N30 – Intermolecular Forces

Vapor Pressure &
Phase Changes

N30 – Intermolecular Forces

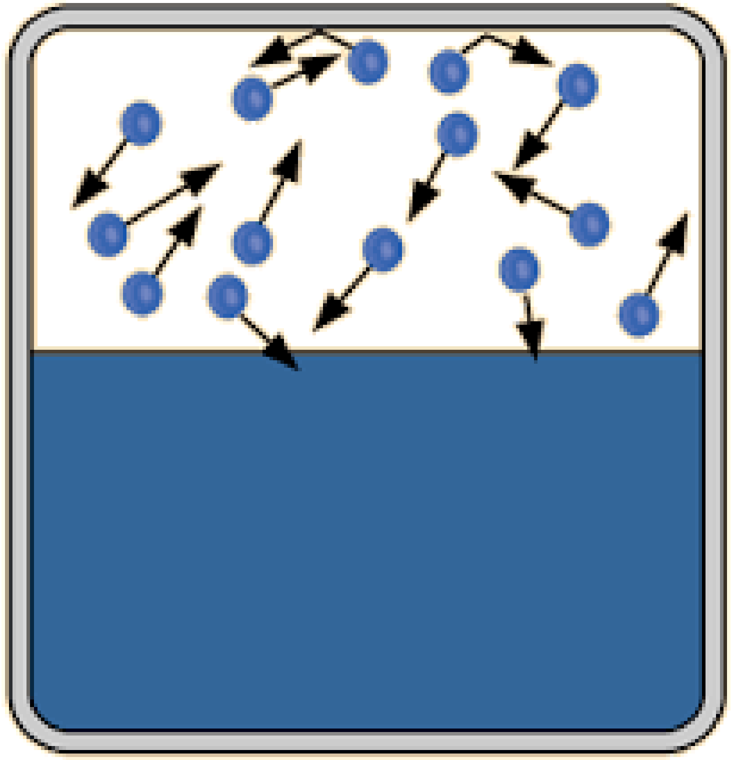
Vapor Pressure & Phase Changes

Target: I can describe the connection between IMFs and vapor pressure, and can use heating curves and phase diagrams to determine information about how substances go through phase changes

Vapor Pressure

The pressure exerted by the vapor when it is in dynamic equilibrium with its liquid

Example: using Dalton's Law of Partial Pressures to account for the pressure of the water vapor when collecting gases by water displacement.



If there is some liquid present, then there is some vapor present!

Equilibrium Vapor Pressure

$H_2O(l) \leftrightarrow H_2O(g)$

The pressure of the vapor present at equilibrium.

- Determined (mostly) by the strength of IMFs in the liquid.
- Increases significantly with temperature.

Volatile liquids have high vapor pressures.

Boiling Point

Temp at which vapor pressure = atmospheric pressure

<u>Vapor Pressure</u>

The weaker the attractive forces between the molecules, the more molecules will be in the vapor.

<u>WEAKER</u> attractive forces = <u>HIGHER</u> vapor pressure.

– The higher the vapor pressure, the more **volatile** the liquid.

HIGH IMF's

LOW Vapor Pressure

LOW IMF's

HIGH Vapor Pressure

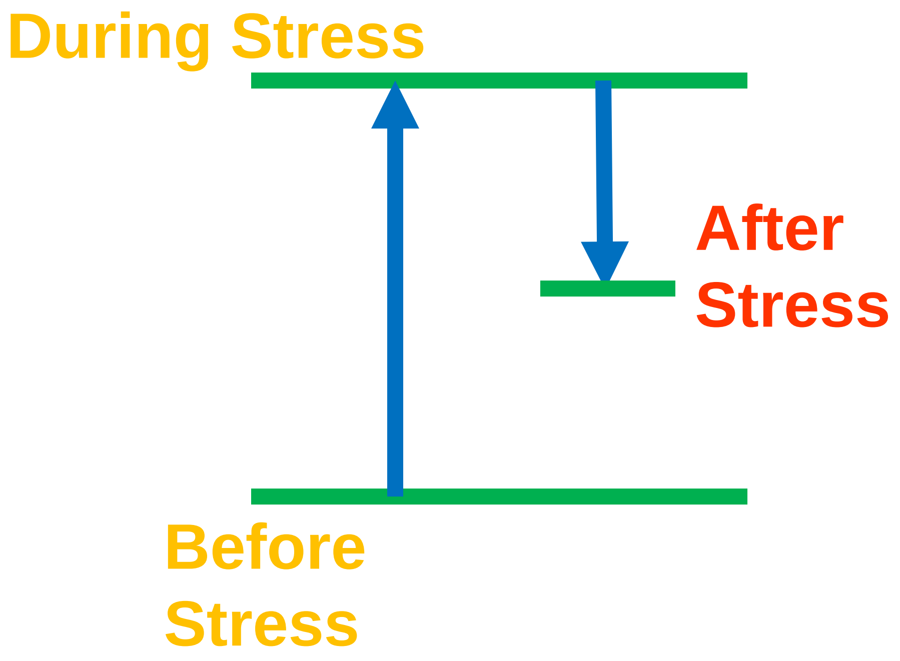
Vapor-Liquid Dynamic Equilibrium

Normally... $A(l) + B(l) \leftrightarrow C(g) + D(g)$

$$K = (P_C)(P_D)$$

- **If you decrease volume of container, P increases.**
- **Therefore Q is larger than K.**
- **Reverse reaction rate increases until you reestablish equilibrium**
- **Same K, *new* P_C and P_D values**
- Pretend K = 6
  6 = (6)(1) or (3)(2) or (6)(1), etc

Remember from Honors Chem? →



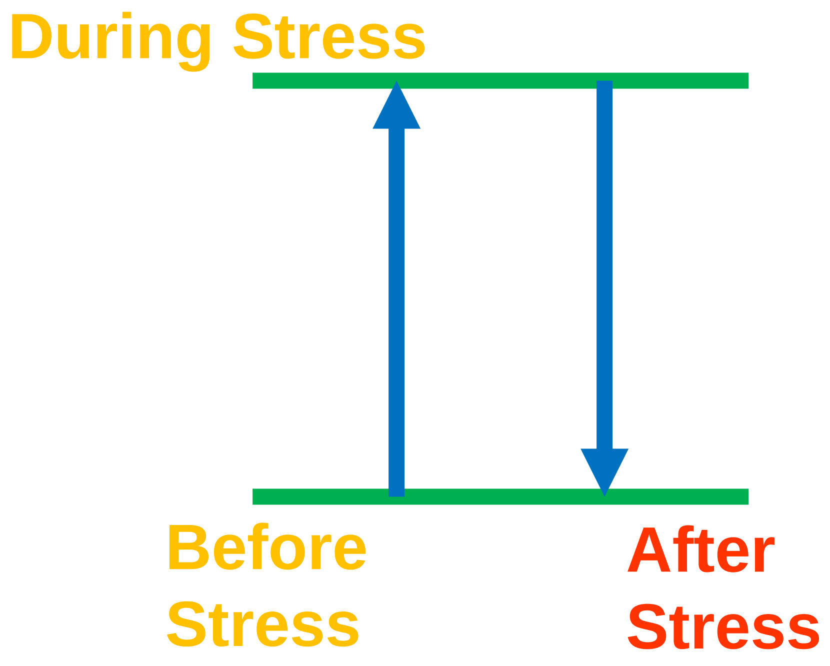
Vapor-Liquid Dynamic Equilibrium

BUT…

$$H_2O(l) \leftrightarrow H_2O(g)$$

$$K = (P_{H2O})$$

- **If you decrease volume of container, P increases.**
- **Therefore Q is larger than K.**
- **Reverse reaction rate increases until you reestablish equilibrium**
- **But your ending pressure of water <u>HAS</u> to match what it was before!!!**
- **Because there is only *<u>ONE</u>* component in your K expression!!!**
- Pretend K = 6, so P_{H2O} has to be 6 every time!



Explain Vapor-Liquid Dynamic Equilibrium

So what if this time...

If you ↑ Volume of chamber = ↓ Pressure inside chamber

Then there are fewer vapor molecules in a given volume

Causing the rate of *condensation* to slow.

Therefore, for a period of time, the *rate of vaporization* will be faster than the rate of condensation,

Causing the amount of vapor to increase.

Explain Vapor-Liquid Dynamic Equilibrium

Eventually enough vapor accumulates

Until the *rate of the condensation* increases to the point where it is once again as fast as evaporation.

