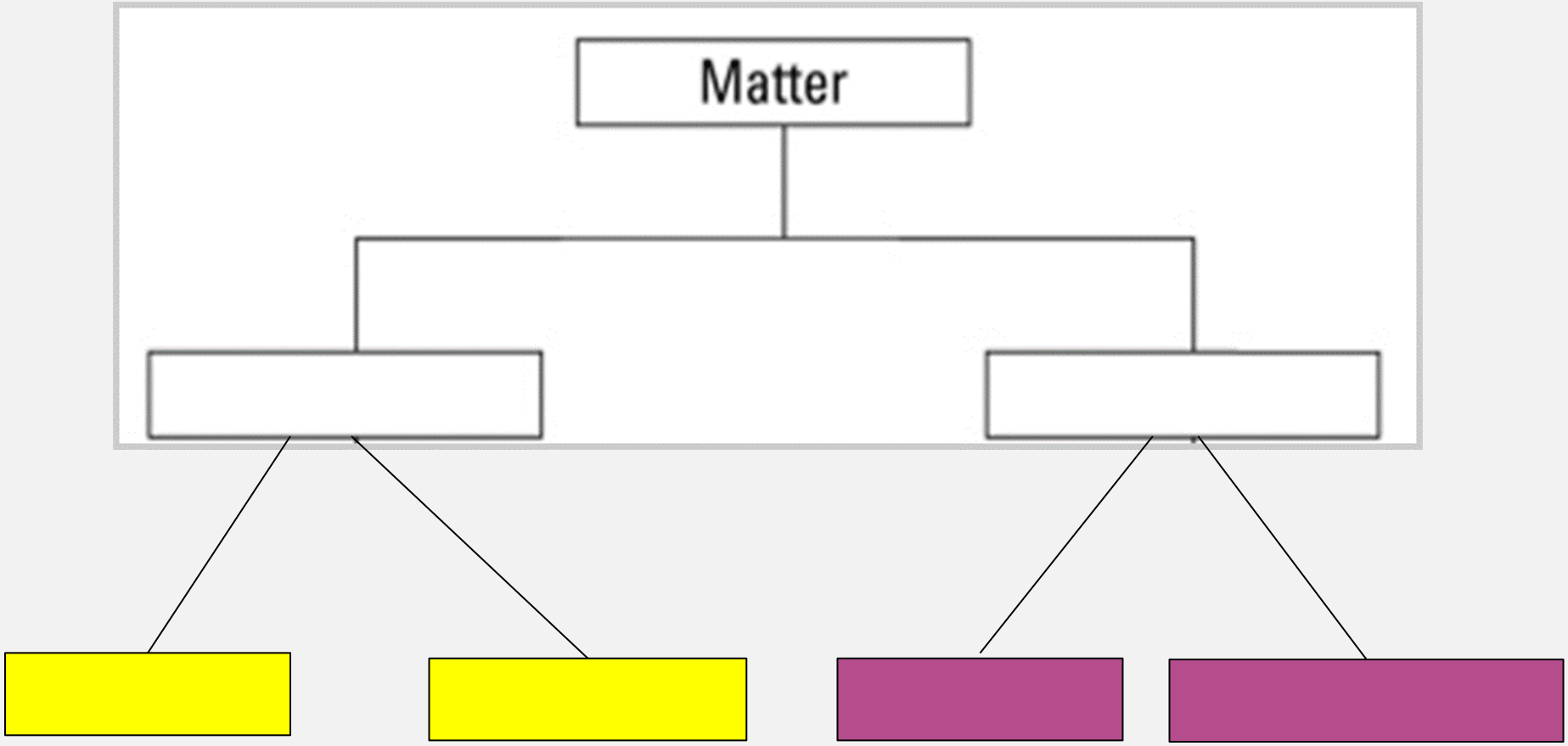
States of Matter

Chapter 2.3 & 3.1, 3.3

What distinguishes all types of matter?

WARM-UP

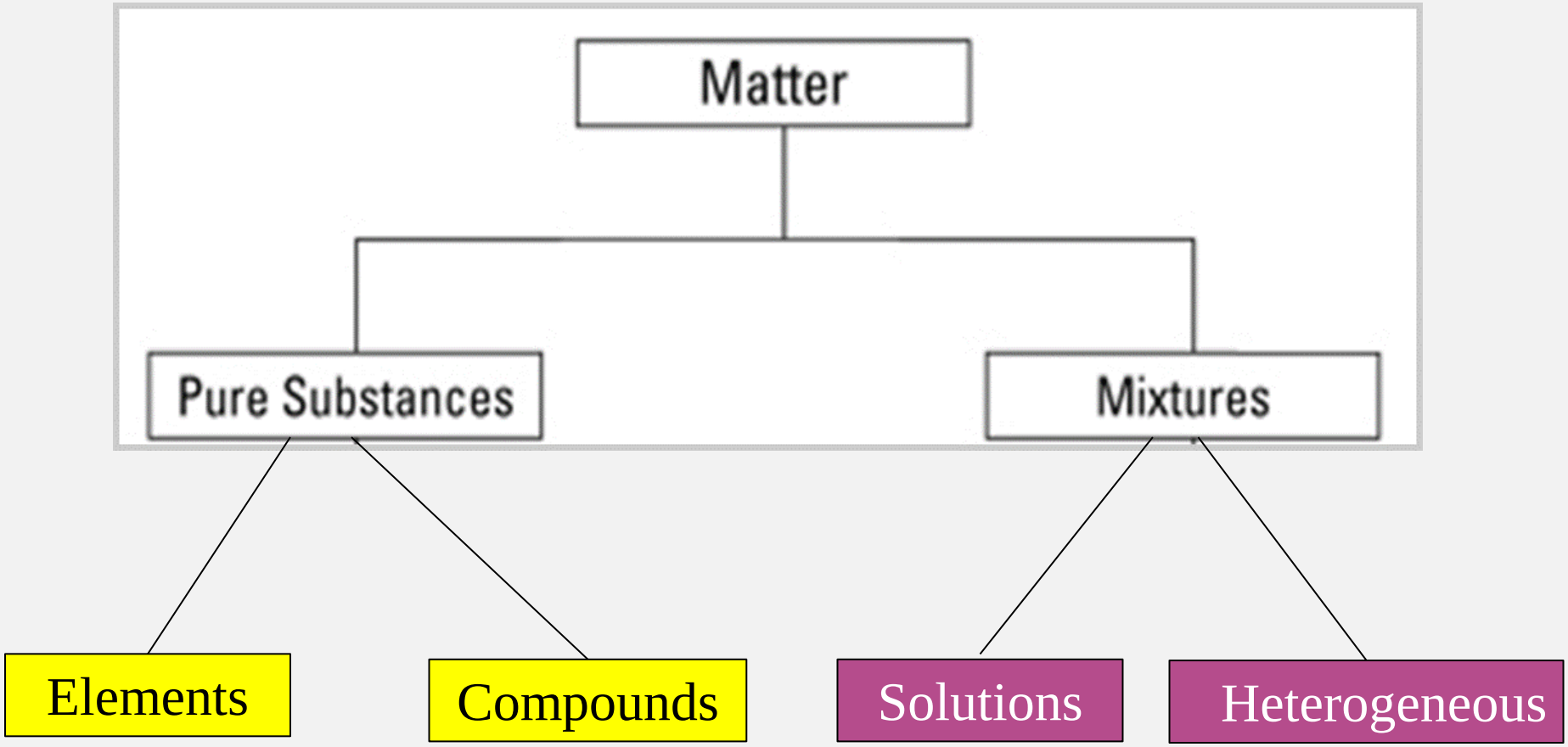
Fill in the chart:



What distinguishes all types of matter?

WARM-UP

Whether they can be separated physically or not (pure vs. mixture)



What is an extensive physical property? Give examples.

What is an intensive physical property? Give examples.

Name 3 ways to separate a heterogeneous mixture.

Name 3 ways to separate a homogeneous mixture.

What one aspect best distinguishes solutions, suspensions, and colloids?

What is an extensive physical property? Give examples.

Amounts (mass, volume, weight)

WARM-UP

What is an intensive physical property? Give examples.

Identifies (melting/boiling point, solubility, etc.)

Name 3 ways to separate a heterogeneous mixture.

Filtration, magnetism, centrifugation

Name 3 ways to separate a homogeneous mixture.

Distillation, crystallization, chromatography

What one aspect best distinguishes solutions, suspensions, and colloids?

Particle Size

States of Matter

Focus Questions

- When can chemical versus physical properties be observed?
- What observations indicate that a chemical change has taken place?
- What are the states of matter and how can shape and volume be used to classify them?
- How can kinetic theory and forces of attraction be used to explain the behavior of gases, liquids, and solids?
- What are the six common phase changes?
- What happens to a substance's temperature and a system's energy (heat) during a phase change?
- Describe the arrangement of molecules and how they change from solid to liquid to gas.
- How are evaporation and boiling different? The same?

Physical Changes

Physical changes involve a change in outward appearance and arrangement, but NOT in chemical identity. NO new substance is produced by the change.

