Answers to Exercise 8.1
Vapour Pressure Curves and Phase Diagrams

1.

(a) The intermolecular forces responsible for the solubility of water in acetone are dipole-dipole forces (including hydrogen bonding between H of water and O of acetone as well as hydrogen bonding between H of one water molecule and O of another water molecule).

(b) *The normal boiling points of acetone and water can be read directly off the graph. Find the temperature at which each vapour pressure curve crosses* $P = 1\ atm = 760\ mmHg$.

The normal boiling point of acetone is approximately 56 ℃.

The normal boiling point of water is 100 ℃.

While we do not expect you to memorize many normal boiling points or freezing points in CHEM 2000, we do expect you to know the normal boiling point and freezing point of water. Those two values will not typically be provided.

(c) *Again, these answers can be read directly off the graph. Find the equilibrium vapour pressure corresponding to* 20 ℃ *on each curve.*

The vapour pressure of water at 20 ℃ is approximately $17\ mmHg = 0.023\ bar$.

The vapour pressure of acetone at 20 ℃ is approximately $178\ mmHg = 0.237\ bar$.

(d) Water molecules can hydrogen bond with each other. Acetone has no hydrogen atoms bonded to N, O or F so acetone molecules cannot hydrogen bond with each other. As such, the intermolecular forces between water molecules are stronger than the intermolecular forces between acetone molecules. If the intermolecular forces are stronger, fewer molecules will have enough energy to escape the liquid phase. Thus, the vapour pressure of water is lower.

(e) The liquid acetone and acetone vapour exist in equilibrium. The stream of air reduces the vapour pressure of acetone so that more acetone must evaporate to reach the equilibrium vapour pressure. In other words, the air pushes the acetone vapour away, so more acetone has to evaporate to restore the equilibrium.

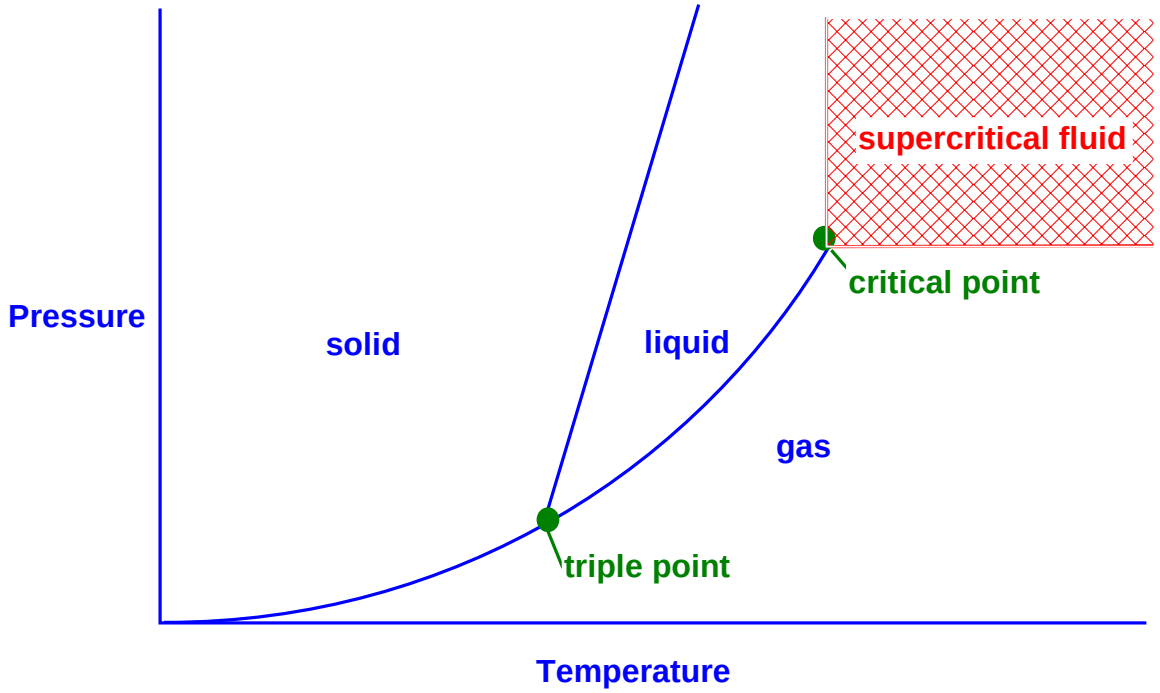
(f) Water has a much lower equilibrium vapour pressure than acetone. As such, there are fewer water vapour molecules to push away and fewer water molecules need to evaporate to restore the equilibrium. This method *would* eventually work but it might take hours!

(g) No, it isn't necessary. As long as the wet glassware is not stored in a sealed environment, the water (or acetone) will slowly evaporate until the glassware is dry.

2.

(a) A supercritical fluid is formed when the temperature and pressure both exceed a substance's critical point. It has the density of a liquid (due to the high pressure) but the high-energy particles of a gas (due to the high temperature).

(b)+(c)



3. The triple point of a substance occurs at a very specific temperature and pressure. This is in contrast with (e.g.) boiling points which vary with pressure.

The first sentence is the key point.