NO PREP

Snowflakes and States of Matter

The Physics of Freezing, Melting, and Vapor

Includes: Student reading, case study, differentiated questions, teacher key

Name: Period: Date:

Snowflakes and States of Matter: The Physics of Freezing, Melting, and Vapor

Water and the Three Common States of Matter

When you think about winter, you're really thinking about water changing between different states of matter. The same H_2O can be a fluffy snowflake, a puddle on the sidewalk, or invisible water vapor in the air. In basic physical science, we talk about three main states: solid, liquid, and gas. In a solid, particles are tightly packed and mainly vibrate in place. In a liquid, particles are still close together but can slide past one

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Phase Changes, Latent Heat, and Energy That Hides

Changing state is called a phase change. When ice melts into liquid water, or water evaporates into vapor, energy must be absorbed from the surroundings. When water freezes or condenses, energy is released back into the environment. This "hidden" energy is called latent heat. It doesn't show up as a temperature change during the

phase change itself, but it's absolutely there in the energy budget. Think about heating a pot of ice on the stove. As you warm it from well below 0 °C up to 0 °C, the temperature of the ice rises. Once it hits the freezing point, something interesting happens: the temperature pauses at 0 °C while the ice melts. All the energy from the stove is going into breaking the bonds that hold the solid crystal together, not into raising the temperature. Only after all the ice has melted does the temperature of the liquid water start to climb again. The same "temperature pause" happens at 100 °C while water boils into steam. You can summarize some of the key phase changes like this: Even when the thermometer doesn't move much, these phase changes quietly move large amounts of energy around. That's one reason winter weather and climate models pay so much attention to ice, snow, and clouds: they're constantly trading latent heat with the air.

Building Snowflakes: Crystals, Temperature, and Humidity

Snowflakes aren't just frozen raindrops; they're tiny ice crystals that grow directly from water vapor in the air. High in a cold cloud, water vapor molecules attach to microscopic dust or salt particles and arrange themselves into a hexagonal (six-sided) structure. As the flake grows and falls, it passes through layers of air with different temperatures and humidities, which shape its final form. Under certain conditions, snow crystals grow into classic dendrites—the lacy, branching shapes you see in drawings. In other conditions, they may form plates, needles, or columns. When the air is just below freezing and fairly moist, snow tends to be wet and sticky, perfect for snowballs. When it's much colder and drier, snow is often powdery, and flakes don't cling together as easily. Ski resorts love that light "powder snow" for certain types of skiing, while kids building snowmen want snow closer to the melting point. You can see state changes within the snowpack itself. If the top layer warms and partially melts during the day, then refreezes at night, it can form a crunchy crust. Deeper layers may stay colder, keeping loose, fluffy crystals. These layers affect avalanche risk on mountains and how easy it is to walk or drive on snowy surfaces. The winter world under your boots is constantly shifting between solid ice, liquid water, and water vapor.

Key Information

Phase Change	Direction (Initial → Final)	Energy Flow	Example
Melting	Solid → Liquid	Absorbs energy (latent heat of fusion)	Ice cube turning into water in a warm room
Freezing	Liquid → Solid	Releases energy	Puddle turning to ice overnight
Evaporation	Liquid → Gas	Absorbs energy (latent heat of vaporization)	Wet gloves drying near a radiator
Condensation	Gas → Liquid	Releases energy	Fogging on a cold window
Sublimation	Solid → Gas	Absorbs energy	Snow shrinking on a cold, sunny day

Case Study Excerpt – Sunny Day, Slippery Night

On a cold January afternoon, Ms. Alvarez's class noticed that the school sidewalks were wet and slushy, even though the air temperature stayed just below freezing. The Sun felt surprisingly strong, and dark pavement soaked up its energy. Snow along the edges began to melt, sending thin streams of water across the concrete. By the time students went home, most of the snow seemed to be gone from the walkway. The next morning told a different story. Temperatures had dropped overnight, and the same stretch of sidewalk was now coated in a thin, nearly invisible layer of black ice. That ice formed when liquid water from the melted snow lost energy to the cold air and surface, releasing latent heat as it froze. The class measured the surface temperature of a sunny patch and a shaded patch and found that the shaded area stayed below freezing all day, so ice lingered there even after the sunny patch dried. They realized that a "warm-looking" afternoon can secretly set the stage for a dangerous freezing event once the Sun goes down.

1. How did the Sun's energy and the dark pavement work together to melt snow even when air temperatures were near or slightly below freezing?

2. Why did the same melted water become a safety hazard the next morning, and how does latent heat help explain this change?

Multiple Choice

1. During the melting of ice at 0 °C, the added energy from the surroundings mainly:

    a) Breaks the solid structure so ice can change to liquid without changing temperature at first

    b) Raises the temperature of the ice above 0 °C immediately

    c) Increases the mass of the ice without changing its state of matter

    d) Turns ice directly into water vapor without passing through the liquid phase, as dry ice does

2. Latent heat is best described as energy that:

    a) Makes objects glow when they reach a certain temperature

    b) Is stored or released during a phase change without changing temperature right away

    c) Only exists in gases, not in solids or liquids

    d) Raises the temperature of a substance without changing its state or its volume at all

3. Sublimation occurs when:

    a) Water vapor turns directly into liquid droplets when it touches a cold window surface

    b) Liquid water boils vigorously at 25 °C

    c) Liquid water turns into ice as it cools at 0 °C

    d) Solid water (ice or snow) changes directly into water vapor without becoming liquid

Matching

Write the letter of the correct definition on the line next to each term.

Term	Definition
1. ___ Solid	A) Gas changing to liquid on a cool surface
2. ___ Latent heat	B) State of matter with particles tightly packed and mainly vibrating
3. ___ Sublimation	C) Temperature at which a liquid becomes a solid under normal conditions
4. ___ Freezing point	D) Energy absorbed or released during a phase change without temperature change
5. ___ Condensation	E) Direct change from solid to gas without becoming liquid

Fill-in-the-Blank

1. The energy involved in a phase change that does not show up as an immediate temperature change is called latent _____.

2. When snow on the ground slowly disappears on a very cold, sunny day without forming puddles, it is likely undergoing _____, changing directly from solid to gas.

3. The temperature at which liquid water turns into solid ice under normal conditions is known as the freezing _____.

Short Answer

Answer each question in 2-4 complete sentences.

1. Using ideas from the reading, explain how a sunny winter afternoon can still lead to icy sidewalks the next morning, even if the air never got very warm.

2. Describe one way latent heat is involved when snow melts during the day and another way it is involved when that water refreezes at night.

3. Think about two different types of snow: dry, powdery snow and wet, sticky snow. Using the concepts of temperature and states of matter, explain why these two types behave differently when you try to pack them into a snowball.