Physical changes can be reversible (*putting a puzzle together*) or irreversible (*breaking a glass*).

Physical changes often involve a reversible change from one state to another:

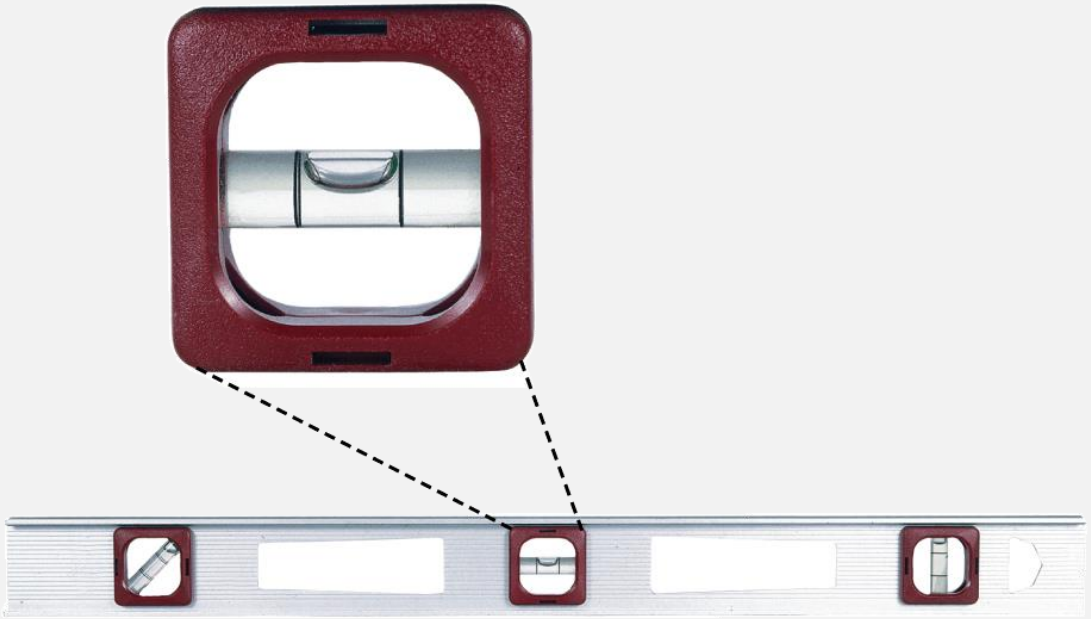
Solid ↔ Liquid ↔ Gas

Mass of Ice Before and After Melting (0:41)

https://screencast-o-matic.com/watch/cYfv3eBO4H

Phase changes are physical changes.

Carpenters use a level to find out if a surface is perfectly horizontal. When a carpenter places the level on a surface that is perfectly horizontal, the air bubble stays in the middle of the horizontal tube. The metal, alcohol, and air in the level represent three states of matter.



States of Matter

Solids

a. *Definite shape*

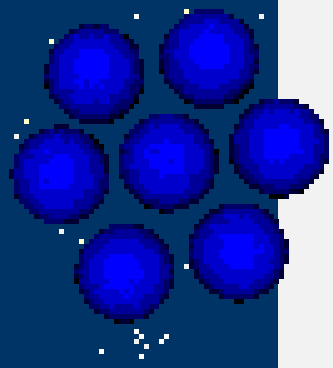
b. *Definite volume*

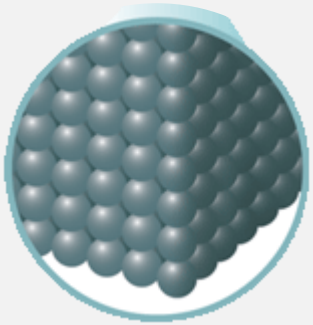
c. *Tightly packed molecules*

d. *Greater density than liquids or gases*

e. *Usually least compressible of phases*

f. *Molecules move slowest of all the phases*





Liquids

a. *NO definite shape*
b. *Definite volume*
c. *Less tightly packed molecules that take the shape of the container*
d. *Lesser density than solids, but greater than gases (usually d ∞ 1/T)*
e. *Relatively non-compressible except for extreme temperatures and pressures*
f. *Molecules move slower than gases, faster than solids*

States of Matter

Gases

a. *NO definite shape*

b. *NO definite volume*

c. *Take the SHAPE and VOLUME of the container*

d. *Least density of all phases*

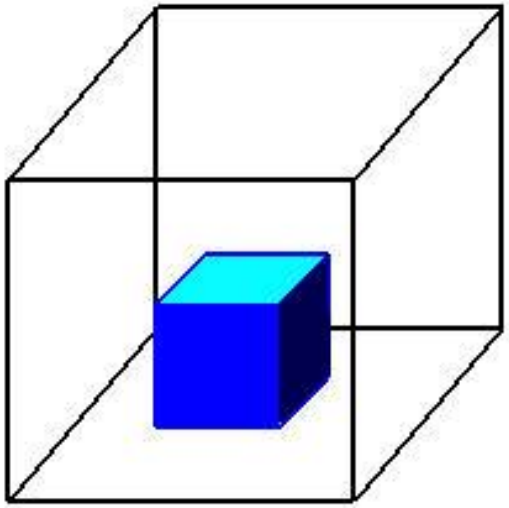
e. *Compressible*

f. *Molecules move fastest of all the phases*

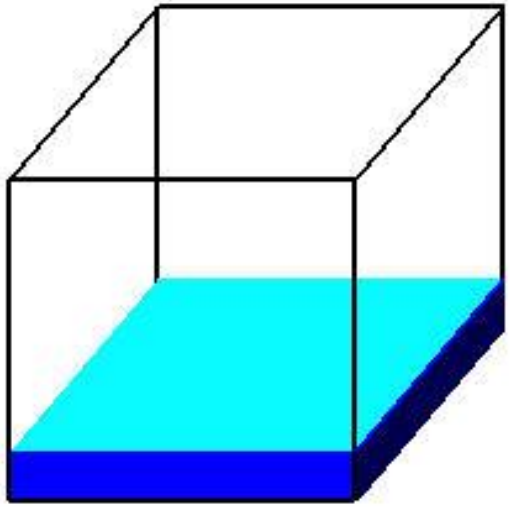
g. *Must consider variables of pressure and temperature*

TRY IT

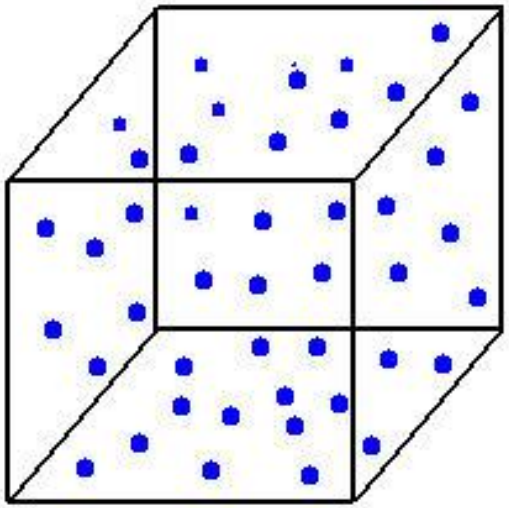
States of Matter



Identify each state of matter



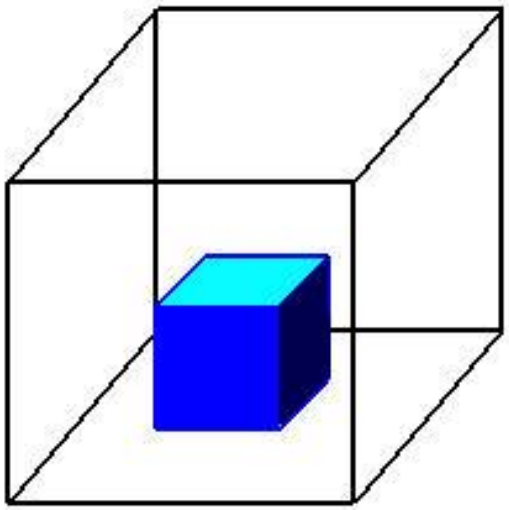
Give a brief description of each state of matter



