Particles Under Cover

Design and test a model of changing states of matter

CHE.7.2 "Enrichment: Use an engineering design process to develop models (e.g., online simulations or student interactive activities) to explain and predict the behavior of each state of matter using the movement of particles and intermolecular..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Read the passage, then underline two rules about particle motion, circle two statements about attractions, and number the steps the club takes to test and improve its model. Use your marks to track how the model explains and predicts changes.

A Chamber That Keeps Count

1. A science club wants to predict what happens inside a sealed, virtual chamber holding ice, liquid water, and space above them. Its floor can warm the water, while its ceiling can stay cold. The club's design goal is a particle model that predicts three visible changes: ice melting, water slowly vanishing from the surface, and droplets appearing on the ceiling. A good model must explain all three without losing water molecules. The students begin with forty H_2O symbols in the chamber. They may move the symbols and change their speed, but they may not create or erase any.

2. First, the team writes rules for its model. In ice, attractions hold molecules in an ordered pattern; each molecule vibrates but stays near its place. As energy enters, enough molecules break out of that pattern to form liquid water. Liquid molecules remain close and slide past one another. At the surface, some fast-moving liquid molecules escape into the space above, even without boiling. Vapor molecules travel far between collisions, so attractions have less effect on their paths. The water molecules themselves stay intact during every change. At a cold ceiling, vapor molecules lose energy and may gather into liquid droplets.

3. The club tests its first simulation against a real, safely observed covered cup of water. The simulation shows no vapor until the liquid boils, yet droplets form on the cup's cool cover without boiling. That mismatch exposes a missing rule: surface molecules can escape at lower temperatures. The team adds that rule and runs two new tests. Raising the simulated floor temperature should make surface escape faster. Lowering the ceiling temperature should make arriving vapor more likely to form droplets. If either prediction fails in a real observation, the students must revise a rule, not invent extra molecules.

2 ANSWER WITH EVIDENCE

Use the passage

1. Your first model shows ice changing to liquid by replacing each ice molecule with a smaller molecule. How must you change it to meet the club's design goal?

2. A model shows liquid particles fixed in place after the ice melts. What motion and attraction rule should replace that rule?

3. The first simulation predicts no droplets because the water never boils. Which missing particle process explains why that prediction fails?

4. If the simulated ceiling becomes colder while the floor stays the same, what should the model predict for vapor molecules that reach the ceiling, and why?

3 YOUR TURN

Your own words

Design three particle-model panels for ethanol as a solid, a liquid, and a gas: use eight molecule dots in each panel, label their motion and the relative influence of attractions, and add heating arrows between panels. Below the panels, predict what cooling the gas will do, then state one model change you would test if condensation happened sooner than your model predicted.

ANSWER KEY

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HIGH SCHOOL · CHE.7.2

PART 1 · READ AND MARK

Read the passage, then underline two rules about particle motion, circle two statements about attractions, and number the steps the club takes to test and improve its model. Use your marks to track how the model explains and predicts changes. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Your first model shows ice changing to liquid by replacing each ice molecule with a smaller molecule. How must you change it to meet the club's design goal?	**Keep the same number of intact H_2O molecules. Change their arrangement and motion so they can slide past one another.**
2	A model shows liquid particles fixed in place after the ice melts. What motion and attraction rule should replace that rule?	**Liquid molecules slide past one another while attractions keep them close.**
3	The first simulation predicts no droplets because the water never boils. Which missing particle process explains why that prediction fails?	**Fast-moving molecules can escape from the liquid surface without boiling. They can later lose energy at the cool cover and condense.**
4	If the simulated ceiling becomes colder while the floor stays the same, what should the model predict for vapor molecules that reach the ceiling, and why?	**More arriving vapor molecules should lose energy and form liquid droplets.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Solid panel: 8 closely grouped dots with short vibration arrows; attractions dominate. A heating arrow points to the liquid panel. Liquid panel: 8 nearby dots with sliding arrows; attractions still matter. A heating arrow points to the gas panel. Gas panel: 8 widely spaced dots with long travel arrows; motion dominates. Cooling slows the gas molecules, allowing attractions to bring them together as liquid. If condensation happened sooner than predicted, I would increase the model's attraction setting and test it again.

Accept models that keep eight intact ethanol molecules in every panel and distinguish vibration, sliding, and gas travel. For the revision, accept any specific rule change that could make the model predict earlier condensation and could be tested.