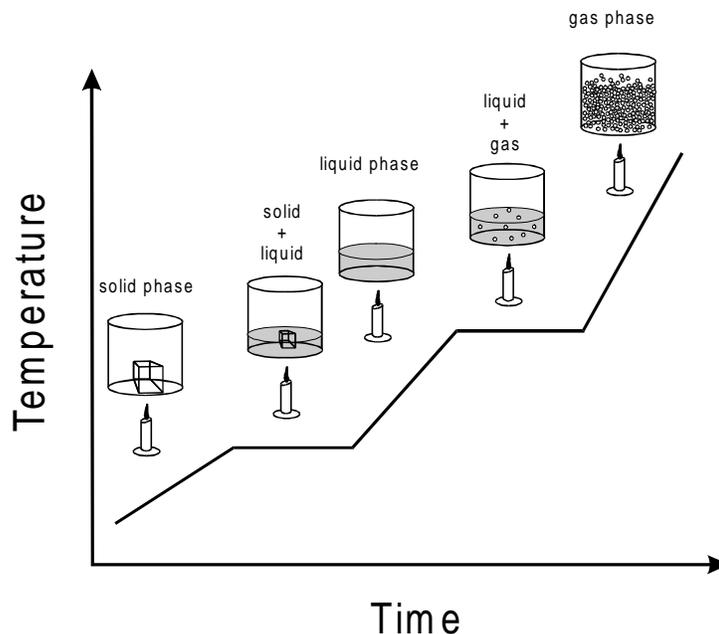


## Demonstration 4

### Latent Heat of Vaporization

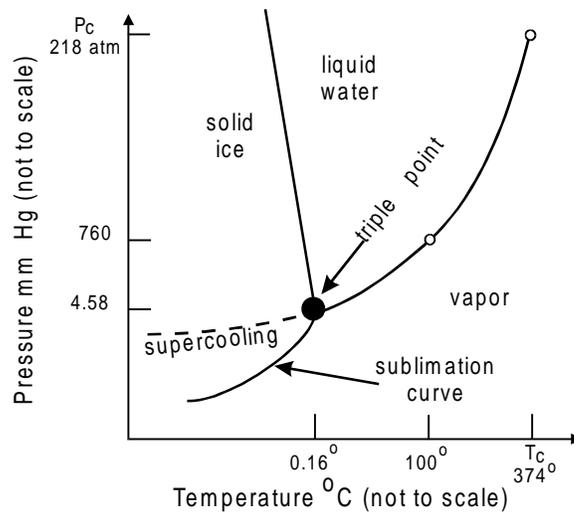
### The Triple Point of Water



When a liquid is boiling, molecules are constantly leaving the surface and in the process changing from a liquid state to a gas state. As each molecule leaves the surface it will take some thermal energy with it. The amount of thermal energy will be determined by the heat required to reach the boiling point of the liquid plus the latent heat of vaporization defined as “the quantity of heat required to change unit mass of liquid into vapor at the boiling point”.

Normally, the thermal energy necessary to reach and sustain boiling is supplied to the liquid from an external source. If instead, the liquid is made to boil by reducing the pressure over the surface with no external heat provided, the process is reversed. The molecules leaving the liquid surface and entering the gas state still require their latent heat as before; but, since no heat is being supplied, the thermal energy is obtained from the molecules that remain in the liquid state. This will result in a reduction in the kinetic energy of the remaining molecules of liquid. The loss of kinetic energy will cause a drop in the temperature of the remaining liquid.

If enough cooling occurs, the liquid will undergo yet another phase change to a solid. When all three phases are present and in equilibrium, the temperature and pressure conditions at which this occurs is called the “triple point”. Once the triple-point is reached, additional pumping will remove the gas phase and the solid phase (ice in the case of water) will remain. The triple point of water in the absence of air occurs at a temperature of  $0.16^{\circ}\text{C}$  and a pressure of 4.58 mm Hg. In the presence of air at one atmosphere, the three phases are in equilibrium at  $0^{\circ}\text{C}$ . However, since the partial pressure of water vapor is only 4.58 mm Hg, the triple point is lowered because both the solubility of air in liquid water and the increase in pressure from 4.58 mm to 760 mm lower the freezing point.



Pressure - Temperature Diagram of H<sub>2</sub>O

**Demonstration #4: Latent Heat of Vaporization**

To demonstrate the latent heat of vaporization, place a small diameter glass cylinder containing a few ml of water in the vacuum chamber. To prevent tipping, place the cylinder in another large flat-bottomed glass container.

As the pressure in the vacuum chamber is reduced, the dissolved air in the water will come out as bubbles. This is quickly followed by more violent bubbling as the water begins to boil. At the same time the temperature of the water will decrease. After the temperature has been reduced to 0.16° C, the latent heat of fusion is removed and ice is formed, thus making ice by boiling water.

The success of the experiment depends on the complete removal of water vapor as soon as it is boiled off and will only work if the pumping speed is adequate and the pump oil does not become saturated with water. To insure that the water will freeze, it is suggested that a small open container of dried desiccant be placed next to the water vessel in the vacuum chamber. The desiccant acts as a non-mechanical pump providing additional pumping capacity to the system.