Specifically describe their shape and volume

TRY IT

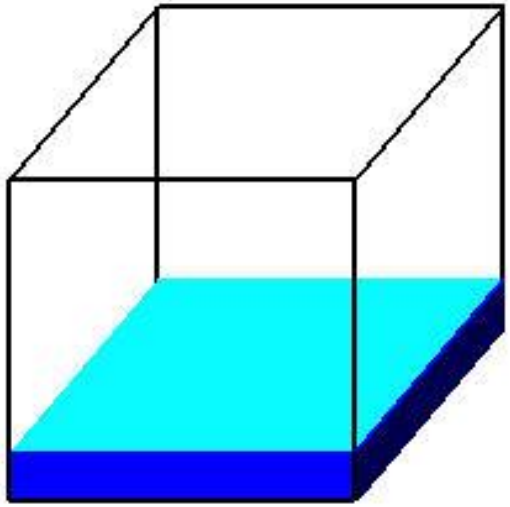
States of Matter



Solid

Holds Shape

Fixed Volume

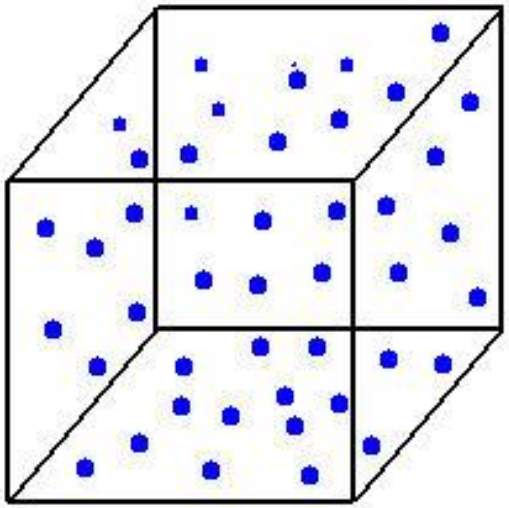


Liquid

Shape of Container

Free Surface

Fixed Volume



Gas

Shape of Container

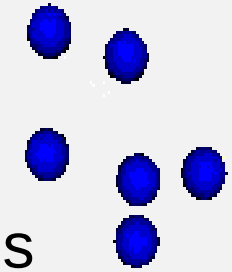
Volume of Container

Forces of Attraction & States of Matter

Attractions between the particles do affect the movement of the particles.

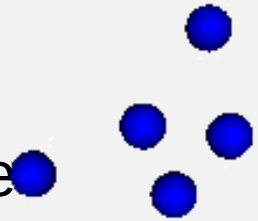
Solids

Each atom vibrates around its location, but it does not exchange places with a neighboring atom.



Liquids

Particles in a liquid can flow to new locations. Forces of attraction do not allow liquids to fill their containers.



Gases

Forces of attraction among particles in a gas can be ignored under ordinary conditions.

Liquids Versus Gases

According to kinetic theory, there are NO intermolecular attractions between the particles in the gas state.

The particles in a liquid are attracted to each other. These intermolecular attractions keep the particles in a liquid close together, which is why liquids have a definite volume.

Gas Versus **Vapor**

A ***gas*** is a substance, *like oxygen (O_2)*, that exists in the gaseous state at room temperature.

Vapor describes the gaseous state of a substance that is generally a liquid or solid **at room temperature**, *as in water vapor*.

Plasma is a high temperature physical state of matter in which atoms **lose most of their electrons**. *Plasma is found in fluorescent bulbs. 99% of the universe is plasma.*

Physical changes that occur in matter

blending

Rubbing/scraping

Phase changes

dissolving

cutting

Chemical changes

- **alter the *chemical composition* of a substance**
- **produce NEW substances with physical & chemical properties DIFFERENT from the constituents.**

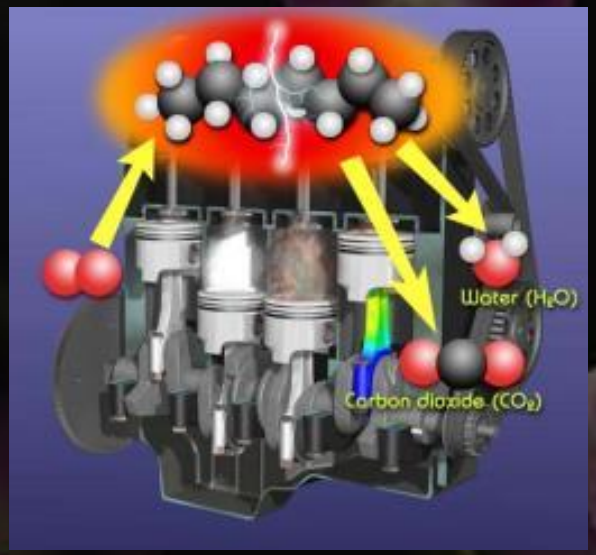
e.g. Sodium (Na) explodes in air, Chlorine gas (Cl_2) is lethal
But table salt (NaCl) tastes great!

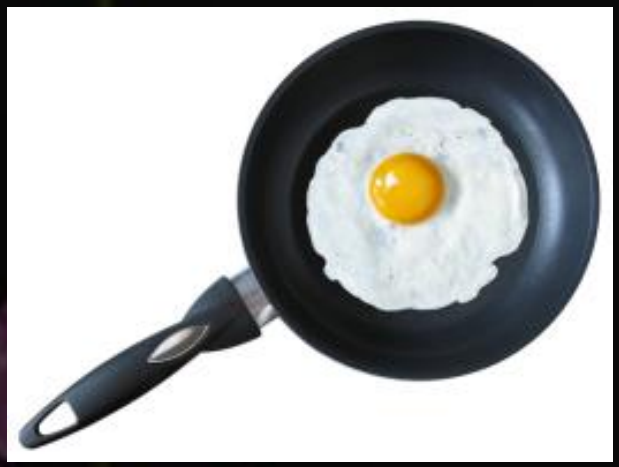
Chemical Changes

Chemical properties can be observed only when the substances are changing into NEW and different substances.

- **Flammability**
- **Reactivity**

Chemical changes that occur in matter





Distinguish Physical & Chemical Changes

$2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$

$H_2O\ (l) \leftrightarrow H_2O\ (s)$

cutting hair	burning of coal	filing nails
A bonfire	pealing or cracking an egg	making a cake
washing your car	a color change in a reaction	dissolving sugar in water
popping a balloon with a pin	exploding a hydrogen filled container	
tearing a piece of paper	kicking a football 40 yards	exploding TNT
excavating of soil	tarnishing of silverware	

TRY IT

Answers

$2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$ … **is a chemical reaction (chemical change)**

Ice melting …. **Is a physical change (changes state)**

Washing your car **physical … dirt is rinsed off**

Dissolving sugar in water … **physical … sugar & water still exist**

A bonfire … **chemical … combustion always produces a new substance**

A color change in a reaction of elements or compounds … ***a general color change can be physical (you turn red when embarrassed), but the word "reaction" indicates a chemical change that produces a new substance is produced***

Popping a balloon with a pin **physical … still a balloon and pin**

Exploding a hydrogen filled container … **chemical … combustion always produces a new substance**

Making a cake … **physical when mixing ingredients … baking includes both physical (increase in size) and chemical changes (yeast + heat produces chemical reactions)**

Burning of coal … **chemical … combustion … new substance**

Tearing a piece of paper … **physical … no new substance, just smaller**

Kicking a football 40 yards … **physical … no new substance**

Tarnishing of silverware … **chemical … similar to rust … new substance**

Excavating soil … **physical … no new substance … just digging up the soil**

How can we distinguish chemical change from physical?

LESSON QUESTION

Similarities of both physical & chemical changes:

- Energy transfer (e.g. absorbed or released)
- State of matter change
- Gas formation*
  - bubbles form when you boil water or open a carbonated drink [physical]
  - **bubbles*** also form when an acid reacts with metal [chemical].

- **Precipitate*** (***a solid forms in a liquid***)
  - rain [physical]
  - solutions chemically react to form a **precipitate*** [chemical]

- Color Change* or Odor
  - “red hot” iron [physical]
  - Rust (corroded iron hydroxide) [chemical]

Recognizing Chemical Changes

When matter undergoes a chemical change, the composition of the matter changes. **When matter undergoes a physical change, the composition of the matter remains the same.**

CHEMICAL CHANGES:

- **NEW** chemical substances form.
- A chemical **"REACTION"** occurred.
- Combustion

Physical Versus Chemical Properties (2:36)

https://screencast-o-matic.com/watch/cFQiooqpMR

Physical Versus Chemical Changes Demonstrations Part 1 (5:01)

https://screencast-o-matic.com/watch/cFQilLqp5O

Physical Versus Chemical Changes Demonstrations Part 2 (5:04)

https://screencast-o-matic.com/watch/cFQiI3qpGD

QUICK CHECK

Which of these properties is a chemical property of sulfur?

a. yellow
b. flammable
c. brittle
d. Soft

Which of the following is not a common type of evidence for a chemical change?

a. a change of state
b. a color change
c. a gas produced
d. a precipitate formed

You can be certain that a chemical change has occurred when

a. there is a visible change.
b. the change is irreversible.
c. the temperature changes.
d. a new substance is formed.

QUICK CHECK

Which of these properties is a chemical property of sulfur?

a. yellow
b. flammable
c. brittle
d. Soft

Which of the following is not a common type of evidence for a chemical change?

a. water turns to steam
b. a color change
c. a gas produced
d. a precipitate formed

You can be certain that a chemical change has occurred when

a. there is a visible change.
b. the change is irreversible.
c. the temperature changes.
d. a new substance is formed.

What happens when a substance changes from one phase to another?