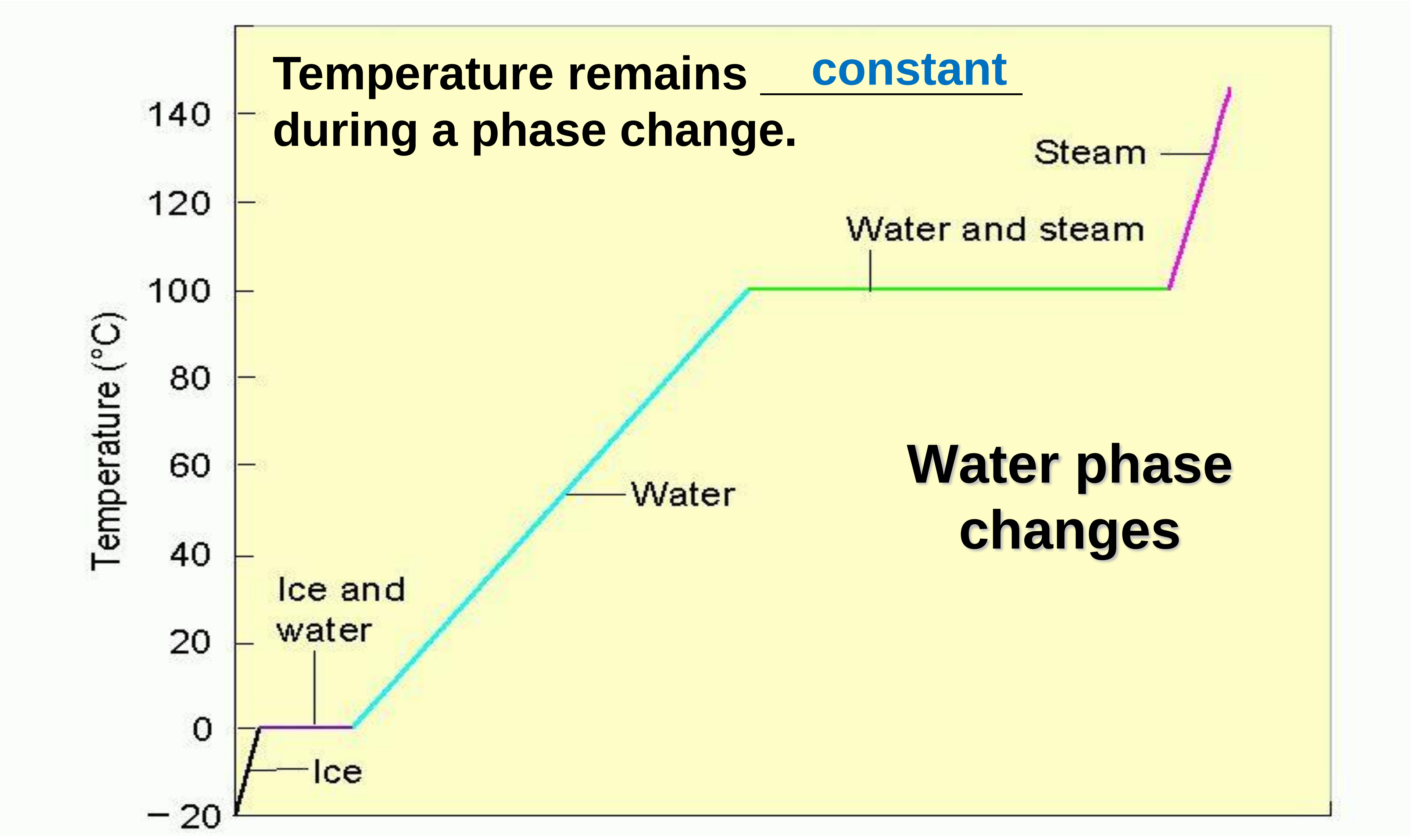
Causing equilibrium to be reestablished!

Therefore the vapor pressure will be back to the original!

This time the equilibrium point will be the SAME as it started. Different than a "normal" eq. scenario where it goes back towards the original but never reaches it.

Phase Changes

Temperature remains ___constant___ during a phase change.

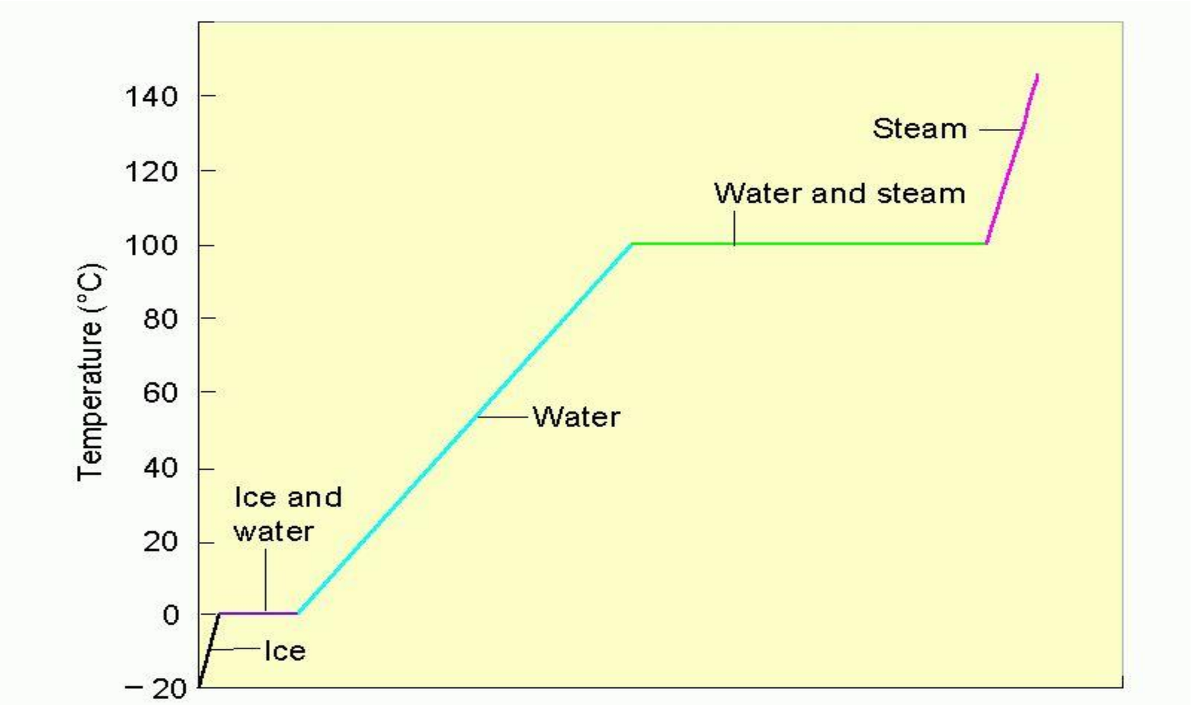


Water phase changes

Heating Curves

REVIEW THE HONORS CHEM MATERIAL!

Not going to cover it again...but it will show up on exams!



Phase Diagrams

Represents phases as a function of temperature and pressure.

Phase Diagrams

Critical temperature: temperature above which the vapor can not be liquefied.

Critical pressure

Pressure required to liquefy AT the critical temperature.

