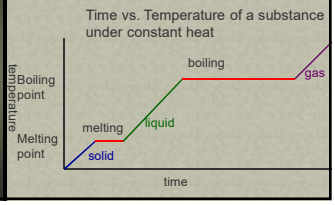
Chapter 14 Liquids and Solids

So a graph would look like…



Terminology

- **Triple point** is the point where the substance can exist in all three phases of matter. It is the meeting point of all three phases
- **Critical point** is the temperature where no matter the pressure, the substance will always be a gas.

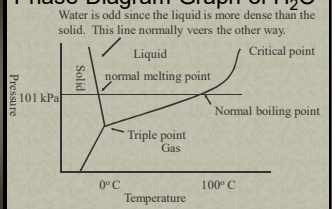
Phase changes and temperature

- Normally when heat is added the temperature goes up.
- However when you hit a phase change point (melting/freezing, boiling/condensation)…
- The temperature stays constant when heat is added, at least until the phase change is complete.

Changes in phase require energy

- It takes more energy to completely turn water at 100° C into steam than it does to take the same water from 0° C to 100° C.
- It actually takes 10x more energy to convert 100° C water to steam than it does to heat 0° C water to 100° C water.
- Steam has a much higher heat energy content than 100° water.
- This is why steam burns are much worse than water burns (scalding).

Phase Diagram Graph of H_2O



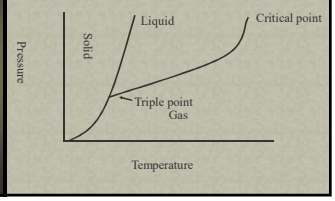
Why should you…

- Turn the heat down once the water is boiling?
- Recipes will always tell you to do this.
- Heat the water to a boil. Add spaghetti, and turn the heat down.
- Won't your spaghetti cook faster if you turn the heat up?
- No
- The water can only get to 100° C
- Increasing the heat would increase how fast it boils off, but that water leaves.

Phase Diagram graphs

- Phase changes normally occur with a temperature change.
- However a change in pressure can also force a phase change.
- Like the butane in a Bic lighter.
- It is a liquid inside (higher pressure), but once released it is a gas (lower pressure).
- No temperature change caused this

"Normal" Phase Diagram



Why is water more dense than ice?

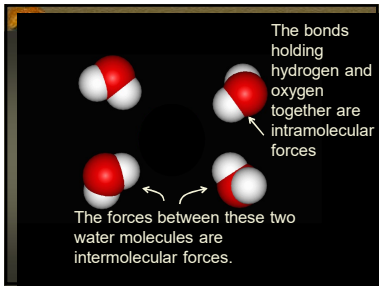
- **Intermolecular forces-** forces of attraction between molecules that forces them to come together to form solids or liquids.
- Intermolecular Forces are collectively called Van der Waals Forces.
- Don't confuse these with bonds which are intramolecular forces or forces that hold a molecule together.

Dipole-Dipole Attraction

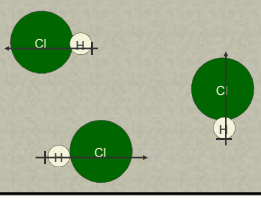
- There are several intermolecular forces that we are not discussing.
- One specific intermolecular force is dipole-dipole attraction.
- Remember we said some molecules have a dipole moment or positive and negative ends.
- A **dipole-dipole attraction** is when the molecules arrange themselves so that the opposite ends face each other.

A really strong dipole-dipole force

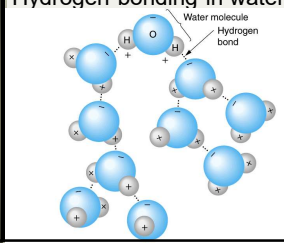
- A strong dipole-dipole force occurs when you have a molecules that have **hydrogen** bonding with **nitrogen, oxygen or fluorine**.
- This is called ***hydrogen bonding***.
- Hydrogen bonding is a misnomer, it is not an intramolecular force (regular bond), it is an intermolecular force.
- It is much weaker than a regular bond, but stronger than the average intermolecular force.



Before Dipole-Dipole Attraction



Hydrogen bonding in water



Phase changes

- When intermolecular forces are strong enough to hold particles in place you have a **solid**.
- As you increase the amount of energy in the particles, they break free of Van der Waals forces and start to move around some. This is a **liquid**.
- When the atoms break free of all significant intermolecular forces they become a **gas**.

Dipole-Dipole Attraction

Now the negative side (chlorine) is next to the positive side (hydrogen)

Why is liquid water more dense…

- Hydrogen bonding.
- In solid water, the molecules can't rearrange themselves.
- In liquid water, they are capable of moving around.
- Normally random movement would increase the spaces between molecules, but with hydrogen bonding the molecules "purposefully" move to a position where they can be pulled in closer.