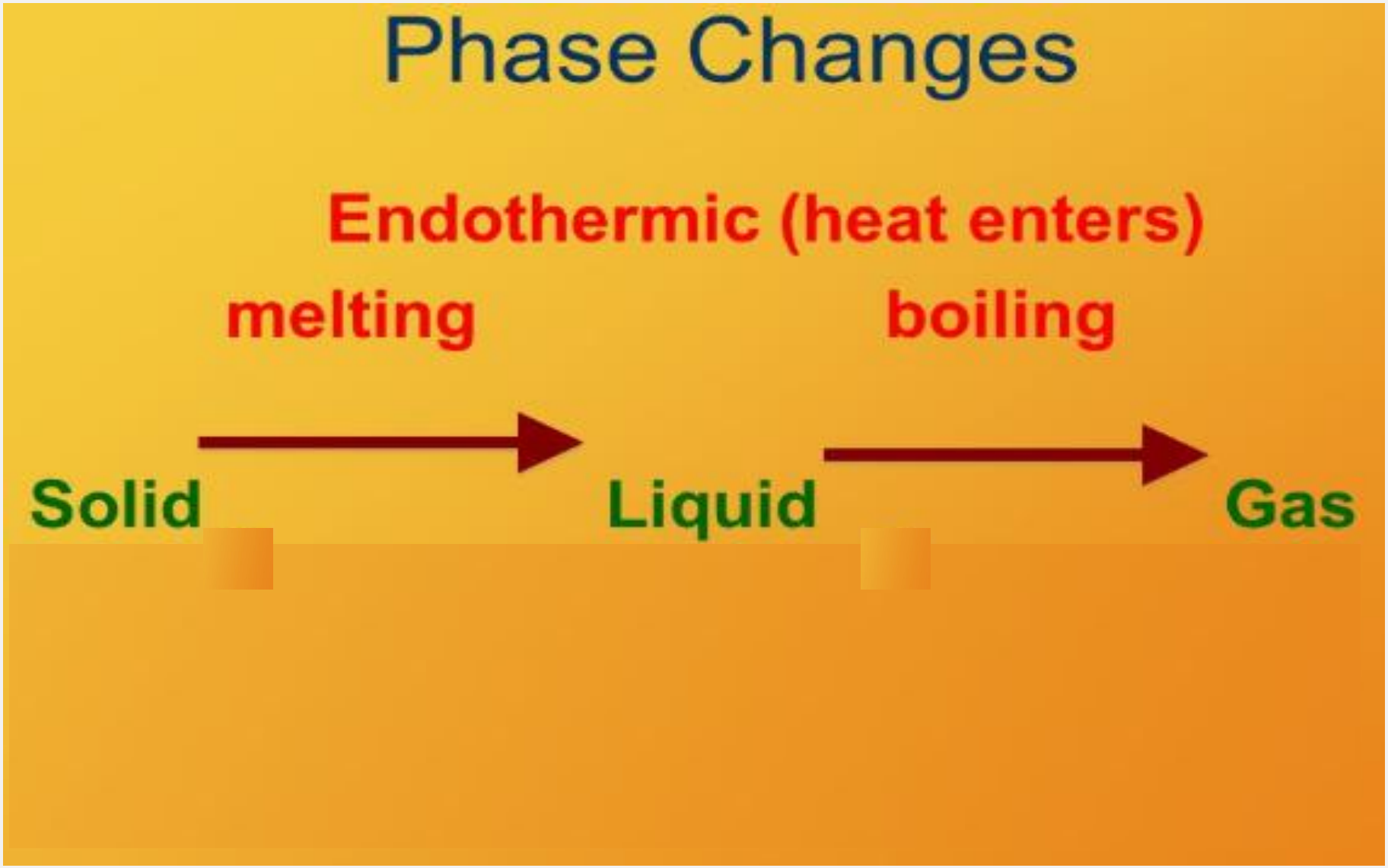
LESSON QUESTION

A large iceberg contains enough fresh water to supply millions of people with water for a year. As it moves into warmer areas, the **ice** changes to **liquid** water and eventually disappears.

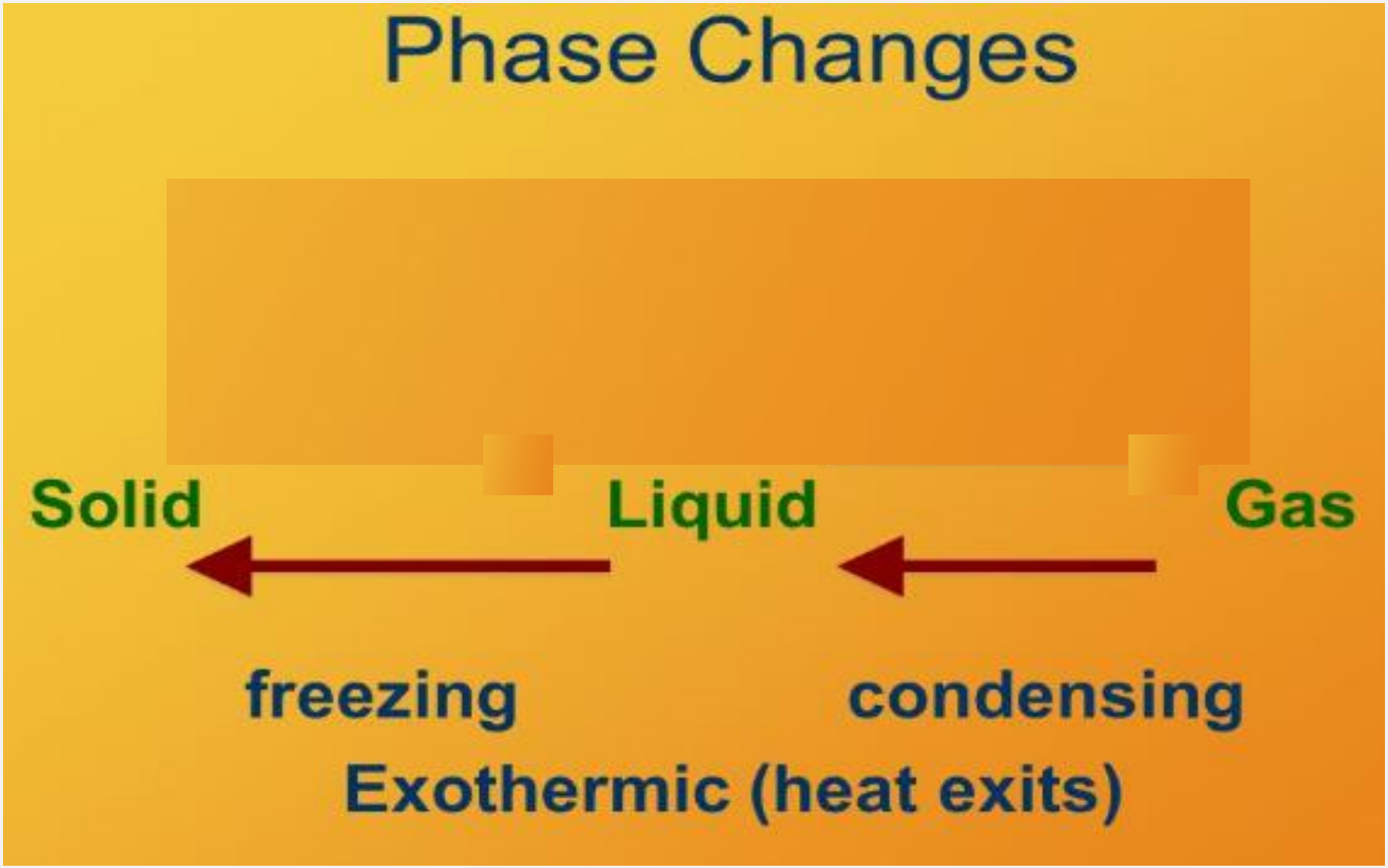
Phase Changes

LESSON QUESTION

All phase changes share certain characteristics related to energy and temperature.



Endothermic changes involve **ABSORBING** (taking in) energy.



Exothermic changes involve **RELEASING** (giving off) energy.

Phase Changes

melting point (mp)

The temperature at which a solid changes into a liquid.

The disruptive vibrations of the particles are strong enough to overcome the attractions that hold them in fixed positions.

Melting: kinetic energy (KE) > intermolecular forces

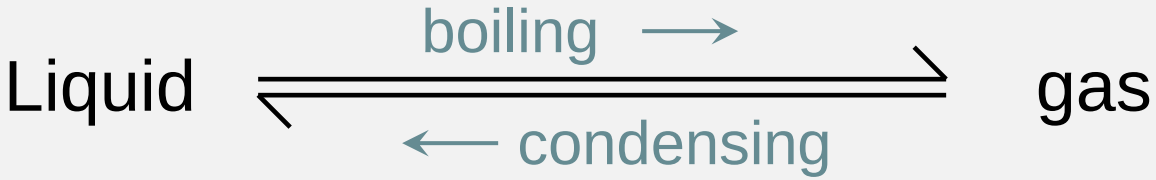
freezing point (fp)

The temperature at which a liquid changes into a solid.