Critical point

Critical temperature and pressure

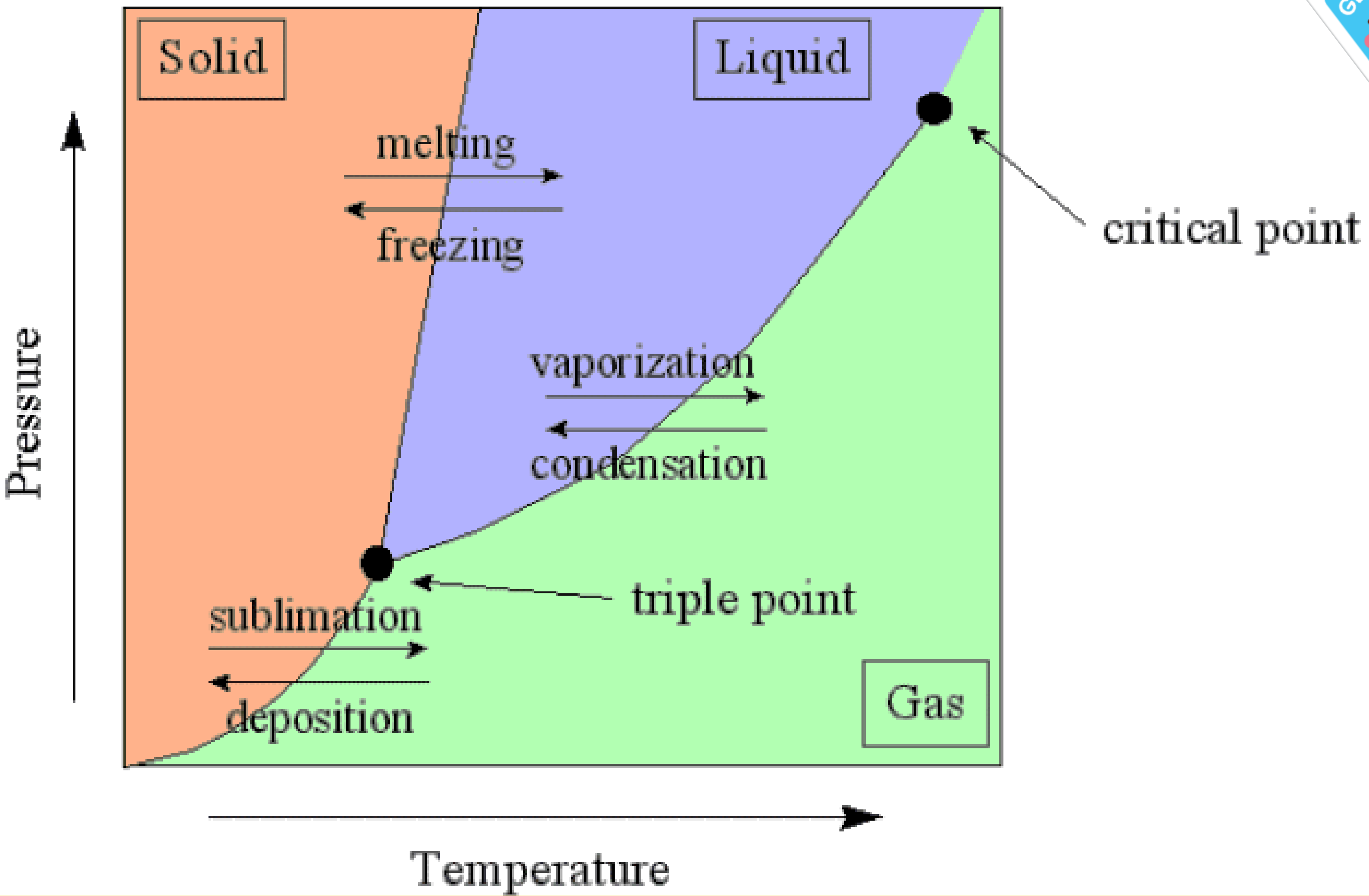
(for water, T_c = 374°C and 218 atm).

Phase Diagrams

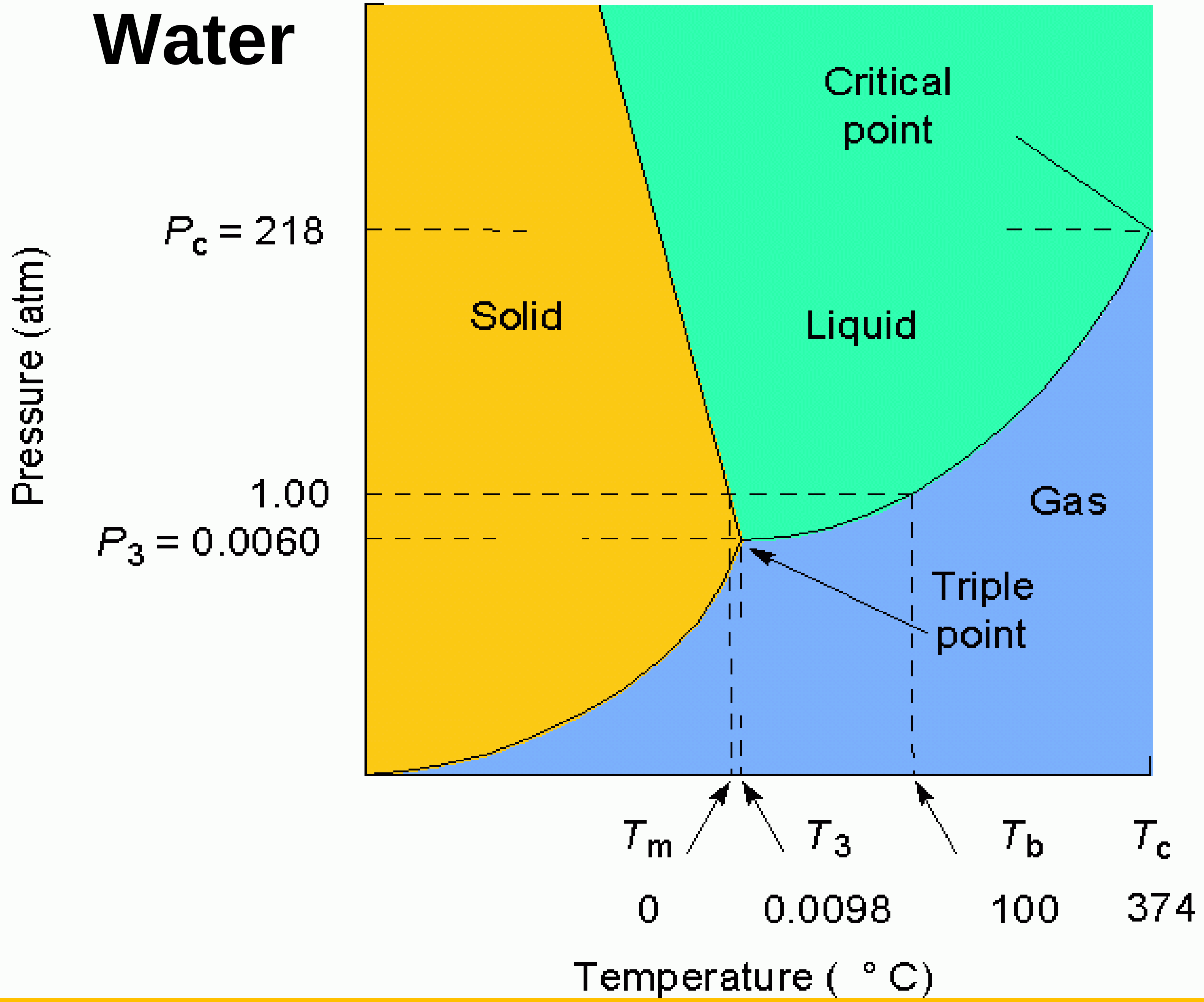
Triple Point

The point at which all three phases are present at the same time.

Phase Changes by Name



Water

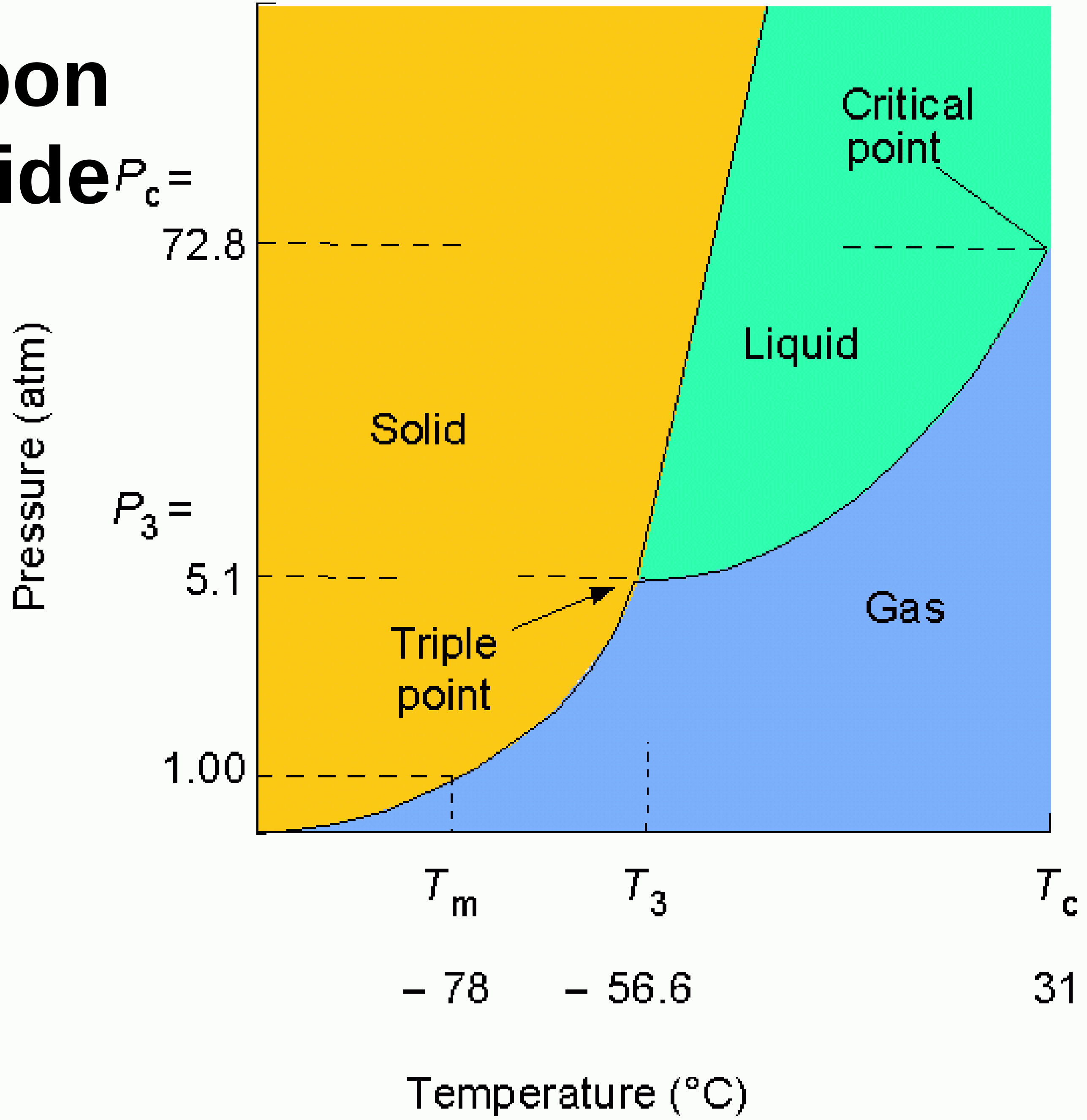


Do you notice how the slope between solid and liquid has a negative slope?

