Edgenuity

Warm-Up | Changes of State

Lesson Question

What is the relationship between heat and changes of state?

Lesson Goals

Explore the relationship between heat and changes of state.

- **Identify and describe** the six changes of state.
- **Explain and interpret** heating curves.
- **Solve** problems involving latent heat of fusion and latent heat of vaporization.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

deposition	the process by which a gas changes directly to a solid
vaporization	a process by which a liquid changes to a gas
condensation	the process by which a gas changes to a liquid
sublimation	the process by which a solid changes directly to a gas
latent heat of vaporization	the amount of energy involved in changing a liquid to a gas or a gas to a liquid
latent heat	the energy a substance absorbs or releases during a change of state

Warm-Up | Changes of State

Words to Know

heating curve	a graph that shows how temperature changes as heat is applied to a substance
latent heat of fusion	the amount of energy involved in changing a solid to a liquid or a liquid to a solid
interpret	to explain what an image, a diagram, a graph, a chart, a picture, or data represents

States of Matter

- There are four state of matter.
  - Solid: mountains
  - Liquid: sea water
  - Gas: air
  - Plasma: Northern Lights

Properties of States of Matter

	Solid	Liquid	Gas
Particle Motion	Atoms vibrate or wiggle, but are locked in place.	Atoms have some freedom to move.	Atoms move freely.
Shape	Rigid shape	Takes shape of container	No definite shape
Compression	Hard to compress	Hard to compress	Easy to compress

Instruction | Changes of State

Slide 2

Changes of State between Solids and Liquids: Melting and Freezing

Melting and freezing are changes of state that occur between [solids] and liquids.

- Melting is the process by which a solid changes to a [liquid].
- [Freezing] is the process by which a liquid changes to a solid.

Changes of State between Liquids and Gases: Vaporization and Condensation

Vaporization and **condensation** are changes of state that occur between [liquids] and gases.

- [Vaporization] is a process by which a liquid changes to a gas.
- Condensation is the process by which a [gas] changes to a liquid.

Slide 4

Changes of State between Solids and Gases: Sublimation and Deposition

Sublimation and **deposition** are changes of state that occur between solids and gases.

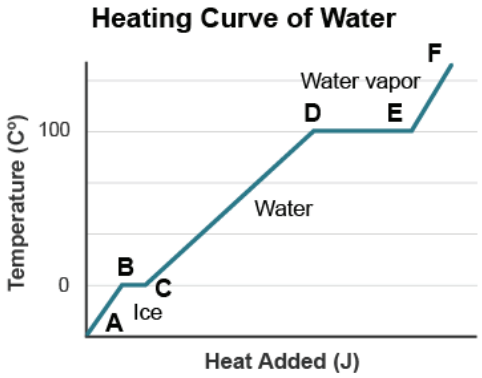
- Sublimation is the process by which a solid changes [directly] to a gas.
- Deposition is the process by which a gas changes directly to a [solid].

Instruction | Changes of State

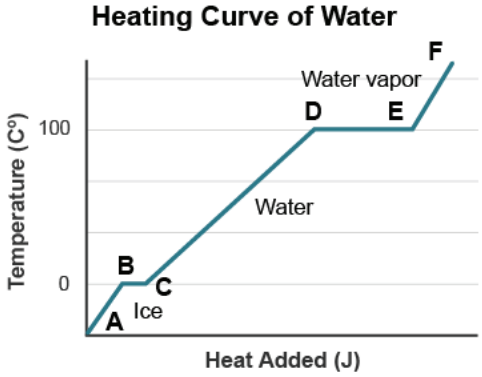
Slide 7

Heating Curves

- **Heating curves** are graphs that show what happens to a substance as it absorbs [heat].
- Features of heating curves:
  - [Temperature] changes
  - Heat changes



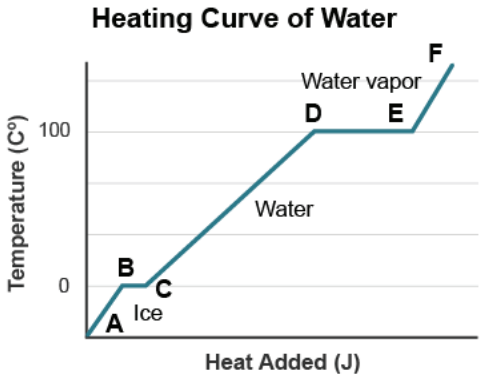
- Heating curves show changes of state.
  - The flat part of the curve is where the change of [state] occurs.
    - Heat is released or absorbed by the substance, but the temperature does not change.
- The energy a substance absorbs or releases during a change of state is called [latent heat].



Slide 9

Analysis of the Heating Curve of Water: Absorption of Heat

- A–B: The temperature of ice increases.
- B–C: Ice is melting and the temperature remains constant at [0°C] (ice and water).
- C: All ice has melted.
- C–D: The temperature of water [increases].
- D–E: Water is undergoing vaporization and the temperature remains constant at [100°C] (water and water vapor).
- E: All liquid has vaporized.
- E–F: The temperature of [water vapor] increases.