Freezing: kinetic energy (KE) < intermolecular forces

$$T_{mp} = T_{fp}$$

Phase Changes



boiling point (bp)

The temperature at which a liquid changes into a gas.

The movement of the particles is strong enough to overcome the molecular attractions that hold them together.

Boiling: kinetic energy (KE) > intermolecular forces

Condensation point (cp)

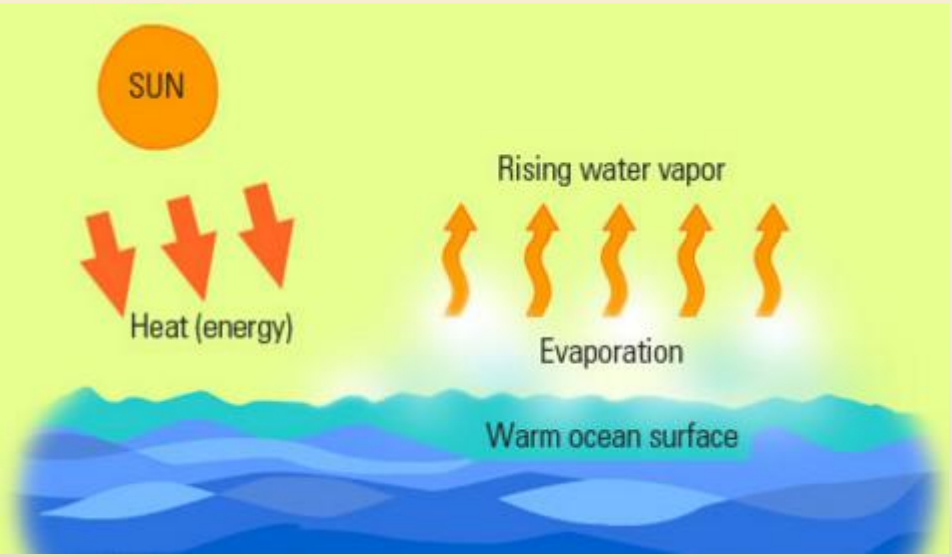
The temperature at which a gas changes into a liquid.

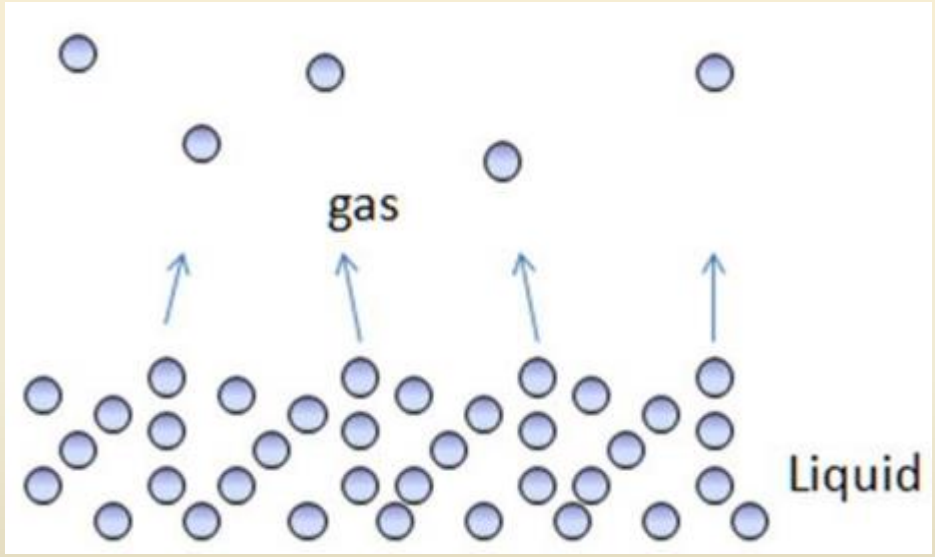
Condensing: kinetic energy (KE) < intermolecular forces

$$T_{bp} = T_{cp}$$

Evaporation

The conversion of a liquid to a gas at the surface of a liquid that is not boiling is called evaporation.

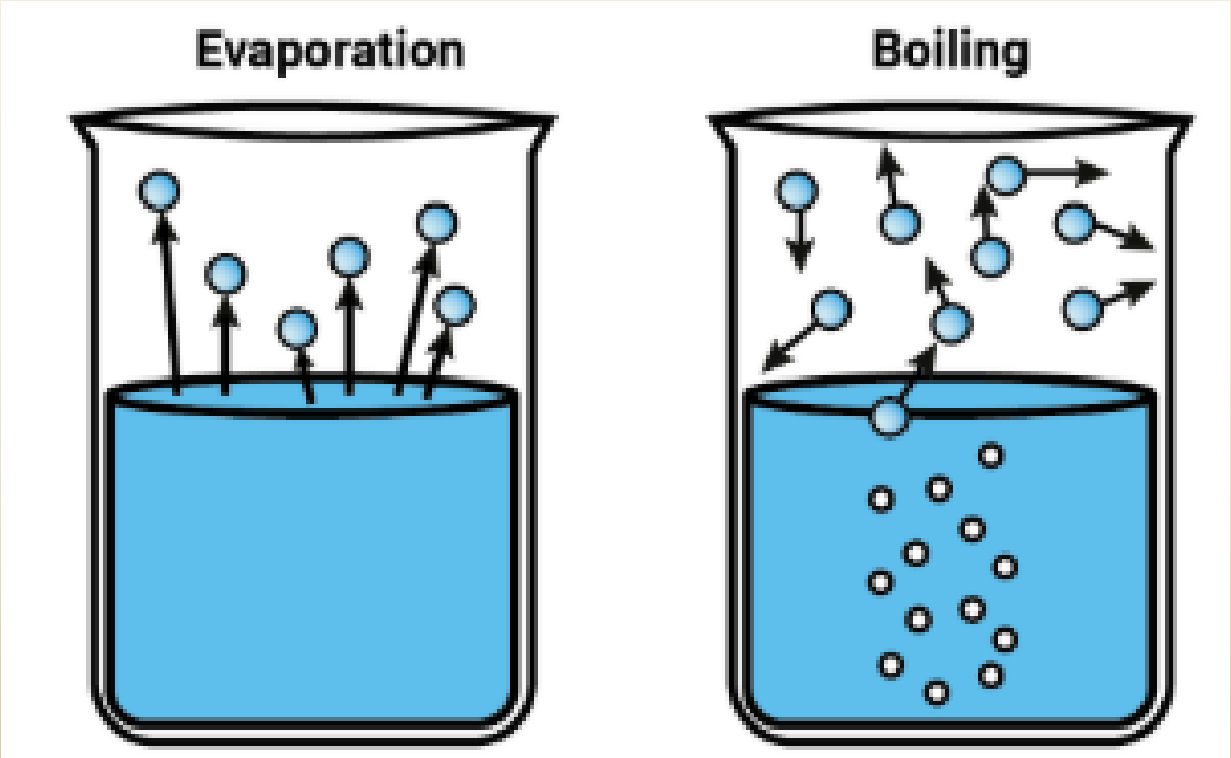




Evaporation is DIRECTLY related to surface area, temperature, wind, and moisture (humidity).

Boiling of Liquids

- Evaporation only occurs at the SURFACE of an object or liquid
- Boiling occurs throughout a liquid, beginning at the heat source
- Avg Kinetic Energy (KE) increases so bubbles (gas) form throughout the liquid, rise to the surface (less dense), and escape into the air.



Phase Changes

Sublimation

The change of a substance from a solid to a vapor without passing through the liquid state is called sublimation. Sublimation occurs in solids with vapor pressures that exceed atmospheric pressure at or near room temperature.

