4.5.5 Phase Rule Examples:

Example 1: You have a container of pure liquid water (which has a density of approximately ρ=1000 kg/m^3). How many degrees of freedom?

$$C = 1, \qquad P = 1, \qquad F = C - P + 2 = 1 - 1 + 2 = 2$$

This means you can only specify two intensive variables in order to fix this system e.g. temp and pressure. Once T and P are fixed, you cannot specify another intensive variable. For example, you cannot say that you want T=20^{o}C, P=1 atm and then also specify that the density should be 1050 kg/m^3.

Example 2: Now let's say we have added a small quantity of NaCl to our liquid water (so we have an unsaturated NaCl solution). How many degrees of freedom?

$$C = 2, \qquad P = 1, \qquad F = C - P + 2 = 2 - 1 + 2 = 3$$

This means we can specify 3 intensive variables. Now you can actually specify that you want T=20^{o}C, P=1 atm, and that density should be 1050 kg/m^3. You can achieve this by adding a little over 7 mass % NaCl to liquid water

Example 3: Now let's say we have added a lot of salt to the liquid water, and there is solid undissolved salt present (i.e. the solution is fully saturated). How many degrees of freedom?

$$C = 2, \qquad P = 2, \qquad F = C - P + 2 = 2 - 2 + 2 = 2$$

This means we can only specify 2 degrees of freedom. If you specify T=20^{o}C, P=1 atm, you can't also specify that we want the density to be = 2000 kg/m^3. This is because you cannot change the concentration of salt in the phases present by adding more salt. The liquid phase is saturated with salt. Adding more salt will not change the salt concentration in the liquid phase. Any extra salt that is added will just accumulate as a solid. The solid phase will grow in size, but its composition will remain as 100% salt. The density will never be 2000 kg/m^3.

Example 4: Now add ice cubes to a supersaturated salt solution containing solid salt. At equilibrium, how many degrees of freedom do you have?

$$C = 2, \qquad P = 3, \qquad F = C - P + 2 = 2 - 3 + 2 = 1$$

This means you can only specify one degree of freedom. In this case let's say that it is a pressure of 1 atm. That's it. Everything else is set. You can not say that you want P = 1 atm and T= 20^{o}C.

Refer to examples 4-4 to 4-6 in the text (similar to the examples we did here)