

Fixing Theo's Kitchen Notes: Eight Claims About Particles and States

Learning target: I can find and correct mistakes in someone else's explanation of melting and boiling, and explain what particles really do, and do not do, when a substance changes state.

Error analysis

About 40 min

Individual

MS-PS1-4 · practice

writing

independent practice

Name _____

Date _____

Period _____

Directions

Theo watched ice melt in a glass of lemonade and a kettle of water boil on the stove, and he wrote eight statements in his notebook. He also drew a particle picture. Some statements are correct and some contain a common mistake. In Part A, decide which are correct and name the idea that went wrong in a few words. In Part B, explain and rewrite. In Part C, find the one confusion behind several of Theo's mistakes.

You will need: This worksheet, Pencil

Facts Theo could have checked — Air pressure at sea level is about 101 kPa. Mammoth Lakes, in the eastern Sierra Nevada, is about 2,400 m above sea level, where the air pressure is about 75 kPa. Water's boiling point is 100 °C at 101 kPa, about 93.5 °C at 80 kPa, about 92 °C at 75 kPa and about 86 °C at 60 kPa. Water vapor is an invisible gas.

Theo's notebook page

1. The ice cubes in my lemonade looked completely still, so the water particles inside them were not moving at all.
2. As the ice melted, its particles got soft and squishy, and that is why the ice turned runny.
3. The melted water spread out to fill the bottom of the glass because its particles stay close together but can slide past one another.
4. When the kettle boiled, the water particles expanded into bigger steam particles. That is why steam takes up so much more space than water.
5. The big bubbles rising in the boiling water were bubbles of air.
6. The white cloud puffing out of the kettle's spout was water vapor.
7. I left the burner on after the water started boiling, so the water kept getting hotter: 100 °C, then 110 °C, then 120 °C.
8. Water always boils at 100 °C, so my aunt's kettle at her house in Mammoth Lakes boils at 100 °C too.

Theo's drawing. Theo drew three boxes. Box 1, labeled 'ice', shows twelve small circles in neat rows with no motion marks. Box 2, labeled 'water', shows twelve medium circles in a loose pile at the bottom, with short arrows. Box 3, labeled 'steam', shows six large circles, each about twice as wide as the circles in Box 1, spread far apart, with long arrows.

Part A: Diagnose

1. Complete the table for all eight statements. If a statement is only partly right, mark it incorrect and name only the part that is wrong.

Statement	Correct or incorrect?	The idea that went wrong (a few words)
1		
2		
3		
4		
5		
6		
7		
8		

Part B: Explain and rewrite

2. Statements 1 and 2: Explain what the particles in an ice cube are really doing, and what actually changes about them when the ice melts. Then rewrite Statement 2 so it is correct.

3. Statement 4: Explain why steam takes up so much more space than liquid water, and rewrite the statement correctly.

4. Statements 5 and 6: What is inside the big bubbles? What is the white cloud made of? Where is the real water vapor? Rewrite both statements.

5. Statement 7: The burner really was adding energy the whole time. Where did that energy go once the water was boiling? Rewrite the statement.

6. Statement 8: Use the facts box to rewrite this statement with the right temperature. Then explain in one sentence why lower air pressure lets water boil at a lower temperature.

7. Redraw Theo's three boxes correctly. Keep twelve particles in the ice and water boxes. Label each box with its state and add a one-line description of the motion.

8. Name the two mistakes in Theo's original drawing and explain why each one matters for the model.

Part C: The rule behind the mistakes

9. Statements 2 and 4 and Theo's drawing all make the same kind of mistake. Name it. Then write a two-sentence rule Theo could tape inside his notebook that would stop him from making it again, and test your rule on one new example of your own (for example, a puddle drying or butter melting in a pan).

Three questions for every statement

For each statement ask: (1) Is it about the particles or about the whole sample? (2) Does it say the particles themselves change (size, softness, temperature) when really only their spacing and motion change? (3) Does it give a number? If so, check it against the facts box. A statement that passes all three checks is probably correct.

The invisible gap at the spout

If you look closely at a boiling kettle, there is a short clear gap between the spout and the start of the white cloud. Explain what is in that gap and why the cloud appears only a few centimeters away. Then use the same idea to explain why you can 'see your breath' on a cold morning but not on a warm afternoon. Use the words *water vapor*, *condense* and *droplets*.