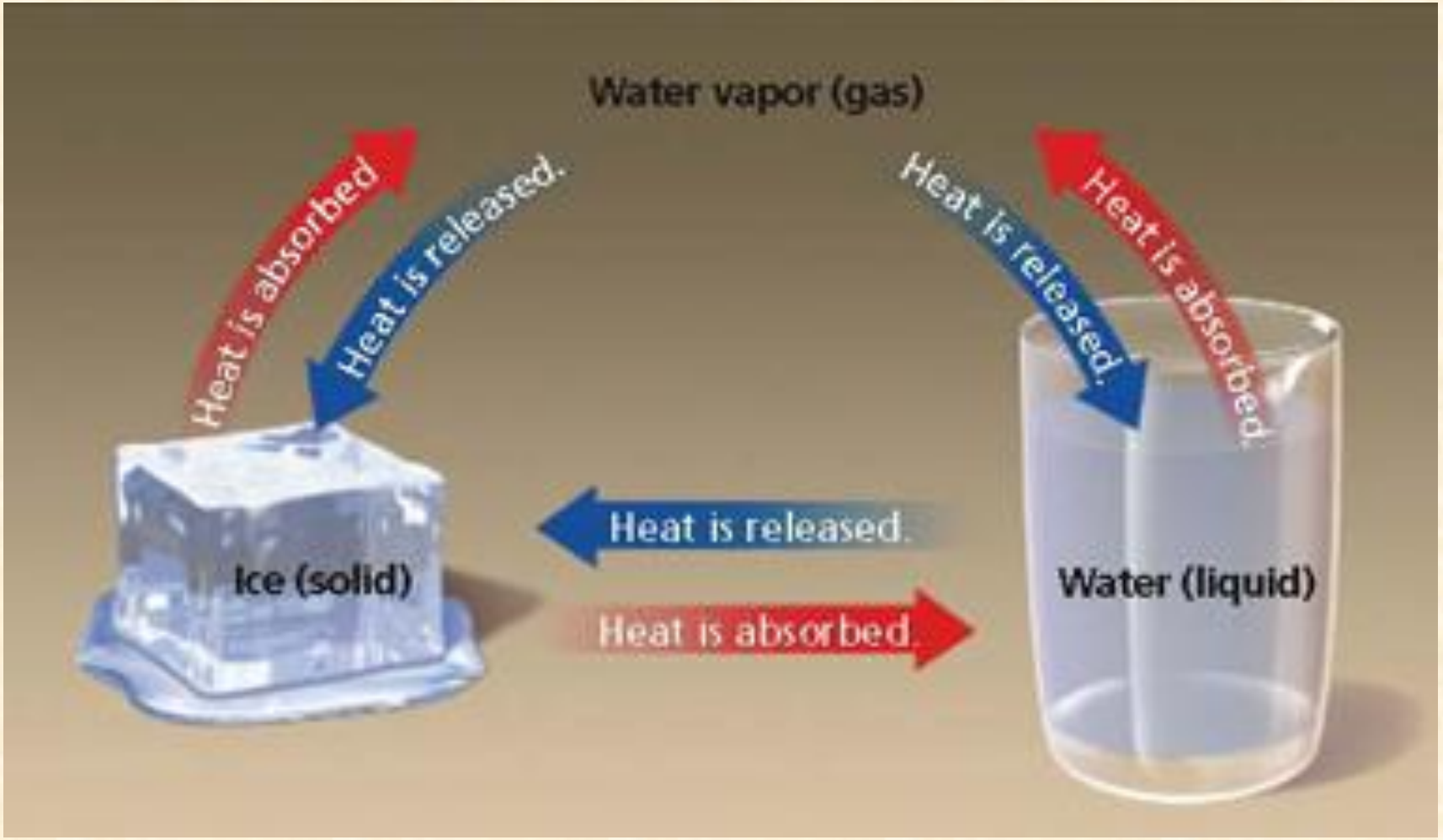
Sublimation: KE > intermolecular forces

Deposition: KE < intermolecular forces

Solid carbon dioxide (dry ice) is often used as a coolant for goods.

https://screencast-o-matic.com/watch/cFQ6XCqEx2 (1:59)

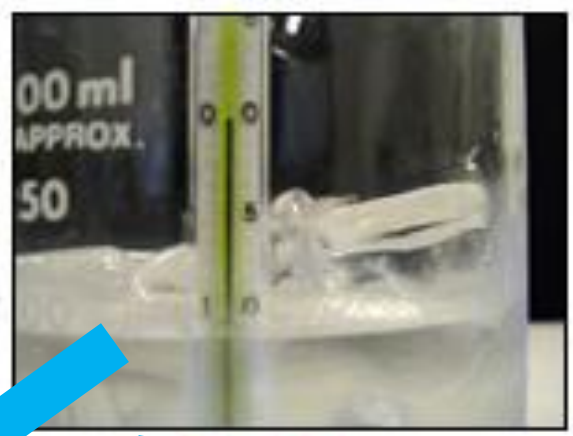
Energy Interactions



Energy Through the Water Cycle

State if energy released or gained for each phase change.

steam



ice

water

TRY IT

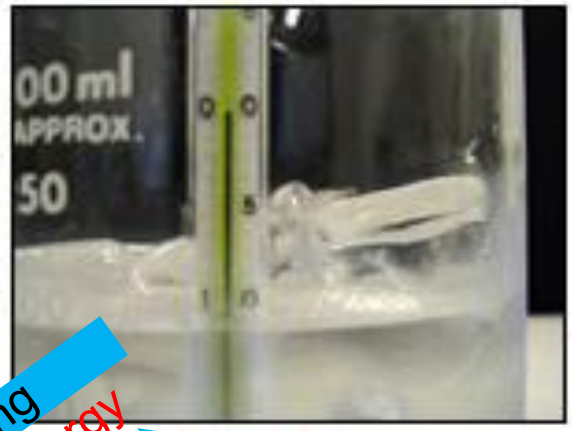
Energy Through the Water Cycle

Endothermic (heat gained); Exothermic (heat released)

steam

Deposition
Releases Energy

Sublimation
Gains Energy



ice

Boiling
Gains energy

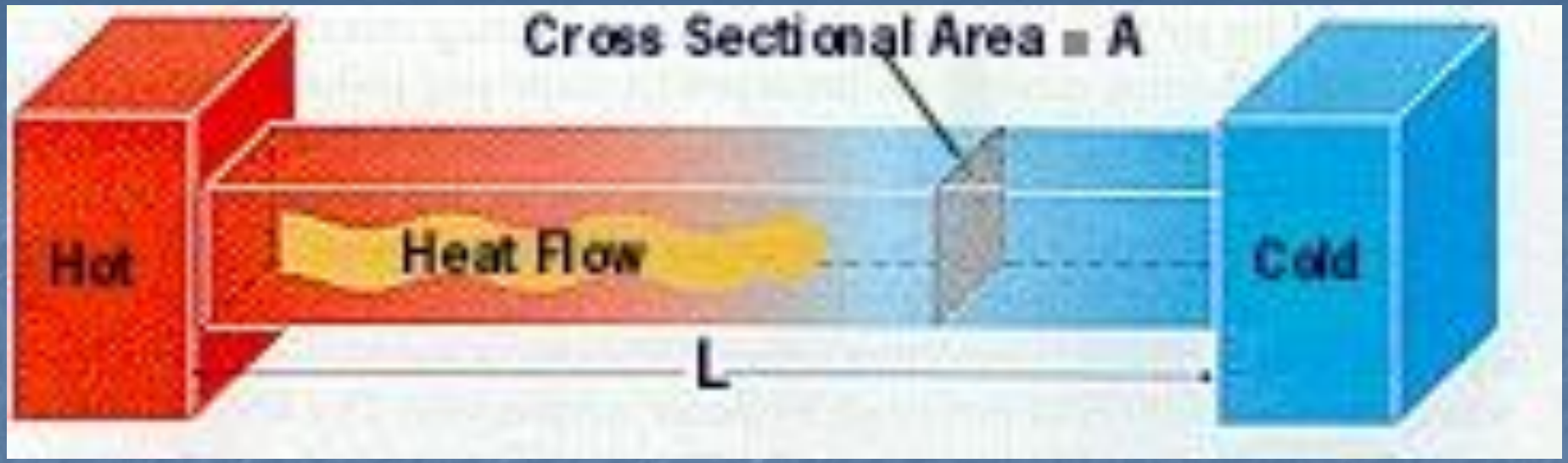
Condensing
Releases Energy

Melting
Gains Energy

Freezing
Releases Energy

water

TRY IT



Heat flows from warm to cold

This represents Kinetic Energy

Heating and Cooling Curves

http://somup.com/cFX6DGni0X (1:11)

Inquiry Questions:

