no station should pass about 40 °C. If a cup feels hot, set it on the tray and tell the teacher; do not pick it up.
- Disposal: all four solutions are drain-safe in these amounts. Pour them down the sink with running water; cups and sticks go in the trash.
- No flames, no hot plates, no sealed bags. This activity has not been physically tested by the authors; pilot it before class.

Procedure

1. Put on goggles. Set the four labeled cups on the tray. Read the spec sheet on your recording sheet so you know the four fillings you will be trying to identify.
2. The safety captain measures 50 mL of room-temperature water into cups A, B and C. Cup D already holds 30 mL of a clear liquid that is not plain water; do not add water to it.
3. For station A: the thermometer reader places the probe in the water, waits ten seconds, and reads the starting temperature. The recorder writes it in the 0 s row.
4. The timer says 'go'; the safety captain tips packet A into the water and stirs gently twice. The timer calls 'read' every 30 seconds for three minutes while the reader reads and the recorder writes. Everyone also notes what they see and hear: fizzing, foam, color change, pellets disappearing.
5. Rinse and dry the probe. Repeat steps 3 and 4 for station B (add packet B to the water) and station C (add packet C).
6. For station D: read the starting temperature of the liquid in cup D, then add packet D (the yeast) on 'go' and record for three minutes. Expect foam; keep the cup on the tray.
7. Compute the temperature change for each station (final minus starting; a drop is a negative number). Classify each station as exothermic, endothermic or close to neutral and write the evidence.
8. Plot all four stations on the one graph, temperature against time, with a different symbol for each station. Label each line with its letter.
9. Match each station to a spec-sheet filling (1 to 4). Write the evidence for each match. Then answer the analysis questions individually and compare within the group.

Record your observations

Lab 1 recording sheet: Four mystery packets

You are a quality tester at a company that makes warming and cooling packs. Four candidate fillings arrived without labels. Measure what each one does in water, then use your evidence to work out which is which.

Manufacturer's spec sheet: the four candidate fillings — **Filling 1, WarmSalt:** an ionic solid that gives out energy as it dissolves; makes no gas. **Filling 2, FizzCool:** a dry mix of an acid and a carbonate; reacts in water, makes carbon dioxide gas and takes in energy. **Filling 3, Plain:** a common salt that dissolves with almost no energy change. **Filling 4, OxyFoam:** a clear liquid that breaks down into water and oxygen gas when a catalyst is added, giving out energy. One of the four stations uses a liquid instead of water; the packet at that station is the catalyst.

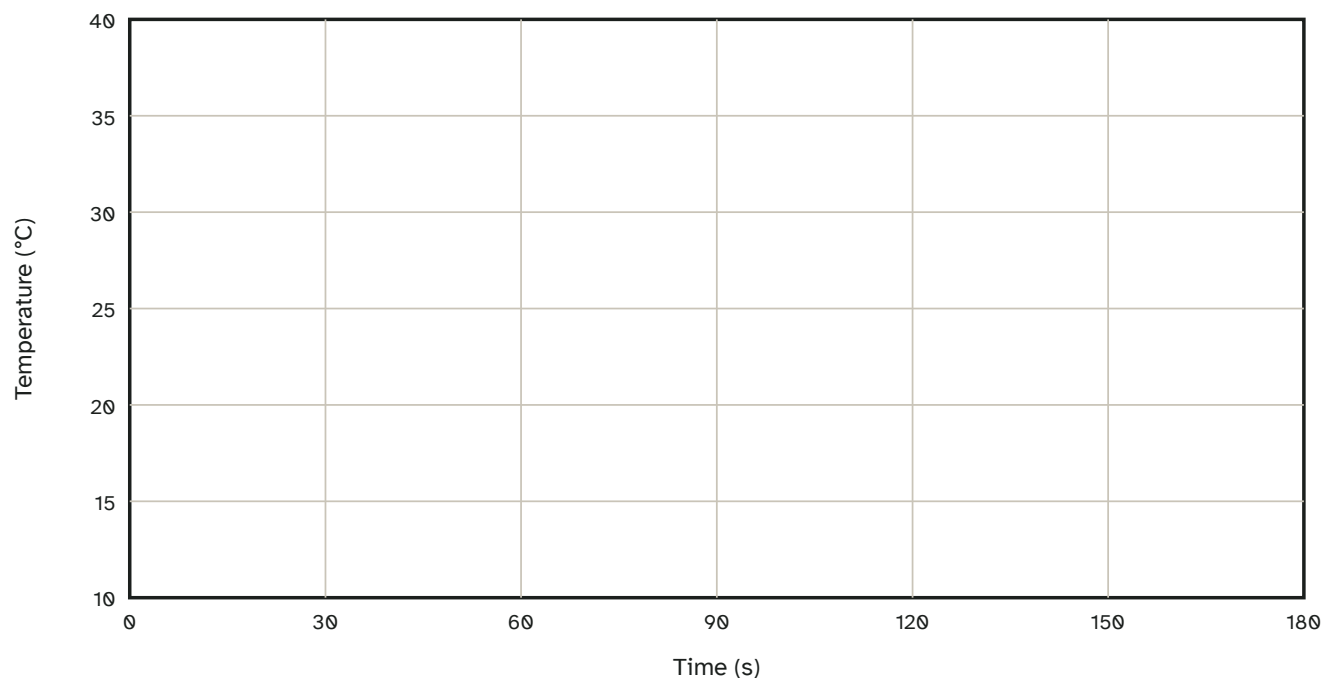
Temperature readings (°C) every 30 seconds