That is not common.

Its because the solid phase of water is less dense than the liquid.

Carbon dioxide

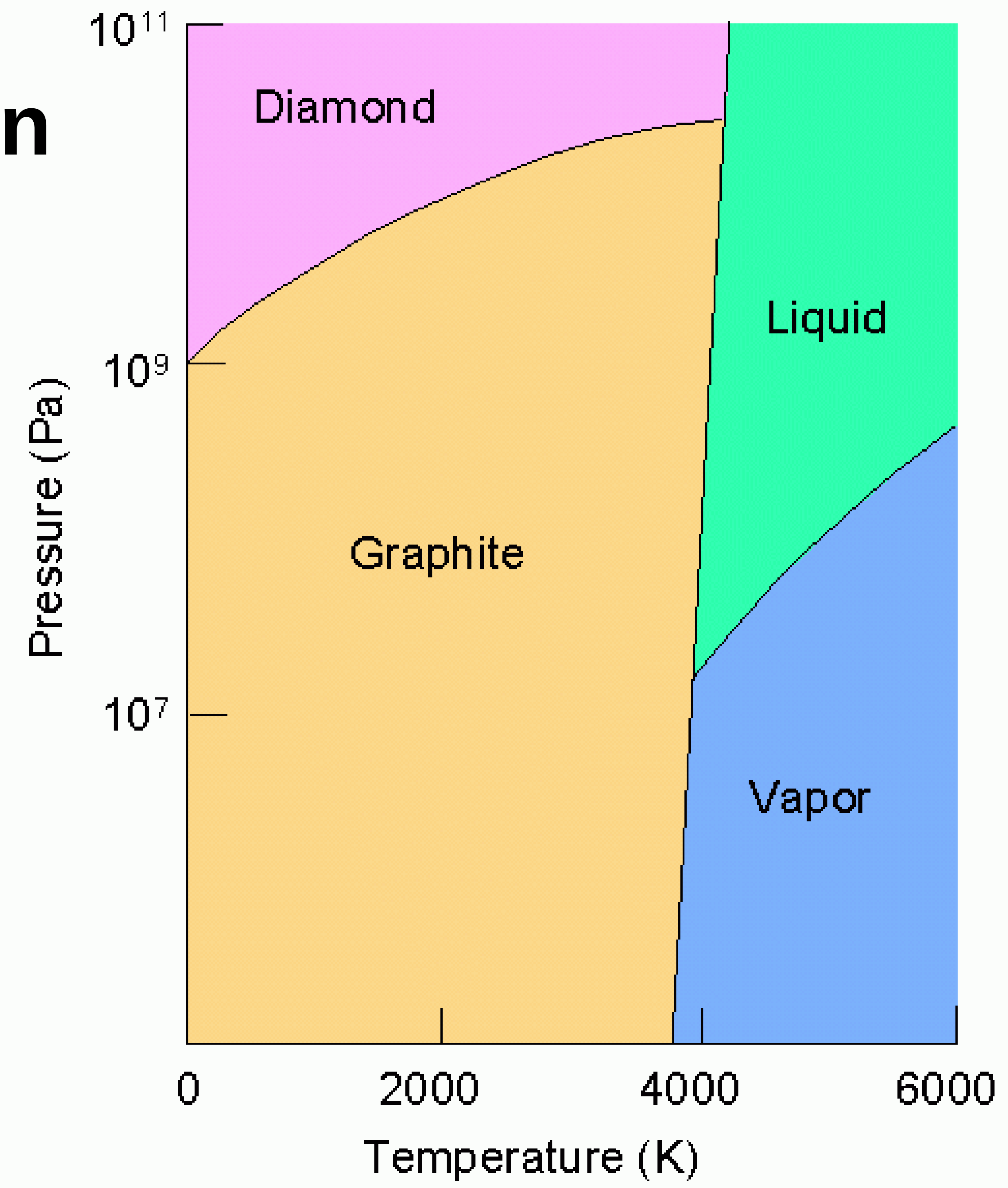


This time the slope between solid and liquid is a positive slope.

More common.

Solid is more dense than the liquid.

