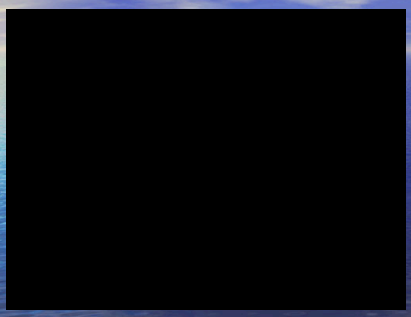
Changes of State

Phase Changes
Chapter 3, Lecture 2

Review from last Time

- 1. What are the 5 states of matter?
  - Solid
  - Liquid
  - Gas
  - Plasma
  - BEC (Bose Einstein Condensate)
- 2. How do the molecules move in the 3 main states?
  - 3 Main States of Matter

States of Matter

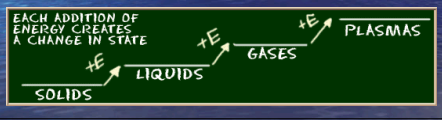


States & phases

- Each of the 5 states is also known as a **phase**.
- Elements and compounds can move from one phase to another phase when special physical forces are present.
- One example of those forces is **temperature**.
- The phase or state of matter can change when the temperature changes.
- Generally, as the temperature rises, matter moves to a more active state.

It's all about the energy!

- It's totally possible to go from a solid to a liquid to a gas, and back again.
- These are called state changes or phase changes.
- But it's all about the energy.
- Which state you go to depends on whether you are adding or removing energy.

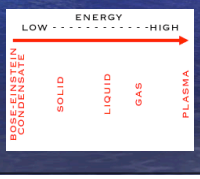


States & Energy

- During a change of state, the energy of the substance **changes**.
- This is related to how the particles move.
- If you add energy to a substance, the particles **speed up**.
- If you remove energy from a substance, the particles **slow down**.
- In fact, **temperature** is a measure of the speed of particles.

See, proof!

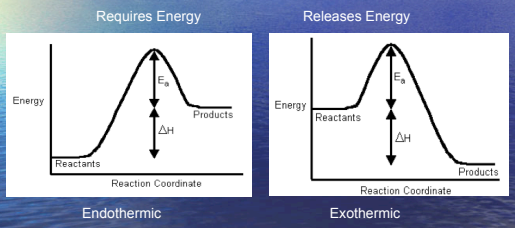
- Each state has a different energy "requirement".
- In order to be a plasma, you need a ton of energy because your particles better be moving!
- In order to be a solid or BEC, the particles are fine just chilling - so they don't need as much energy.



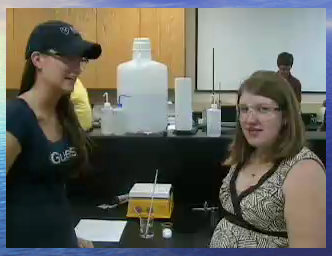
Two Types of Energy Change

1. **Endothermic**: energy is absorbed, or taken in, by a substance- the coaches Boo-Boo bag!
   (absorbs heat - feels **colder**)
2. **Exothermic**: energy is removed, or taken out, of a substance- Elvis has LEFT the building!
   (releases heat - feels **warmer**)

Endothermic and Exothermic



2. An Endothermic Experiment



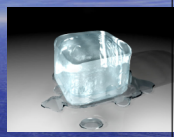
- **Endothermic**: energy is absorbed, or taken in, by a substance (absorbs heat - feels **colder**)
- Think of the ice bags the coach gives you if you get hurt

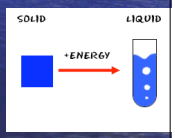
3. An Exothermic Experiment

Exothermic: energy is removed, or taken out, of a substance
(releases heat - feels **warmer**)

Melting: **Solid** to **liquid**

- Let's start with an ice cube.
- This ice cube starts off as a solid.
- When we add heat (energy), it begins to melt into a liquid.





How does melting work?

- When a substance is heated, it absorbs energy and its atoms and molecules begin oscillating, or moving.
- Eventually, they move so much that they break some of their bonds of attraction which are holding them tightly in place.
- They move *so* vigorously that they begin to move past one another, flowing like a liquid.
- Thus, as energy is being absorbed, this is an **endothermic** change.

Awful Science Humor

- A small piece of ice which lived in a test tube fell in love with a Bunsen burner.
- "Bunsen! my flame! I melt whenever I see you" said the ice.
- The Bunsen burner replied: "It's just a phase you're going through."

