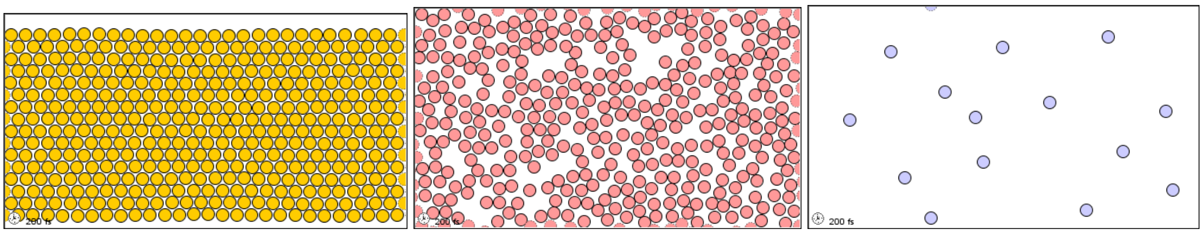
4.6: Phase Transitions

We have now looked at the physical properties which chemists use to define the solid, liquid, and gas phases. In a solid, atoms, ions or molecules, are locked into an organized, long range lattice structure, unable to move beyond an average position due to intermolecular forces. In a liquid, this structure breaks down, molecules can slip past each other, but they are still held together by attractive forces. In a gas, these attractive forces are overcome, and the substance expands to fill space, each particle having gained mobility to break free of the others. Below, all 3 phases are shown at the submicroscopic level in animations. Notice how the movement and freedom of molecules steadily increases as attractive forces decrease from solid to liquid to gas phase.



Substances can be transformed from one phase into another. Solids melt into liquids and liquids boil to form vapors at temperatures which depend on their molecular properties, so chemists are interested in these transitions between phases. We are all familiar with the changes in macroscopic properties that accompany these transitions. YouTube has time lapse movies of ice melting on a small scale, or of the more environmentally critical arctic ice melt from 1979 to 2007.

This is a familiar process. As the solid melts, the resulting liquid is able to flow and conforms to the shape of the container. Heat from a flame is needed to bring about this transition. On a microscopic level melting involves breaking the intermolecular interactions between molecules. This requires an increase in the potential energy of the molecules, and the necessary energy is supplied by the Bunsen burner. Melting (or freezing) can, in some cases, be caused by changing just the pressure.

Boiling is equally familiar. Under specific temperature and pressure conditions, liquids start to bubble, and are converted to a gaseous form. A YouTube video "Boiling water with ice" shows that water boils at low temperatures if the pressure is reduced. Heat energy is absorbed when a liquid boils because molecules which are held together by mutual attraction in the liquid are jostled free of each other as the gas is formed. Such a separation requires energy.

In general the energy needed differs from one liquid to another depending on the magnitude of the intermolecular forces. We can thus expect liquids with strong intermolecular forces to boil at higher temperatures. It should be noted as well, that because there is a distribution in the kinetic energies of molecules, an equilibrium between gas and liquid phase is established at temperatures other than the boiling point, and this behavior is another aspect of phase transitions that chemists study.

For phase transitions from solid to liquid, liquid to gas, or solid to gas, energy is required because they involve separation of particles which attract one another. Further, we can predict under which conditions of temperature and pressure such transitions will occur.

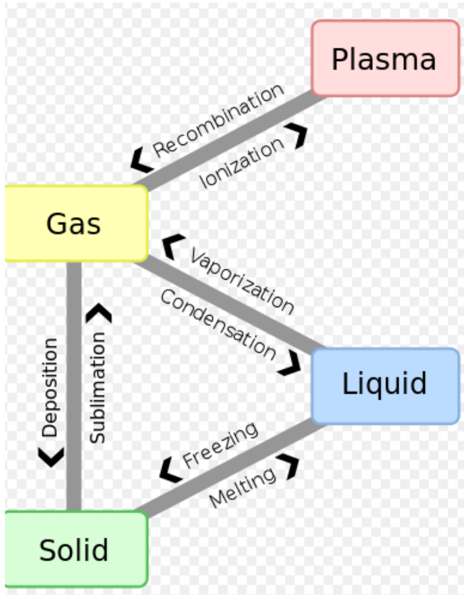


Figure 10.8.1 The figure above shows the transitions between phases and the corresponding names for each transition.