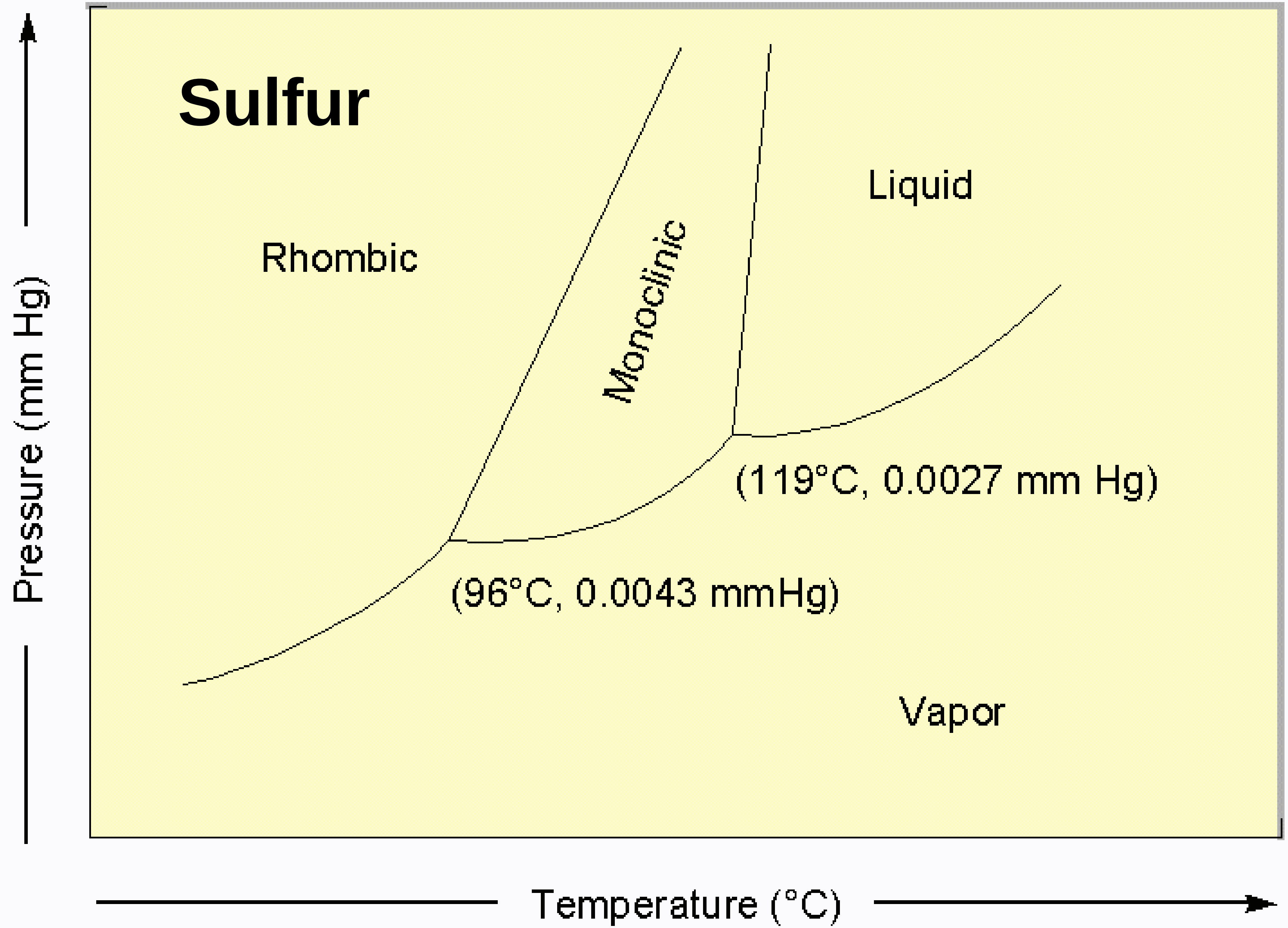
Carbon



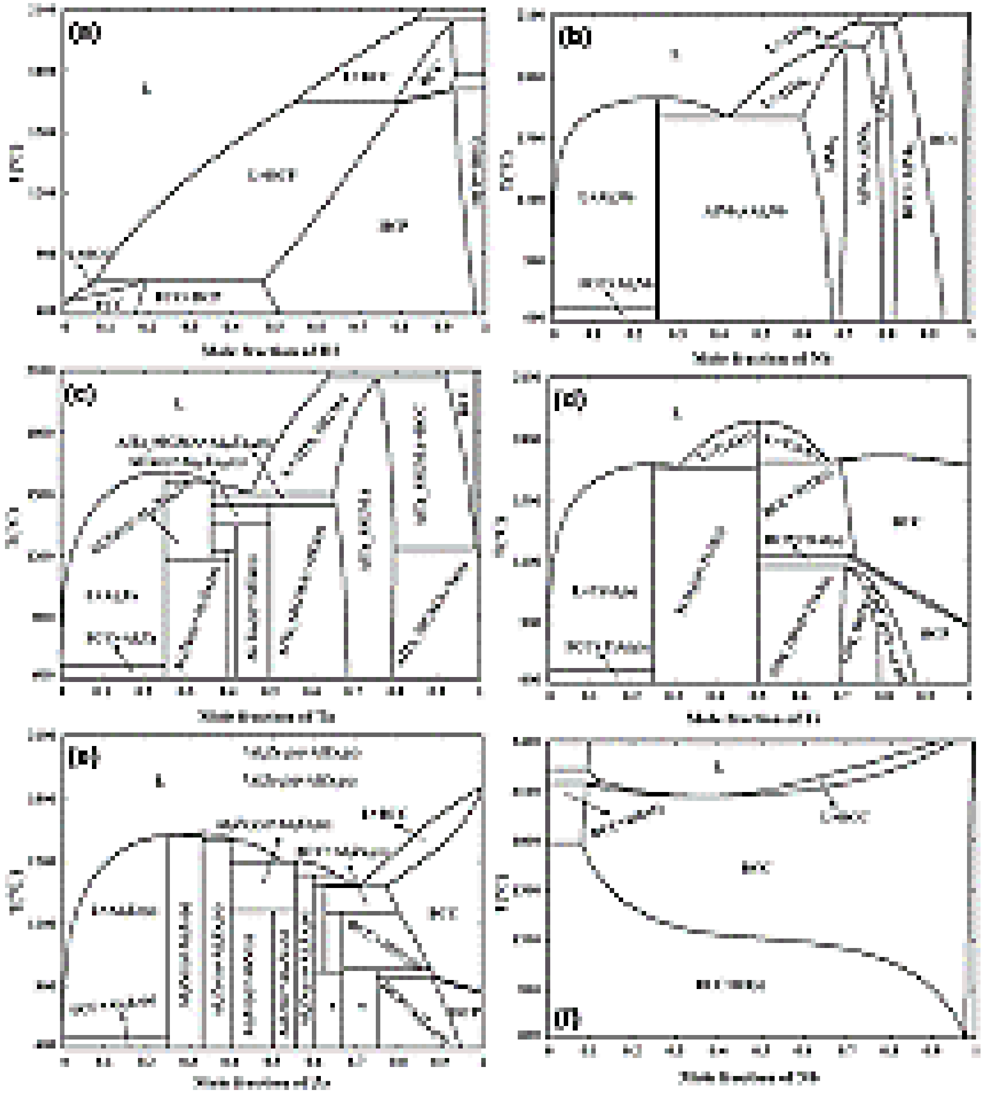
Some substances have more phases than we are used to seeing because there might be different versions of the solid. Different crystal structures.

See how carbon can be diamond or graphite when solid?

At higher pressures it is diamond.


Sulfur
Rhombic
Monoclinic
Liquid
Vapor
(119°C, 0.0027 mm Hg)
(96°C, 0.0043 mmHg)
Pressure (mm Hg)
Temperature (°C)

They get REALLY crazy!



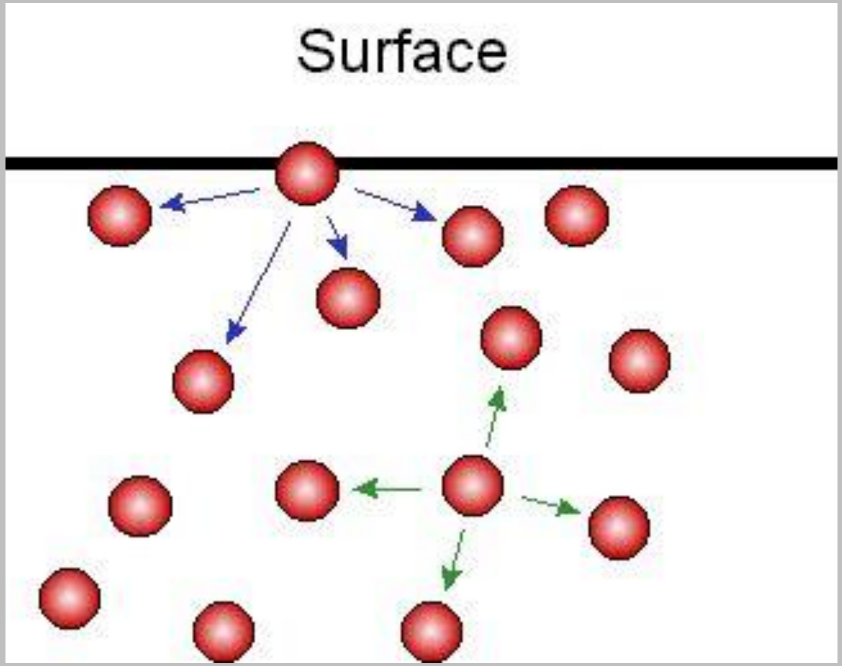
YouTube Link to Presentation:

https://youtu.be/LTxUFe7jlV4

Can stop here!

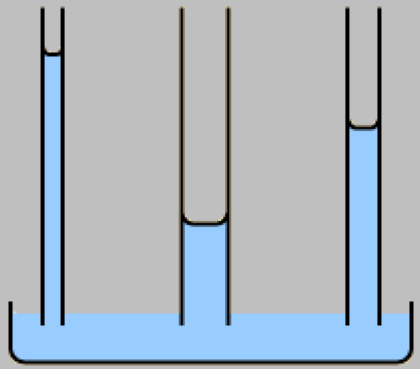
Different types of crystal structures are not covered anymore. You can keep going if interested though!

Some Properties of a Liquid



Surface Tension: The resistance to an increase in its surface area (polar molecules, liquid metals).

Capillary Action: Spontaneous rising of a liquid in a narrow tube.



Some Properties of a Liquid

Viscosity:
Resistance to flow

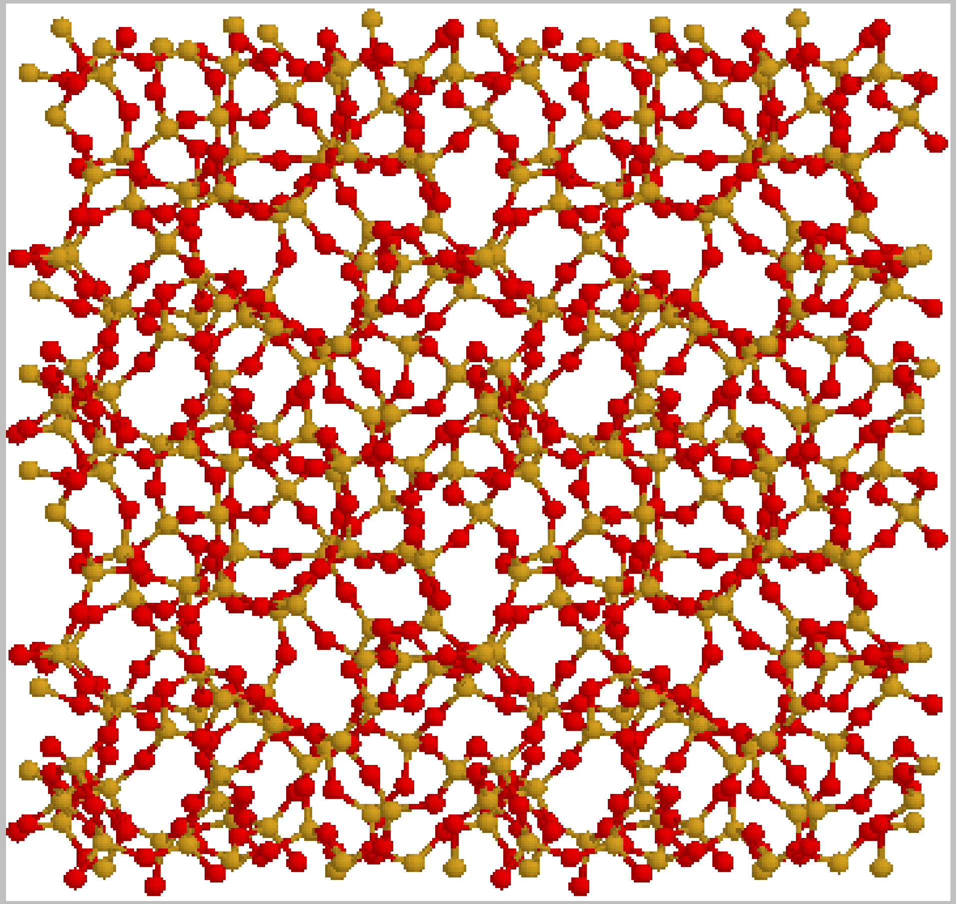
High viscosity is an indication of strong intermolecular forces