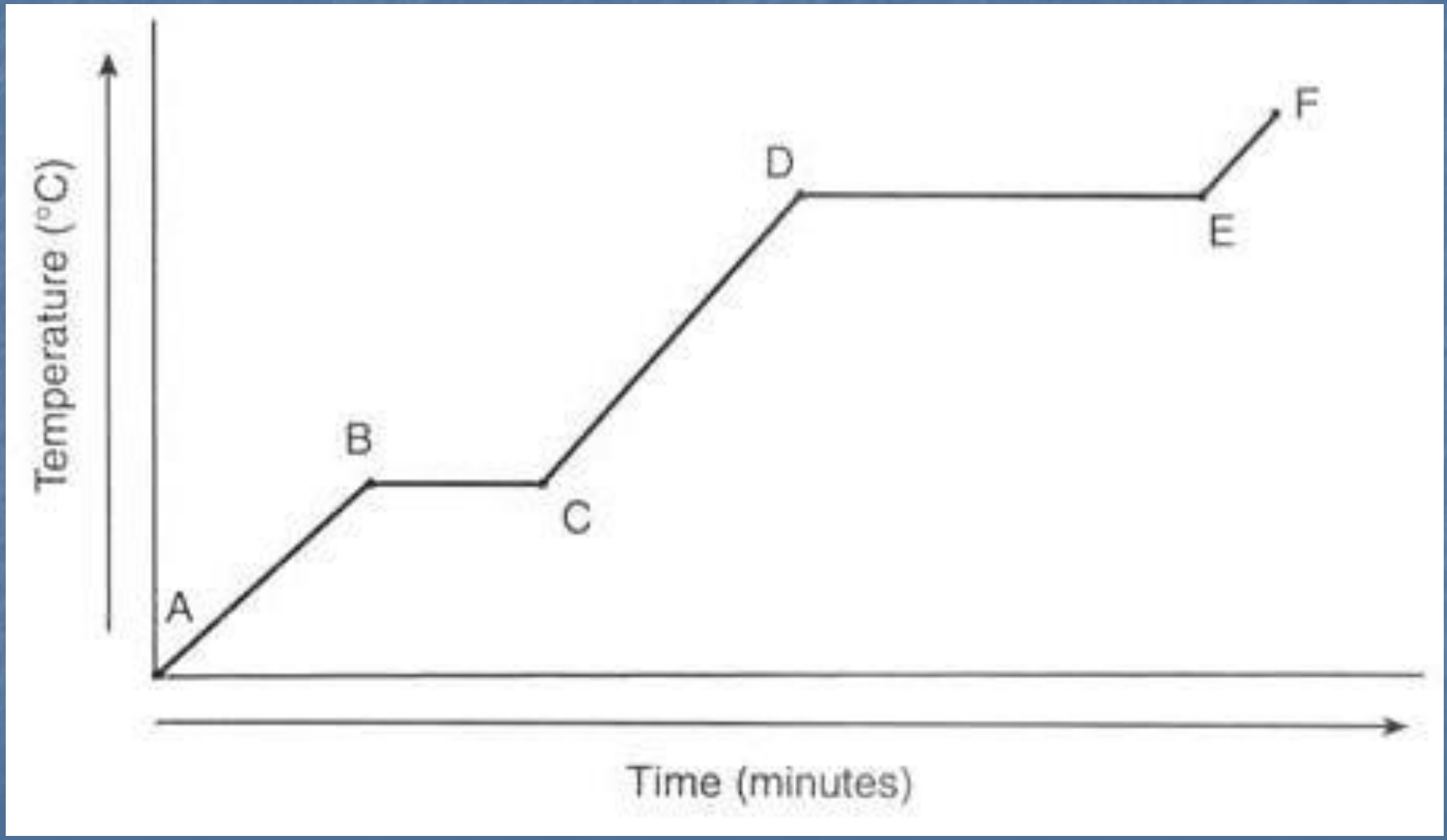
- What happens to the temperature as ice melts? As water boils?
- What kind of energy relationships are occurring as ice melts and then boils?
- What do we call the stages when ice melts and water boils?

Heating and Cooling Curves

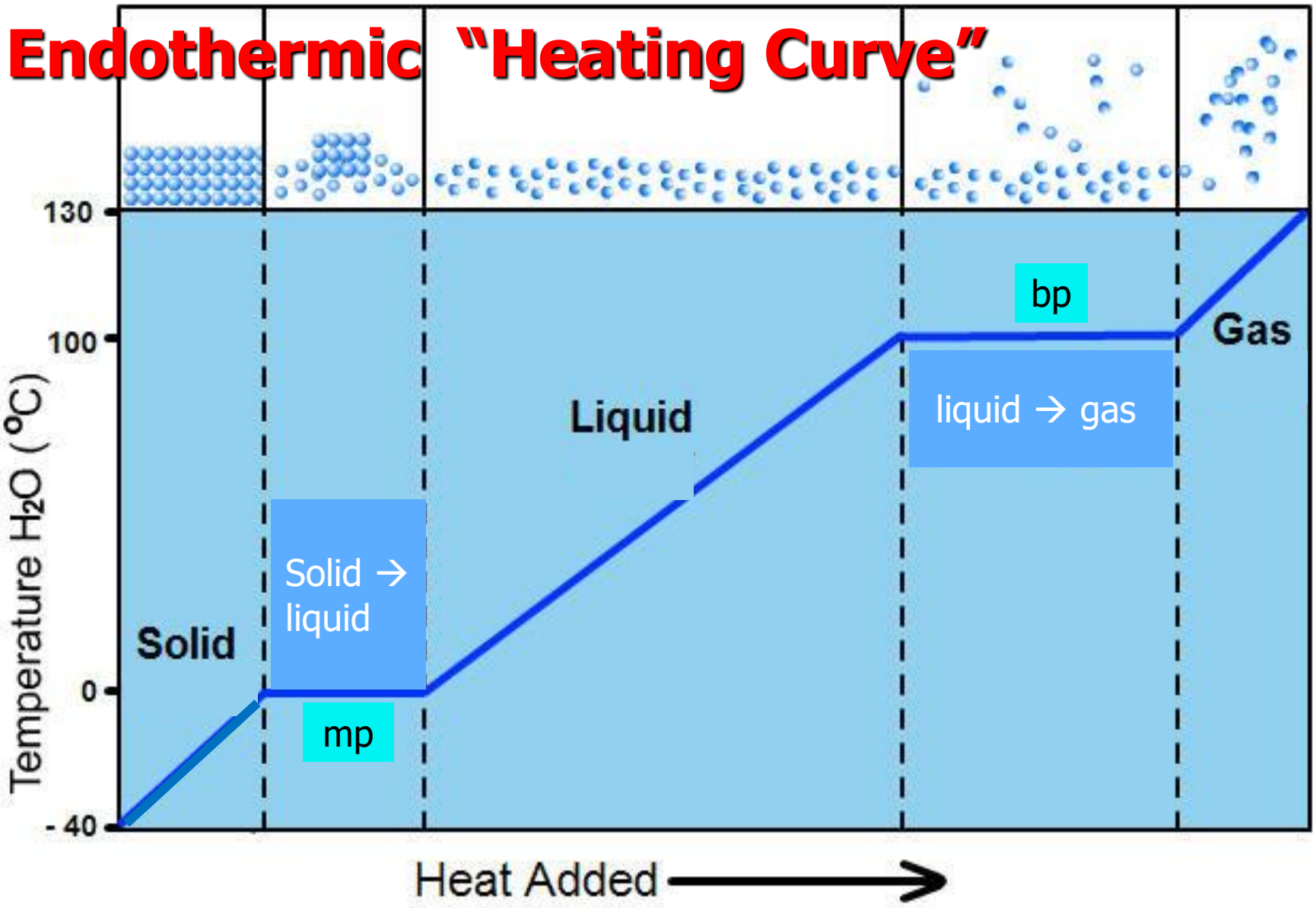
Inquiry Questions:

- Temperature does NOT change during PHASE changes (as ice melts or as water boils).
- What kind of energy relationships are occurring as ice melts and then boils? (*Endothermic*)
- What do we call the stages when ice melts (*melting point*) and water boils (*boiling point*)?

Label the States of Matter, phase changes, and energy change.