Vaporization: **Liquid** to **Gas**

- Now let's take that water and put it into a pot over flame.
- Eventually, the water will start to boil and turn into a gas.
- Vaporization is the name of this process.
- **Boiling** is vaporization that occurs throughout a liquid.
- The temperature at which a liquid boils is its **boiling point**.
- The boiling point of water = **100°C**

How does boiling work?

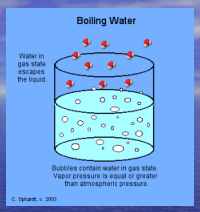
- When you're heating a pot of water, the heat energy is making the water molecules move faster and faster.
- When enough thermal energy (heat) is added, the intermolecular forces in the substance are completely overcome and the liquid becomes a gas.

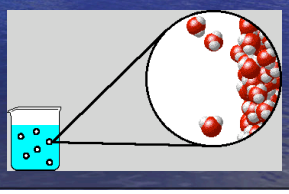
A Special Kind of Vaporization

- **Evaporation** is vaporization that occurs at the surface of the liquid, below its boiling point.
- This happens because as the liquid is heated, some particles manage to escape early, before the boiling point is reached.
- When they escape, they leave the surface of the liquid to become a gas.
- Sweating is a natural process used by humans to cool off.
- When we sweat, the water absorbs the heat (energy) and gives the sensation of cooling.

So Far…

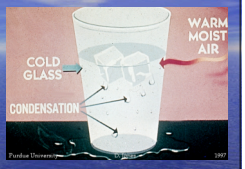
- We've gone from a solid to a liquid (melting) and from a liquid to a gas (vaporization)
- Can you go back the other direction?
- Of Course!



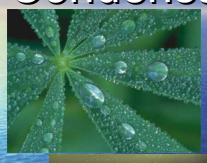


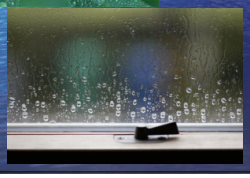
Condensation: **Gases** to **liquids**

- Condensation happens when several gas molecules come together and form a liquid.
- It all happens because of a loss of energy.
- Gases are really excited atoms.
- When they lose energy, they slow down and begin to collect.
- They can collect into one drop.
- Water condenses on the lid of your pot when you boil water.
- It cools on the metal and becomes a liquid again.
- You would then have a condensate.

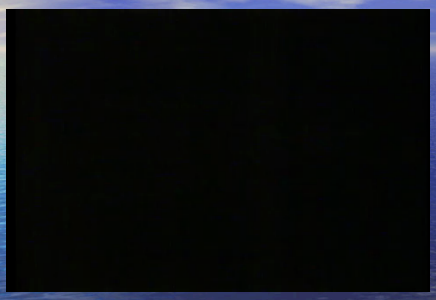


Examples of Condensation





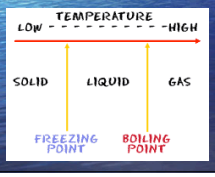
Eureka! Evaporation & Condensation



Freezing: **Liquids** to **Solids**

- Now let's reverse melting.
- Let's take our liquid water and put it in the freezer - where it will turn into a solid.
- The temperature at which a liquid changes into a solid is its **freezing** point.
- Freezing is an **exothermic** change, because energy is taken out of the substance.

How does freezing work?



- As energy leaves, the particles begin to slow down.
- They become pulled into a more ordered arrangement, or a locked position.
- Or basically, into a solid!

Sublimation: **Solids** directly to **Gases**

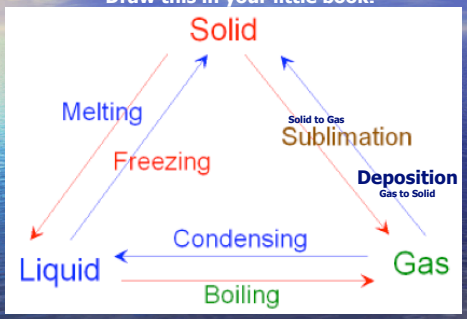
- This phase change totally bypasses the liquid state.
- This is an **endothermic** change, because the only way this can happen is if the atoms are suddenly moved very far apart (think of how much space a gas wants to take up).
- And the only way the atoms can be moved far apart from one another is if the attraction between particles is completely overcome…which requires lots of energy!