Types of Solids

Crystalline Solids:
highly regular arrangement of their components

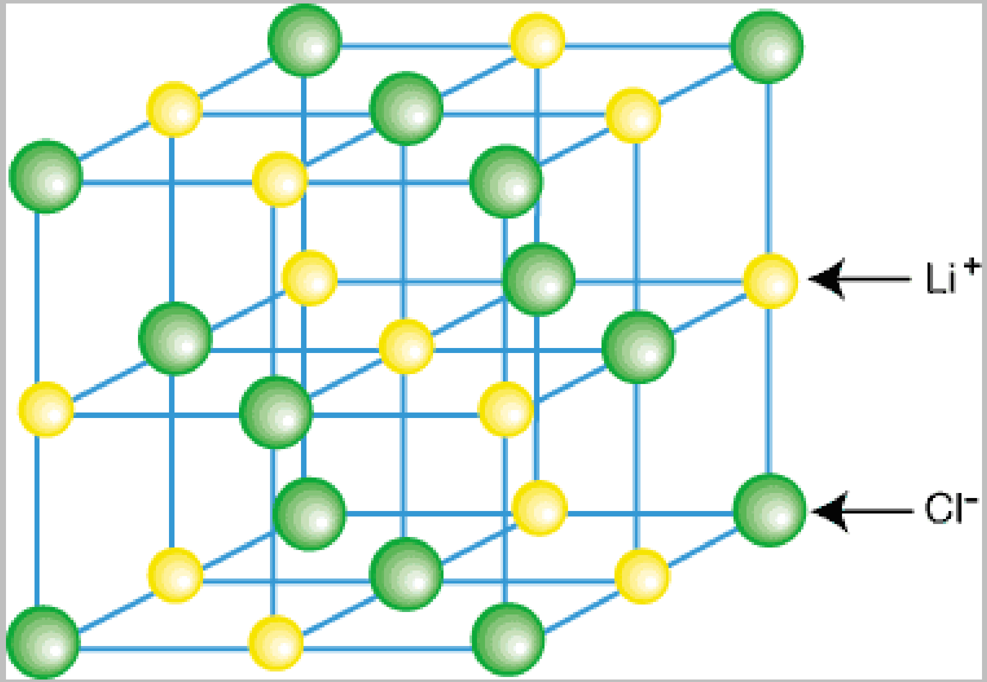
Types of Solids

Amorphous solids:
considerable disorder in their structures (glass).

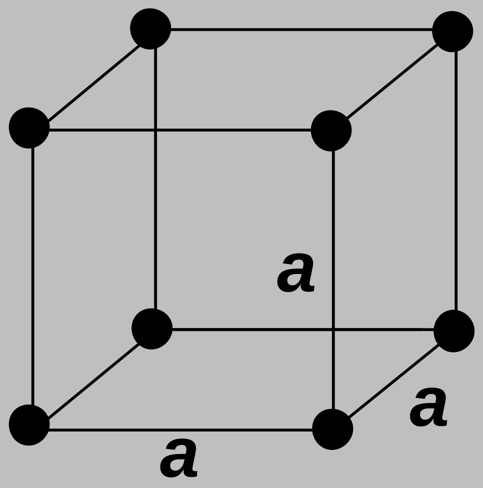


Representation of Components in a Crystalline Solid

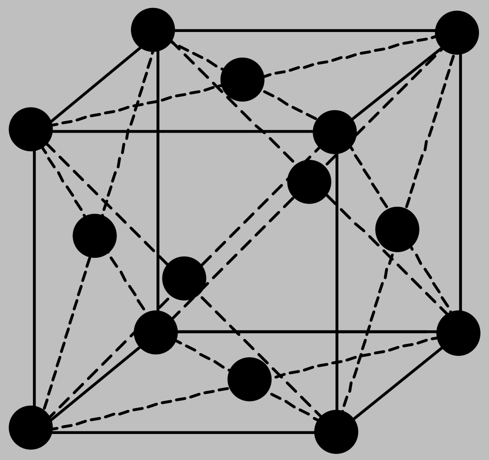
Lattice: **A 3-dimensional system of points designating the centers of components (atoms, ions, or molecules) that make up the substance.**



