

All matter is composed of small, fast moving particles. Gases, solids, and liquids differ in IMF and compressibility

---**Compressibility** – gasses are compressible, liquids and solids are not

---**Diffusion** – gasses diffuse much quicker than solids/liquids because the new substance can travel relatively farther between collisions than with solids/liquids. Fewer interruptions, greater **Mean Free Path (Average travel time)**

---**Volume** – gases expand, liquid retains volume, solids retain both shape and volume. Solids/liquids have more IMF

Although gases do have IMF's, they have little effect, esp. London and dipole, since the atoms are so spread out

---**Surface Tension** – the amount of energy needed to expand the surface area of a liquid. Molecules on the surface are being pulled downward (3 directions instead of 4) and therefore need energy to rise to the top. Since the molecules at the top have higher PE than those not at the surface, liquids try to lessen surface area, and the shape with the least surface area is a sphere. Surface tension is **indirectly proportional to the temperature** (higher KE, easier to escape), **prop to IMF's**

---**Evaporation** – molecule's escape through the surface as vapor. Need high enough KE to overcome IMF's.

Sublimation – direct from solid – gas. As liquid evaporates, temperature drops (as the molecules with high KE leave, the average KE drops, and temp is prop to KE). **The Evaporation rate is proportional to the temp, surface area, but indirectly prop to the amount of IMF's**

---**Dipole Dipole** – Polar molecules, +/- attract. 1% the strength of normal covalent bonds. In a gas, the molecules are too far apart, so the dipole attract has little or no effect.

---**Hydrogen Bonds** – a really strong Dipole, Hydrogen bond covalently to N, O, and F to form REALLY polar molecules

---**London Forces** – The electron cloud becomes “uneven,” or more electrons on one side than on another, called a polarized electron cloud. Creates instantaneous dipoles, but only last for a moment due to the movement of the electrons. Much weaker than other types of bonding. C₈H₁₈ has more London force than CH₄, longer chain, more places to bond. Also, the larger the molecule, the less +/- attraction of electrons, more easily polarized electron cloud, easier to get instantaneous dipoles

---**Heat of Vaporization - H_{VAP}** – to keep the temperature constant when evaporation is taking place, addition heat must be added. H_{VAP} is the amount of energy required to evaporate 1 mol of liquid. $H_{VAP} = H_{VAPOR} - H_{LIQUID}$. Deals with PE, needed to turn liquid – gas. **As IMF's increase, H_{VAP} increases (More attraction, more NRG required)**

---**Vapor Pressure of Liquid – THE VAPOR PRESSURE AT A CONSTANT TEMPERATURE IS INDEPENDENT OF THE VOLUME OR AMOUNT OF LIQUID.** When the volume of the system changes, the rate of evaporation does not, so even though it disturbs the equilibrium, as long as there is water left to reestablish equilibrium, the rate of evaporation will ALWAYS equal the rate of condensation, and the vapor pressure will remain constant. To measure vapor pressure, use a barometer, and add liquid to it, then use the difference in the readings to find vapor pressure. The Vapor pressure is dependent on the Rate of Evaporation, because if rate of evaporation is low, rate of condensation is also low, so the vapor pressure is low. **It is also indirectly proportional to the IMF's (slow rate of evap, low vapor pressure), and directly proportional to the temperature (higher KE, more molecules escape, more evap, higher pressure).** The Vapor Pressure, if graphed, is a curve that is not infinite. As vapor pressure rises, the gas gets denser, while the liquid becomes less dense. Eventually, they will be equal at the **CRITICAL POINT**, with a **CRITICAL PRESSURE**. Above this point, everything exists as a gas. To condense, must be under critical point

---**La Chatelier's principle** – When an equilibrium is disturbed, the system will try to change to regain equilibrium.

---**Boiling Point** – When bubbles start forming in the water. **Vapor Pressure of water must equal the atmospheric temp.** When something boils, the temperature does not change. Adding more heat just causes more bubbles and causes more evaporation, but temperature doesn't change. **The higher the atmospheric pressure, the higher the boiling point. The higher the IMF, the higher the boiling point (More KE needed to escape and evaporate)**

---**Heat of Crystallization** – amount of energy needed to freeze 1 mol of liquid. **Heat of Fusion** – amount of energy needed to melt 1 mol of solid. Same number, just one positive, 1 negative. When going from solid – liquid, the molecules move apart slightly, so little energy is needed. To go from liquid to gas, move apart a lot, so more NRG needed

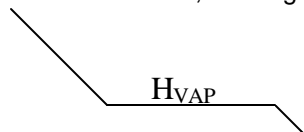
---**Molecular crystals** – individual atoms at lattice points, London forces, Dipole, H-Bonds. Small lattice energy, easily deformed, soft, low melting points. Bad conductors due to e-'s are bound to molecules and can't move around freely

---**Ionic** – Ions at lattice points, bonded by electrostatic (non-directional) bonds. When crystals form, they move themselves to maximize attractions and minimize repulsion. Strong electrostatic, high lattice energy, hard, high melting points, brittle, tend to shatter due to ions slip by one another, pattern gets disrupted, starts repelling instead of attracting. Bad conductors in solid form since ions are held in place, but good in aqueous solution

---**Covalent** – everything bonded to everything else, ultra high melting points, ultra hard, bad conductors

---**Metallic** – positive ions at lattice points, held by electrostatic between + ions and a sea of electrons. e-' move around freely, so they're good conductors. They range from hard to soft, low to high melting points, and high luster

---When solids reach their melting point, the temperature becomes constant, so no KE change, but PE begins to rise. When all the solid melts, KE begins to rise again.



---**Super cooling** – for some liquids, the molecules aren't arranged correctly to form crystals. Goes below Freezing Point. When a small crystal gets in place, it acts as a seed, releases the PE, KE rises back to FP, and freezing begins

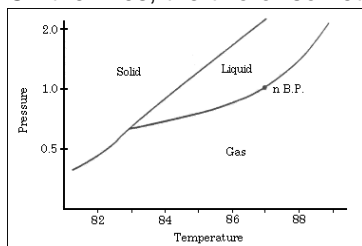
---**amorphous solid** – a supercooled solid that still moves so slowly they never find their crystal shape. Glass and plastic are two examples

---**Vapor Pressure of Solids** – similar to those of liquids, but much smaller due to tiny evaporation rate

---**Phase Diagrams** – points bordering solid – gas, both states, sublimation, two phases at equilibrium

Triple Point – all three phases coexist in equilibrium with each other simultaneously.

On the lines, the two or sometimes three phases are coexisting simultaneously, in equilibrium with each other.



Le Chatelier said that when pressure is increased, it would lead to a denser phase. The rise in pressure leads to the packing of molecules. If one starts at where the solid/liquid are at equilibrium, or at the triple point, and increase the pressure at constant temperature, it should encounter a denser phase. Water, with the curve slanting to the left, is denser as liquid than solid. However, most are like this one, to the right, so solid more dense than liquid.

Questions that I can't answer

Dealing with Vapor Pressure, above the critical point, everything is a gas, right?

Why does the boiling point increase with an increase of IMF's?

Is the critical point of the phase diagram same of the critical point of the vapor pressure. If not, what's the difference?