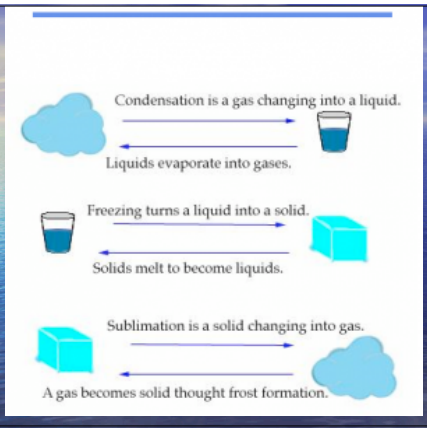
Example of Sublimation

- **Dry ice** is an example of sublimation.
- Dry ice is solid carbon dioxide (CO_2).
- Carbon Dioxide is typically found as a gas.
- When it is frozen into a solid, it turns directly into a gas and totally skips the liquid stage.

The Triangle of Phase Changes!

Draw this in your little book!

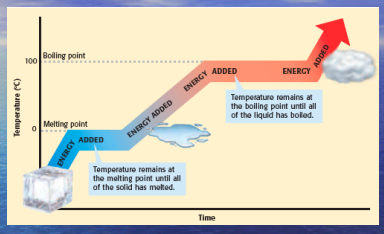




Two more REALLY important Points

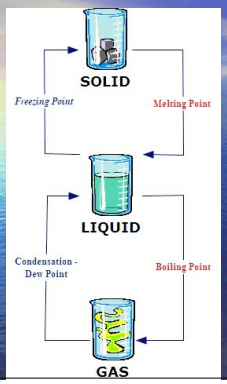
- First, all phase changes are **physical** changes, not chemical changes.
- This is because the substance stays the same before and after the state change.
- It is just changing its shape, not itself!

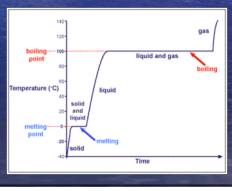
Two more REALLY important Points



- Second, the temperature of a substance does NOT change during a phase change.
- It only changes before or after the change.

States of Matter





Summary: (fill in the boxes-this might be really good to have in your LB too!)

Summarizing the Changes of State

Change of state	Direction	Endothermic or exothermic?	Example
Melting	solid → liquid	endothermic	Ice melts into liquid water at 0°C.
Freezing	liquid → solid	exothermic	Liquid water freezes into ice at 0°C.
Vaporization	liquid → gas	endothermic	Liquid water vaporizes into steam at 100°C.
Condensation	gas → liquid	exothermic	Steam condenses into liquid water at 100°C.
Sublimation	solid → gas	endothermic	Solid dry ice sublimes into a gas at –78°C.

Review Questions:

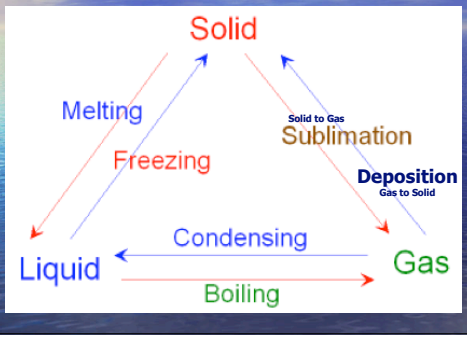
Identify these phase changes:

- 1. the substance changes directly from a gas to a solid without going through the liquid phase.
- 2. the substance changes from a liquid to a solid.
- 3. the substance changes from a liquid to a gas.
- 4. the substance changes from a gas to a liquid
- 5. the substance changes back from the solid to the liquid.
- 6. the substance changes directly from a solid to a gas without going through the liquid phase.

Answers:

- 1. **Deposition:** the substance changes directly from a gas to a solid without going through the liquid phase.
- 2. **Freezing:** the substance changes from a liquid to a solid.
- 3. **Vaporization:** the substance changes from a liquid to a gas.
- 4. **Condensation:** the substance changes from a gas to a liquid
- 5. **Melting:** the substance changes back from the solid to the liquid.
- 6. **Sublimation:** the substance changes directly from a solid to a gas without going through the liquid phase.

The Triangle of Phase Changes!



BrainPop Review:

- Matter Changing States

Brain Pop Answers: Matter Changing States

- **1. What are the states of matter?** A. Solid, Liquid, Gas
- **2. What is matter?** B. Anything that has mass & takes up space
- **3. What type of change is a change of state?** A. Physical change
- **4. How do the molecules in a solid move?** C. They vibrate
- **5. The heat required to change a solid into a liquid is its:** C Heat of fusion
- **6. What is the melting point of water?** B. 0 degrees Celsius
- **7. The heat required to change a liquid into a gas is its:** C. Heat of vaporization
- **8. What is it called when a solid turns directly into a gas?** A. Sublimation
- **9. What is dry ice?** B Solid carbon dioxide
- **10. How do the molecules of a gas behave?** C. They bounce around randomly