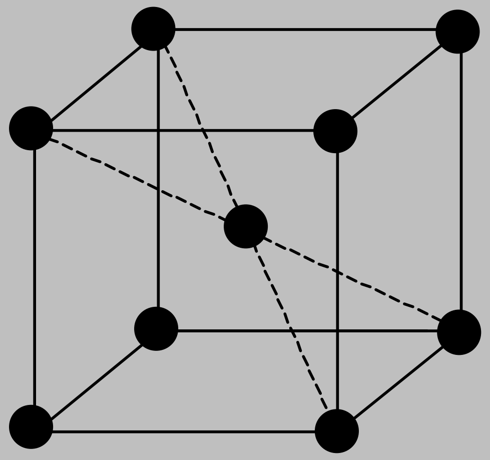
Crystal Structures - Cubic



Simple

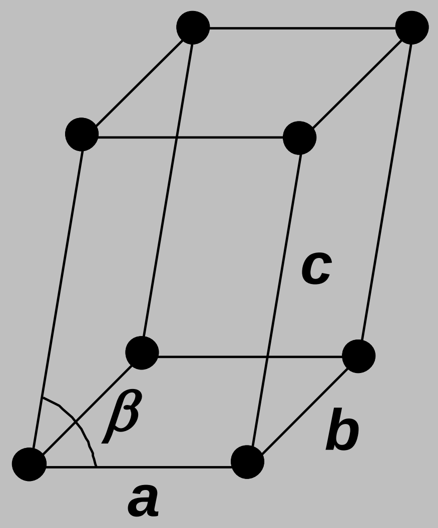


Face-Centered

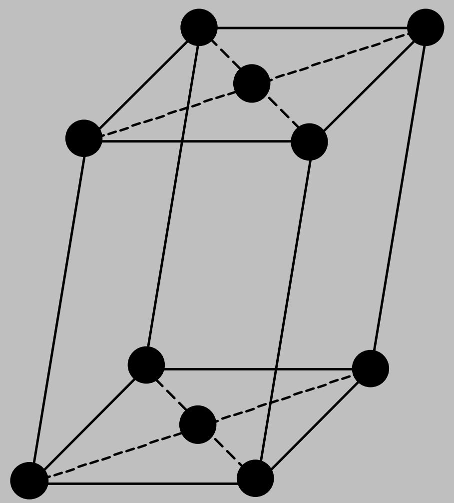


Body-Centered

Crystal Structures - Monoclinic

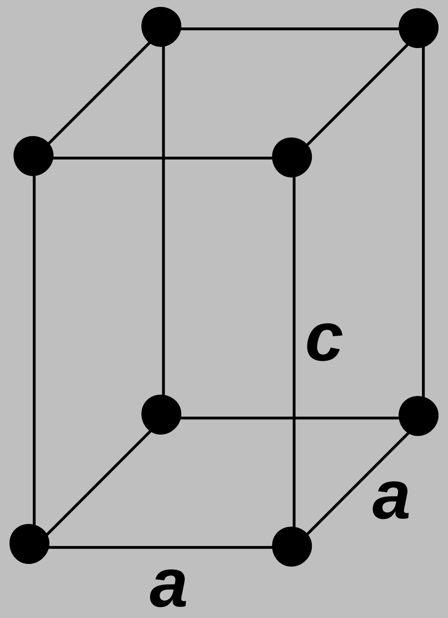


Simple



End Face-Centered

Crystal Structures - Tetragonal



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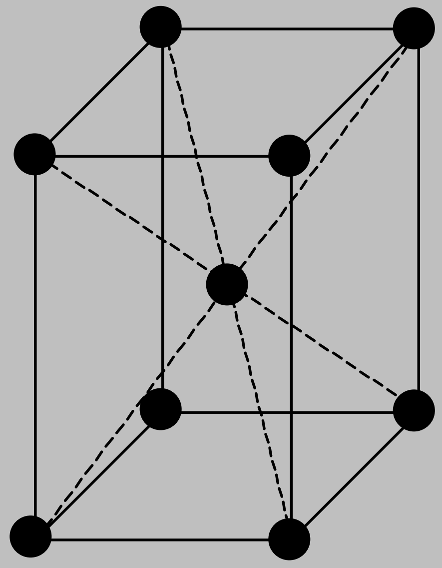
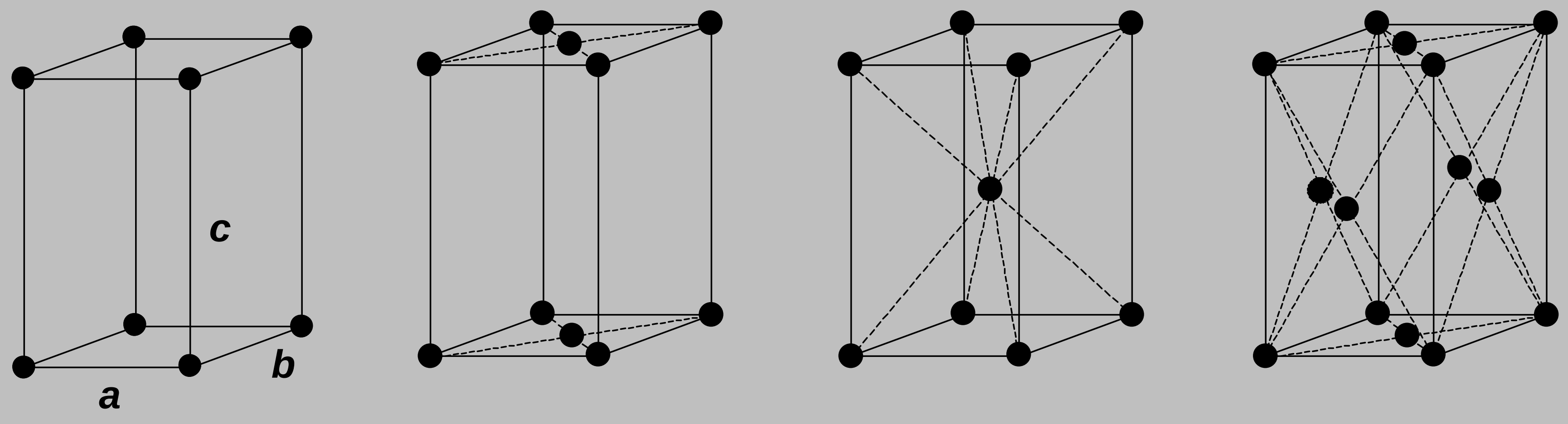


