Introduction to Phase Changes and Intermolecular Forces

There are three states of matter; gas, liquid and solid. A change between these states is called a **phase change** or phase transition. Note that the terms 'state' and 'phase' are not interchangeable. There are only three states, but there can be many phases (e.g., diamond, graphite and 'bucky balls' are different phases of carbon in the solid state). Changes of state involve changes in the arrangement of molecules with respect to one another and NOT changes within the molecules themselves. Changes of state are governed by the strength of attractive forces between molecules (called intermolecular forces).

G → L → S

Characteristics of Gases, Liquids and Solids

GASES	LIQUIDS	SOLIDS
No definite shape (fill containers completely)	No definite shape (assume shape of containers)	Definite shape (resist deformation)
Highly compressible Lots of 'empty space'	Definite volume (slightly compressible)	Nearly incompressible
Low density (~ g/L)	High density (~ kg/L)	Usually higher density than liquids
Fluid	Fluid	Not Fluid
Diffuse rapidly	Diffuse rapidly	Diffuse only very slowly
Extremely disordered	Disordered clusters of particles	Highly ordered arrangement of particles
Rapid random motion (rotation, vibration & translation)	Random motion in three dimensions (rotation, vibration & translation)	Very limited motion (vibration only)

INTRAMOLECULAR FORCES:

INTERMOLECULAR FORCES:

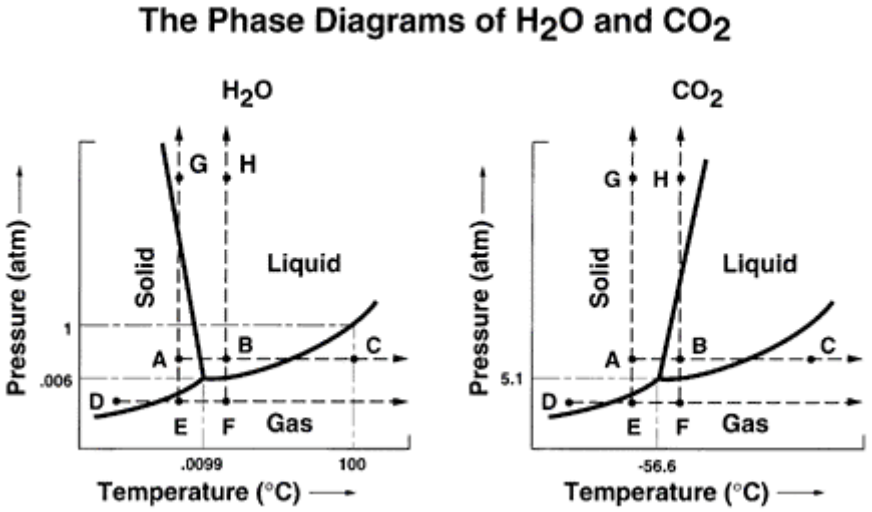
Phase changes go by many names:

Liquid → Solid is referred to as freezing, solidification or crystallization.
Solid → Liquid is referred to as melting or fusion.
Liquid → Gas is referred to as evaporation, boiling or vapourization
Gas → Liquid is referred to liquification or condensation.
Solid → Gas is called sublimation.
Gas → Solid is called deposition.

Do not confuse these processes with those involving solutions. Solid solutes depositing from solution is called precipitation. The process of dissolving a substance in a liquid is called dissolution or if we are dealing with two liquids, we could say that they are miscible or mutually soluble.

Phase Diagrams

It is common to represent the different phases of a given substance as a function of both pressure and temperature on a single diagram called a **phase diagram**. The set of pressure and temperature conditions under which a substance undergoes a phase change are represented by solid lines (phase boundaries) on the phase diagram. Crossing a line on a phase diagram by varying either pressure and/or temperature corresponds to one of the phase changes listed above.



It is important to remember that during a phase change no chemical bonds are broken (note: 'hydrogen bonds' are <u>not</u> covalent bonds, but rather the name given to a particular type of inter-molecular forces). Phase changes occur when there are changes in the nature and magnitude of the intermolecular forces <u>between</u> molecules. Consequently, there are dramatic changes in the degree of molecular motion present that accompany a phase change. For instance, melting a molecular solid involves increasing the temperature (i.e., an increase in molecular motion) sufficiently to overcome the intermolecular forces that hold the molecules in the ordered lattice within the solid. Molecules in the liquid state have greater mobility and freedom to move with respect to one another. Molecules in the gas phase have the greatest degree of molecular motion.