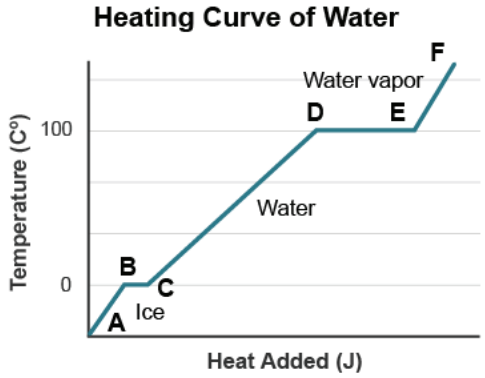


Instruction | Changes of State

Slide 11

Analysis of the Heating Curve of Water: Release of Heat

- F–E: The temperature of water vapor [decreases].
- E–D: Water vapor is condensing and the [temperature] remains constant at 100°C (water vapor and water).



- D: All water vapor has condensed.
- D–C: The temperature of [water] decreases.
- C–B: Water is freezing and the temperature remains constant at 0°C (water and ice).
- B: All water has frozen.
- B–A: The temperature of [ice] decreases.

Slide 14

Latent Heat of Fusion

- **Latent heat of fusion** is the amount of [energy] involved in changing a solid to a liquid or a liquid to a solid.

$$S \leftrightarrow L$$

Substance	Latent Heat of Fusion (J/g)
Mercury	11.8
Copper	205
Gold	66.6
Water	333.7

Instruction | Changes of State

Slide 14

Latent Heat of Fusion Equation

- Variables:
  - Q = amount of heat [absorbed] or released by the substance
  - m = mass of the substance
  - L_f = [latent] heat of fusion of the substance

$$Q = \pm mL_f$$

Latent Heat of Fusion Example

How much heat is needed to melt 25.50 grams of ice at 0°C? The latent heat of fusion of water is 333.7 J/g.

- Given information:
  - $m = 25.50\ \text{g}$
  - $L_f = 333.7\ \text{J/g}$
- Unknown: Q
- Formula to be used: $Q = \pm mL_f$

$$Q = mL_f$$
$$Q = (25.50\ \text{g})(333.7\ \text{J/g})$$
$$Q = \boxed{8{,}509\ \text{J}}$$

Slide 16

Latent Heat of Vaporization

- **Latent heat of vaporization** is the amount of energy involved in changing a [liquid] to a gas or a gas to a liquid.

Substance	Latent Heat of Vaporization (J/g)
Helium	21
Ethyl alcohol	854
Nitrogen	199
Water	2,259

Instruction | Changes of State

Slide 16

Latent Heat of Vaporization Equation

- Variables:
  - Q = amount of heat absorbed or released by the substance
  - m = mass of the substance
  - L_v = latent heat of vaporization of the substance

$$Q = \pm mL_v$$

Latent Heat of Vaporization Example

How much heat is needed to vaporize 12.75 grams of water at 100.0°C? The latent heat of vaporization of water is 2,259 J/g.

- Given information:
  - $m = 12.75\ \text{g}$
  - $L_v = 2{,}259\ \text{J/g}$
- Unknown: Q
- Formula to be used: $Q = \pm mL_v$

$$Q = mL_v$$
$$Q = (12.75\ \text{g})(2{,}259\ \text{J/g})$$
$$Q = 28{,}800\ \text{J}$$

Summary | Changes of State

Lesson Question

What is the relationship between heat and changes of state?

Answer

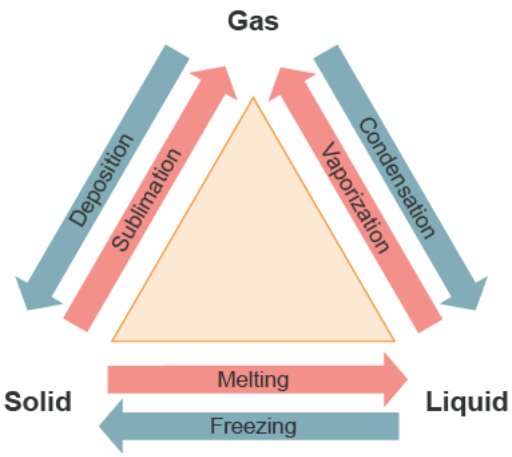
(Sample answer) When substances undergo melting, vaporization, or sublimation, the substances absorb heat. When substances undergo freezing, condensation, or deposition, the substances release heat.

Slide 2

Review: Key Concepts

When energy is [absorbed]:

- a solid can change into a liquid through melting.
- a liquid can change into a gas through vaporization.
- a solid can change directly into a gas through [sublimation].



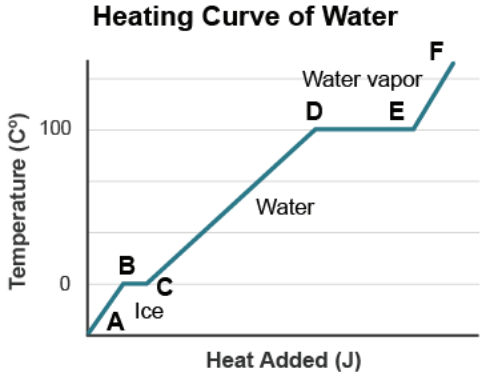
When energy is [released]:

- a gas can change into a liquid through condensation.
- a liquid can change into a solid through [freezing].
- a gas can change directly to a solid through deposition.

Summary | Changes of State

Slide 2

- Heating curves are graphs that show what happens when heat is added to a substance.



- Latent heat of fusion is the amount of energy involved in changing a solid to a liquid or a liquid to a solid without a change in temperature.

$$Q = \pm mL_f$$

- Latent heat of vaporization is the amount of energy involved in changing a liquid to a gas or a gas to a liquid without a change in temperature.

$$Q = \pm mL_v$$

Summary | Changes of State

Use this space to write any questions or thoughts about this lesson.