Time (s)	Station A	Station B	Station C	Station D
0 (before packet)				
30				
60				
90				
120				
150				
180				
Change (180 s minus 0 s)				

Observations and classification

Station	What you saw and heard	Exothermic, endothermic or neutral?	Evidence (use a number)	Spec-sheet filling (1-4)
A				
B				
C				
D				

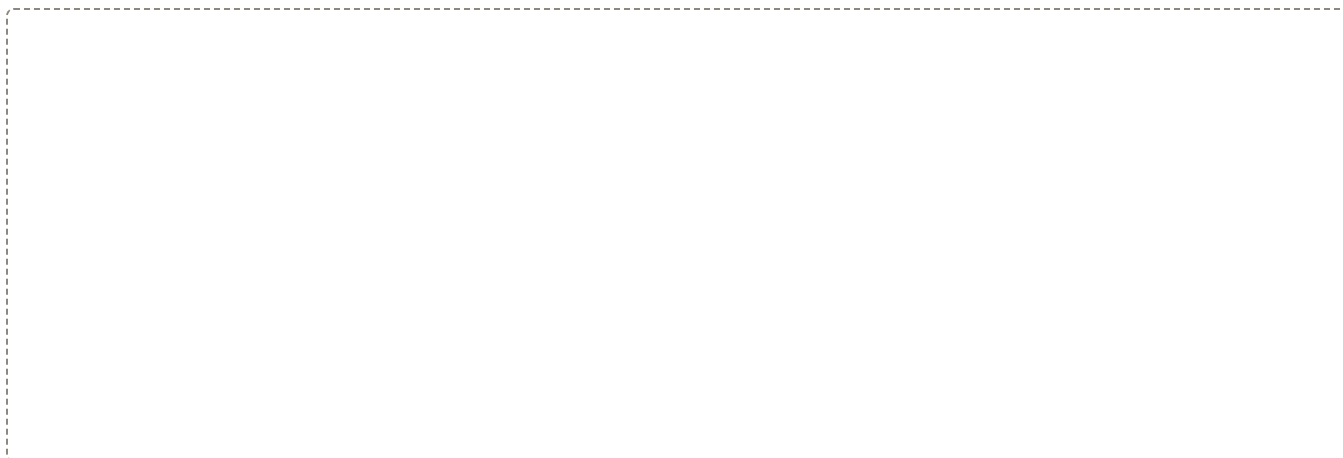
Temperature of each station over three minutes



1. For station A, name the system and name two things in the surroundings. Which of those surroundings did your thermometer actually measure?

2. Two stations fizzed. Did they move the temperature in the same direction? What does that tell you about using fizzing as evidence of energy direction?

-  Draw two boundary diagrams side by side: one for station A and one for station B. In each, draw a dashed boundary around the system, label the system and the surroundings, and draw an arrow showing which way energy crossed the boundary. Label each diagram exothermic or endothermic.



Analysis questions

3. Station A's water went from 22.0 °C to 31.5 °C in 90 seconds and then stopped rising. Calculate the temperature change and the average change per 30-second interval during the rise. Show your work.

4. Explain how you matched station B to its spec-sheet filling. Give two separate pieces of evidence and say which one could not have been replaced by just looking.

5. Station C changed by about one degree or less. Does dissolving always involve an energy change? Use what you know about separating particles and about water surrounding them to explain why the change can be nearly zero.

6. Write a word equation for station B that includes the word 'energy' on the correct side. The reactants are citric acid and baking soda (sodium bicarbonate); the products are sodium citrate, carbon dioxide and water. Then do the same for station D, where hydrogen peroxide becomes water and oxygen. Explain how you decided where to put 'energy' each time.

7. At station B, the cup felt cold to the recorder's hand after two minutes. Describe the direction of thermal energy flow between the hand, the cup, the water and the reacting system. Is anything called 'cold' moving?

8. You must choose one filling for a cooling pack and one for a warming pack to be sold in a camping store. Which do you pick for each, and what is one reason, based on your data or on safety, that you rejected the other exothermic filling for the warming pack?

9. Your group measured each station once. The class table shows station A's change ranged from +7.0 °C to +10.5 °C across groups. Give two reasons the values might differ and explain why pooling the class data makes the classification more trustworthy than one cup alone.