Body-Centered

Crystal Structures - Orthorhombic



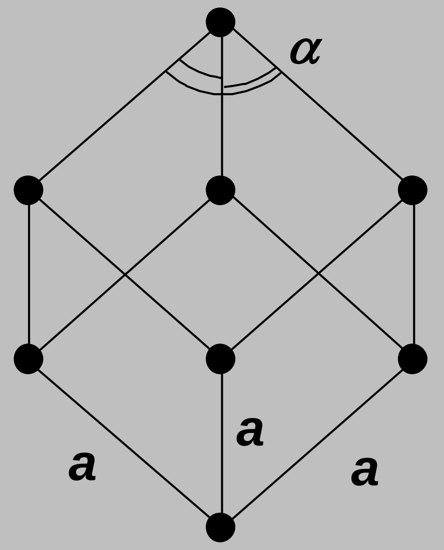
Simple

End Face-Centered

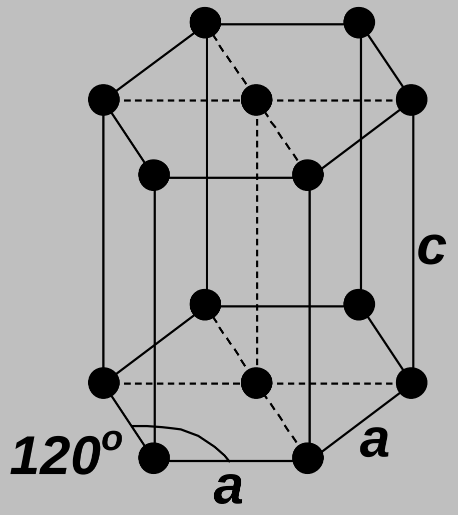
Body Centered

Face Centered

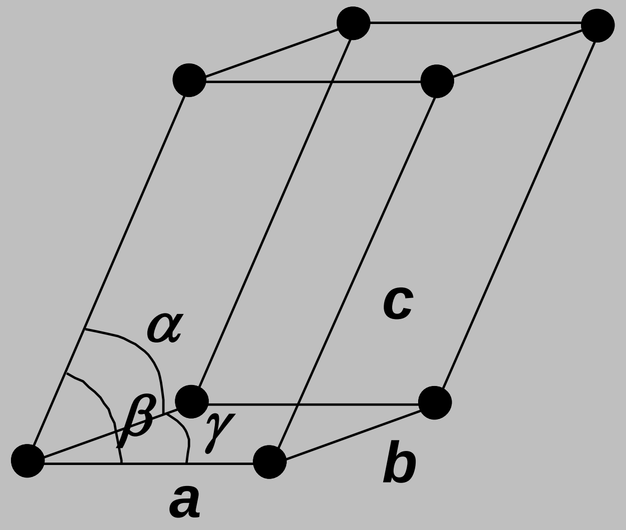
Crystal Structures – Other Shapes



Rhombohedral

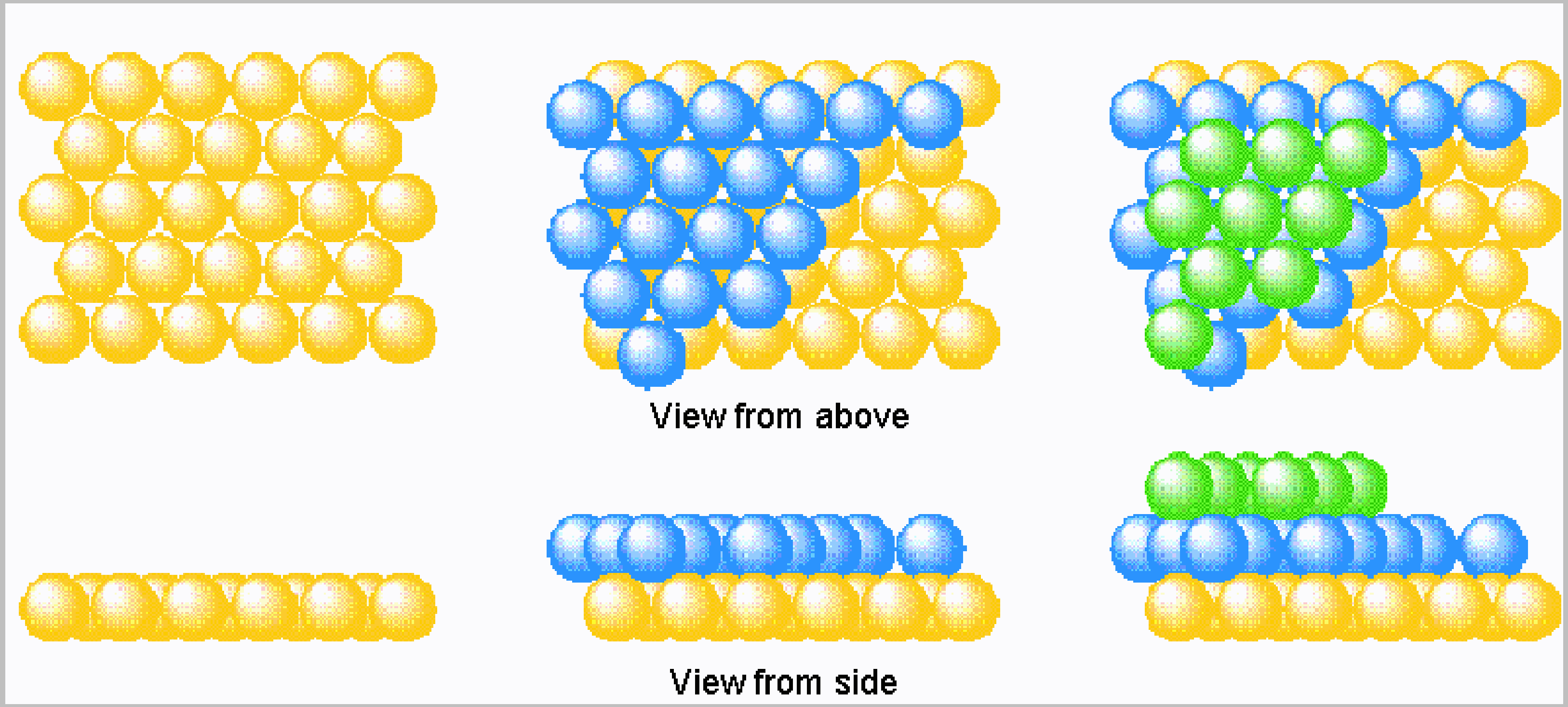


Hexagonal



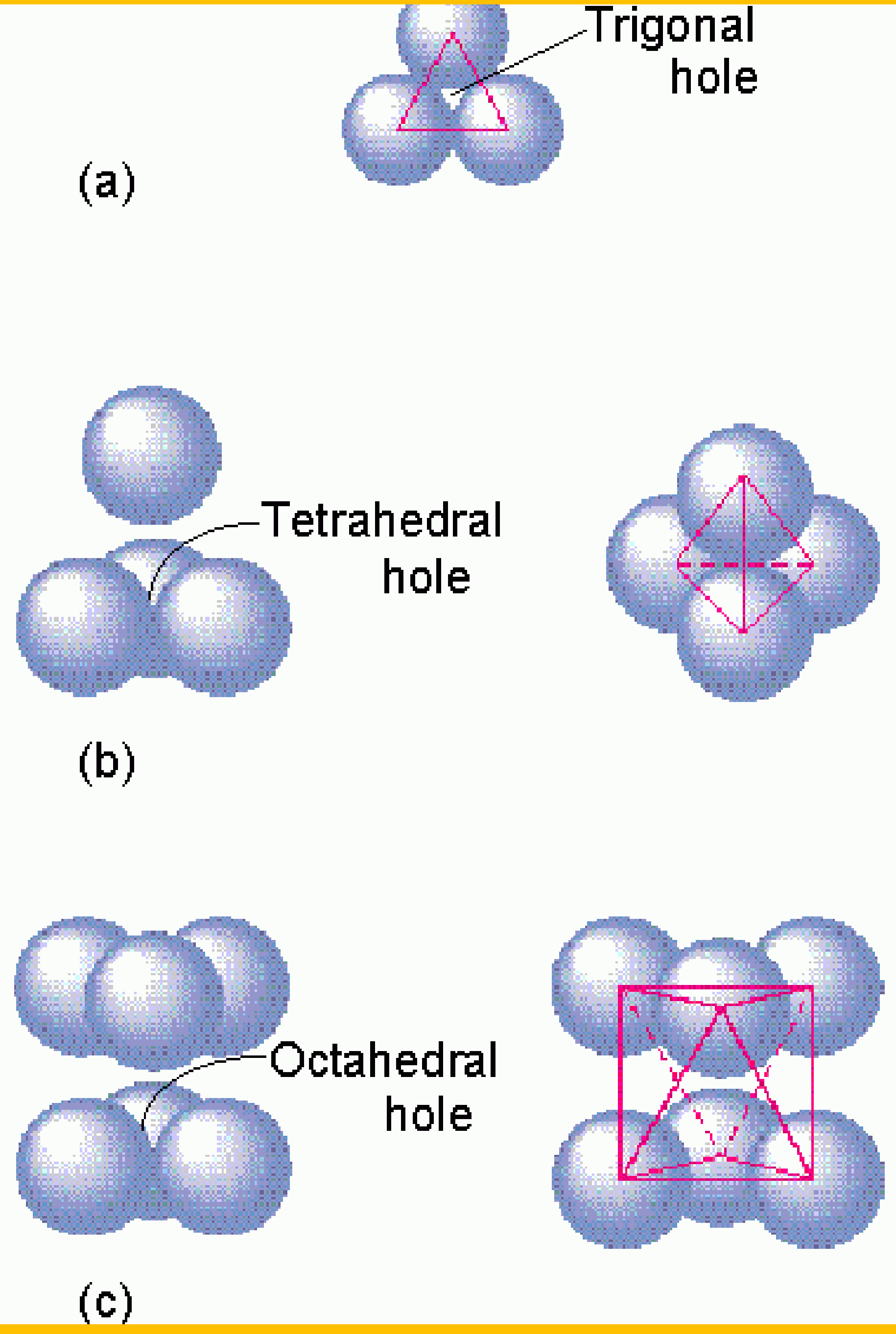
Triclinic

Packing in Metals



Packing uniform, hard spheres to best use available space. This is called closest packing. Each atom has 12 nearest neighbors.

Closest Packing Holes

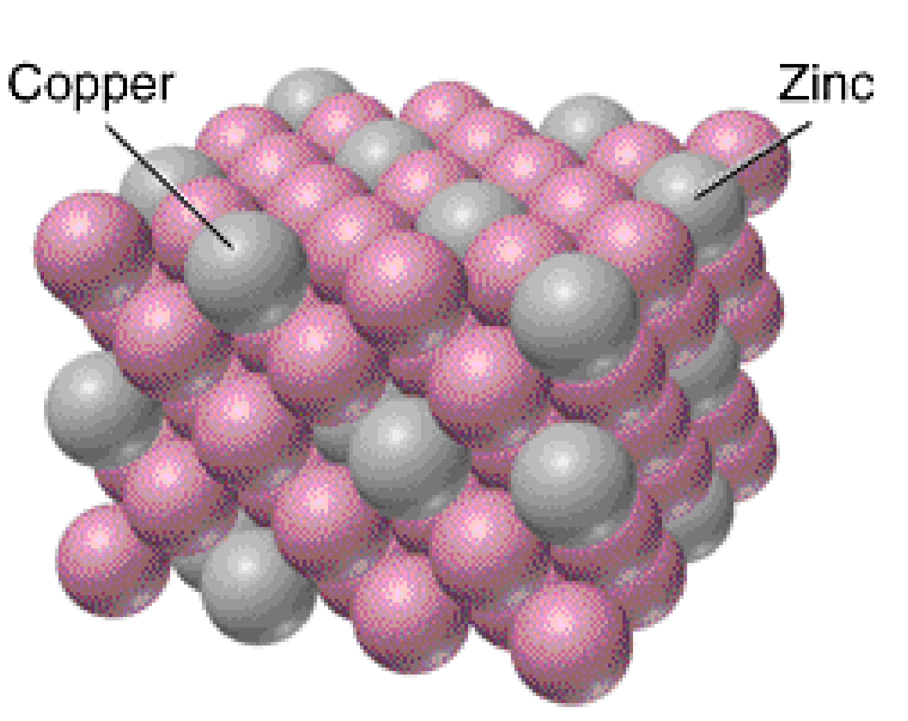


Metal Alloys

Substitutional Alloy: some metal atoms replaced by others of similar size.

Brass = Cu/Zn

Bronze = Sn/Cu

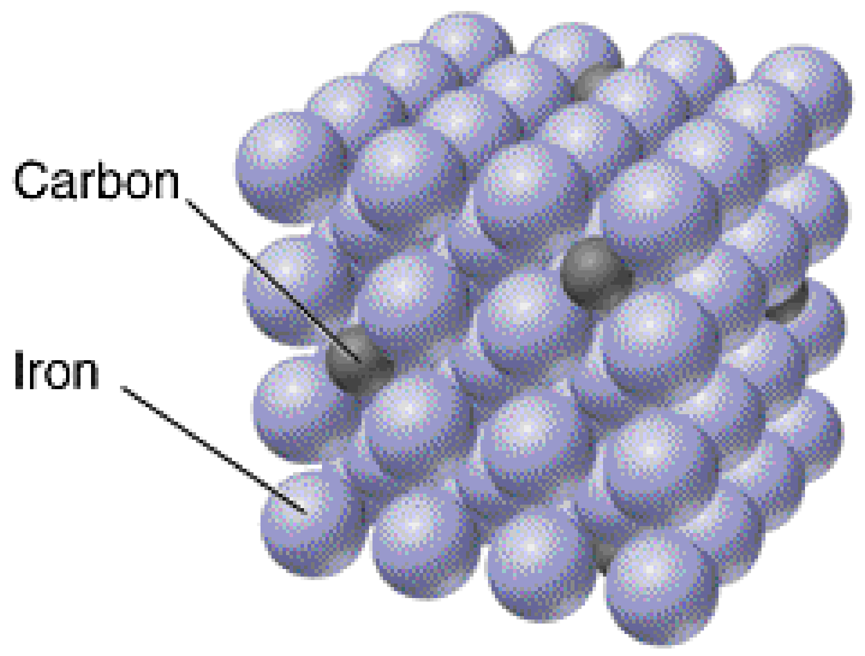


A Brass, a substitutional alloy

Metal Alloys

Interstitial Alloy: **Interstices (holes) in closest packed metal structure are occupied by small atoms.**

- **steel = iron + carbon**



B Carbon steel, an interstitial alloy