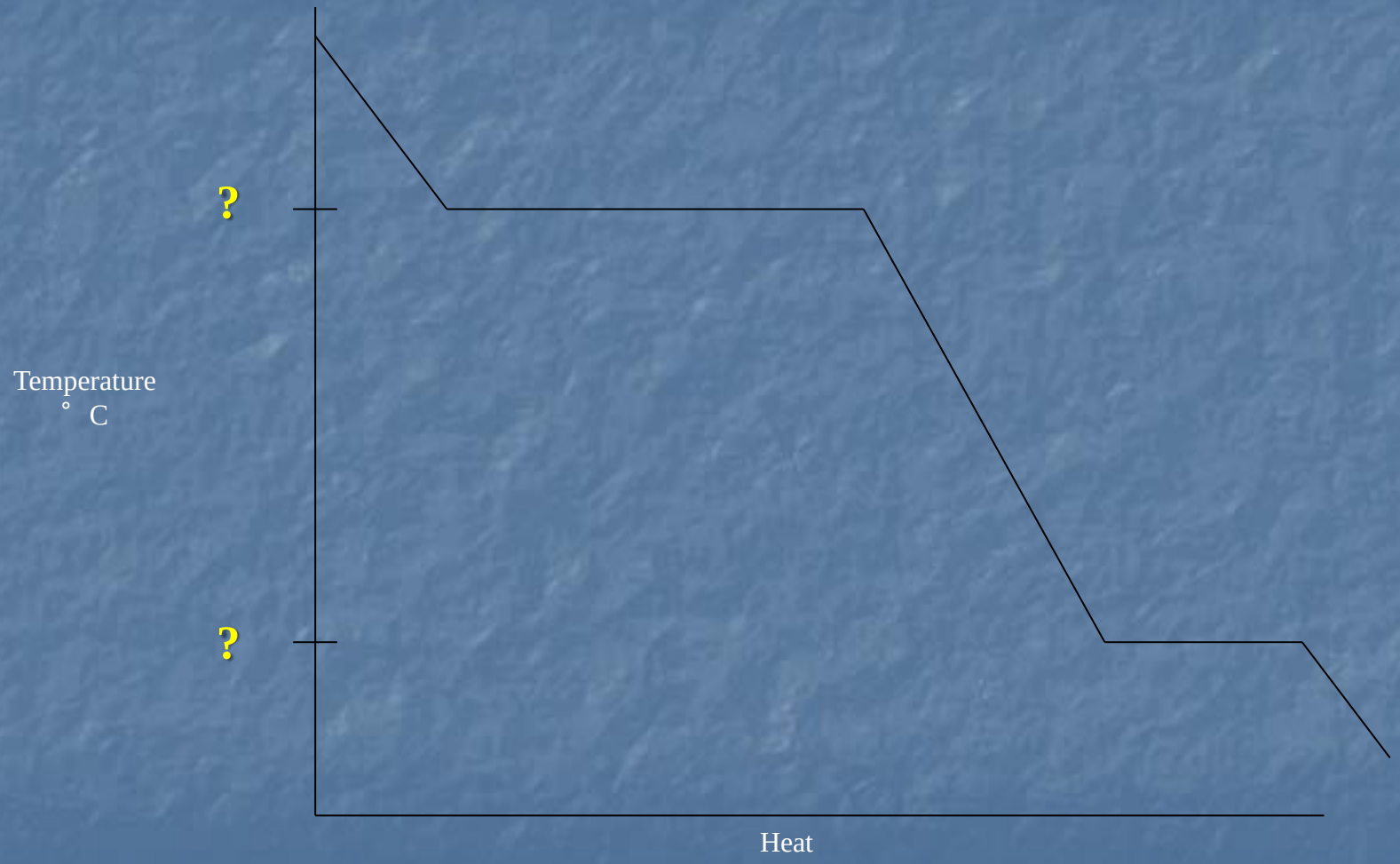


Endothermic "Heating Curve"

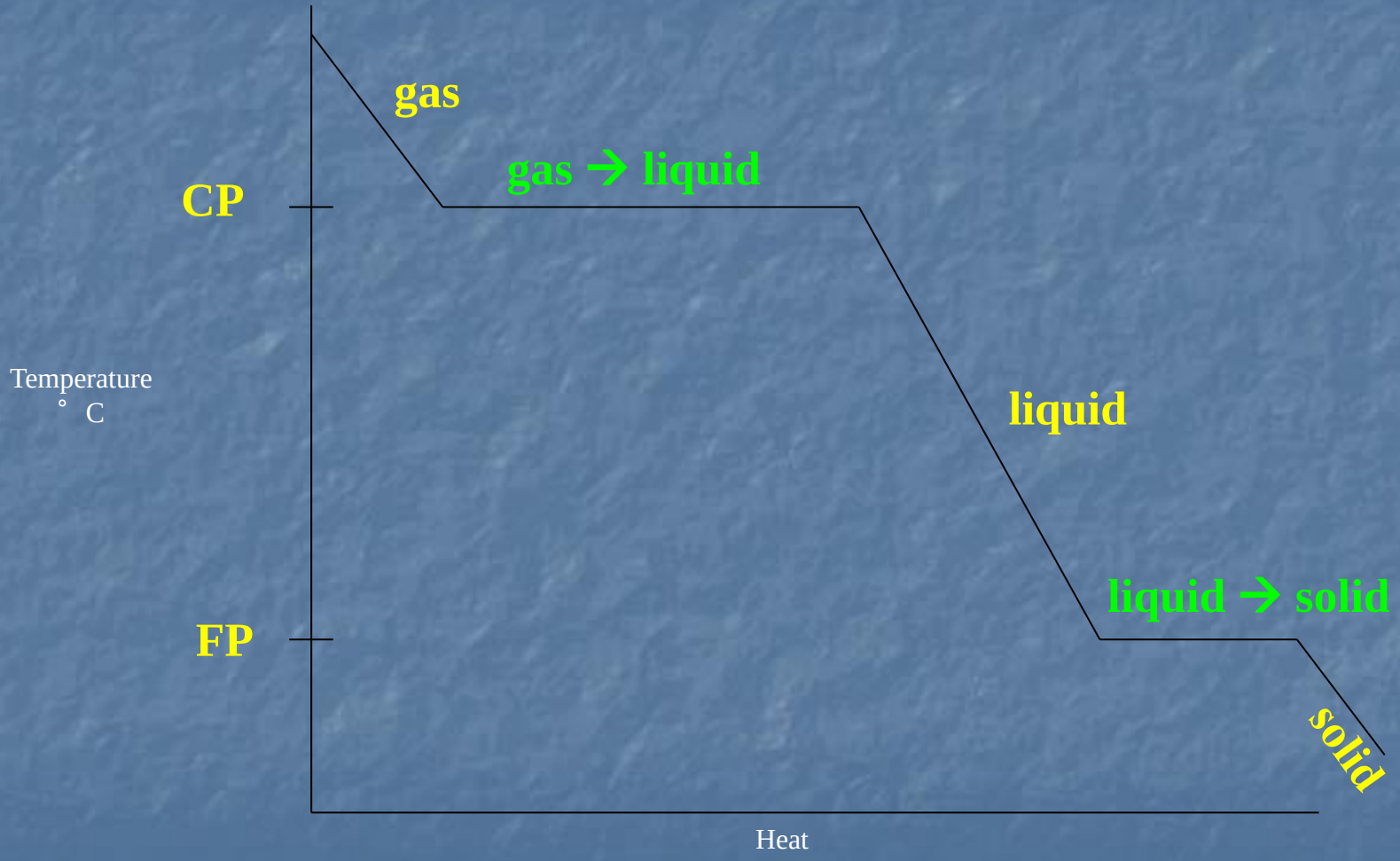


Label the States of Matter, phase changes, and energy change.

TRY IT



Exothermic (Cooling) Curve



Heating Curve Song

https://screencast-o-matic.com/watch/cq6f2UuDuF (3:20)

QUICK CHECK

Review

Classify the following phase changes as endothermic or exothermic.

Endothermic	Exothermic

liquid to solid | solid to liquid | gas to liquid | solid to gas | liquid to gas | gas to solid

QUICK CHECK

Review

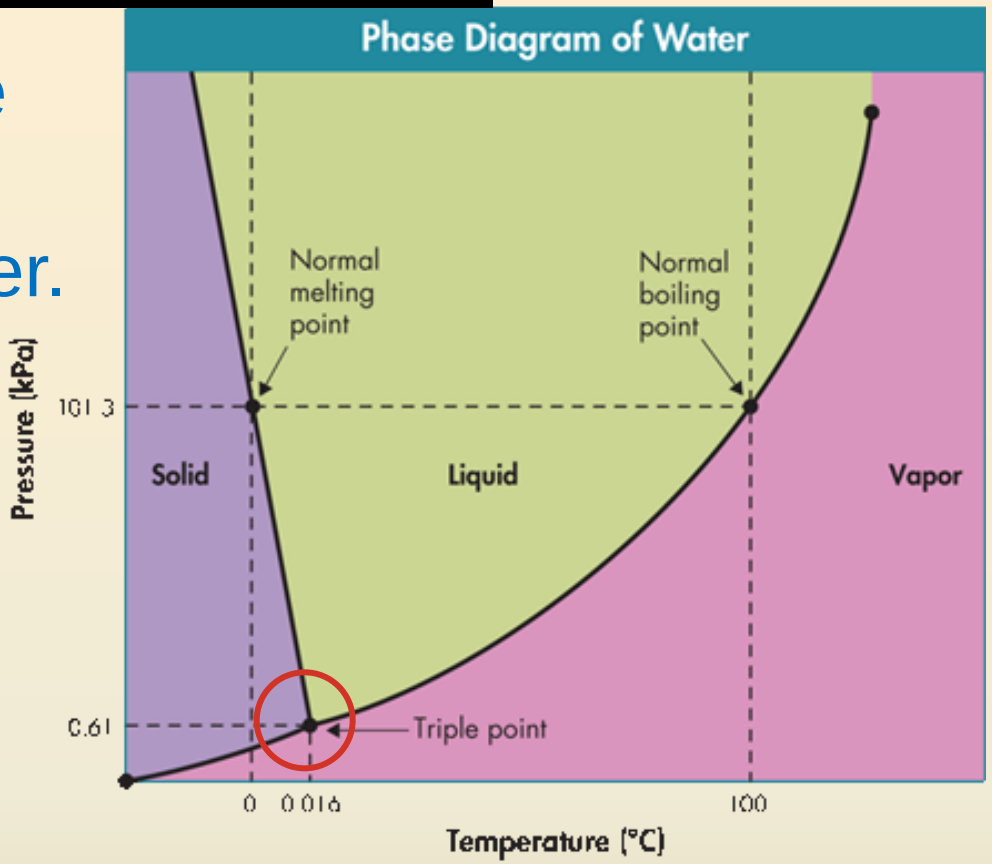
Classify the following phase changes as endothermic or exothermic.

Endothermic	Exothermic
solid to liquid liquid to gas solid to gas	gas to solid liquid to solid Gas to liquid

liquid to solid | solid to liquid | gas to liquid | solid to gas | liquid to gas | gas to solid

Triple Point

The point at which all three phases can exist in equilibrium with one another.



Water's triple point is 0.016º C & 0.61 kPa.

The flask is at the triple point. Freezing, melting, boiling, condensation, sublimation, & deposition are all occurring at the same time.