The Slushy Syrup

Design a fair test of freezing-point change

CHE.5.e "Design and conduct experiments to evaluate the effect of solute concentration on the colligative properties of a solution."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the three concentration levels, circle two conditions held constant, and number two ways the students guard against misleading temperature readings.

Why Did the Syrup Stay Slushy?

1. At a winter market, a vendor notices that fruit syrup stays slushy when a nearby cup of plain water has frozen. Syrup contains dissolved sugar, but that observation alone does not prove sugar caused the difference. The cups might have started at different temperatures or held different amounts of liquid. Freezing point is a colligative property: it depends on the number of dissolved particles in a given amount of solvent. For a dissolved substance such as sucrose, adding more particles per kilogram of water generally lowers the temperature at which freezing begins.

2. A class wants to test that cause-and-effect claim with three batches: pure water, water with 0.5 mole of sucrose per kilogram of water, and water with 1.0 mole of sucrose per kilogram of water. This unit, called molality, describes solute amount relative to solvent mass. Each batch uses the same mass of water, identical containers, and the same starting temperature. Students place the containers together in a cooling bath and use calibrated thermometers. They stir each batch gently and record temperature every 30 seconds. They repeat the trial to see whether a pattern holds.

3. A sample may briefly cool below its usual freezing point before crystals form, a process called supercooling. Students therefore look for a stable temperature as ice begins forming rather than trust the lowest reading on the thermometer. Sucrose solutions may not show a perfectly flat freezing plateau, so they compare temperatures near the first sustained ice formation across trials. They record each trial separately and compare the batches, not just one unusually low reading. If a higher sucrose concentration repeatedly begins freezing at a lower temperature, that pattern supports the predicted effect. It does not show that every dissolved substance has an identical effect at equal mass.

2 ANSWER WITH EVIDENCE

Use the passage

1. Which factor does the class change between batches, and which result will it compare to test the effect?

2. Name two conditions the class keeps the same. Why does keeping them the same strengthen the test?

3. Predict the freezing order of the three batches, from highest freezing temperature to lowest. Explain your prediction.

4. A batch briefly reaches a very low temperature before ice forms. Which temperature evidence should the class compare instead, and why?

3 YOUR TURN

Your own words

Design a new experiment to test how glycerol concentration affects the freezing point of water. State at least three concentrations, what you would keep the same, how you would measure and repeat the test, and what result would support your prediction.

The Slushy Syrup

PART 1 · READ AND MARK

Underline the three concentration levels, circle two conditions held constant, and number two ways the students guard against misleading temperature readings. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Which factor does the class change between batches, and which result will it compare to test the effect?	**The class changes the sucrose concentration and compares the temperatures at which the batches begin to freeze.**
2	Name two conditions the class keeps the same. Why does keeping them the same strengthen the test?	**For example, the water mass and starting temperature stay the same. This helps isolate sucrose concentration as the cause of any freezing-temperature difference.**
3	Predict the freezing order of the three batches, from highest freezing temperature to lowest. Explain your prediction.	**Pure water, then 0.5 mole of sucrose per kilogram of water, then 1.0 mole per kilogram. More dissolved sucrose particles lower the freezing temperature.**
4	A batch briefly reaches a very low temperature before ice forms. Which temperature evidence should the class compare instead, and why?	**Compare temperatures near the first sustained ice formation across trials. The brief low reading may result from supercooling rather than represent the freezing point.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would prepare three batches with 0, 0.4, and 0.8 mole of glycerol per kilogram of water. I would keep the water mass, container size, starting temperature, and cooling bath the same. I would stir gently and record each batch's temperature every 30 seconds as ice begins to form. I would use the temperature near sustained ice formation, not a brief low reading, as the freezing estimate. I would repeat the test twice more and compare the estimates for each concentration. If concentration causes freezing-point depression, the 0.8-mole batch should freeze at the lowest temperature.

Accept other controlled conditions named in the passage, such as identical containers or use of the same cooling bath. For the open task, accept any three clearly stated glycerol concentrations with a fair comparison, repeated measurements, and a prediction that higher concentration lowers the freezing point.