1)
Below is the skeleton of a Txy diagram (at constant P of 1 atm) for a binary system VLLE.

a) Fill in the diagram as much as you can, given the following information:
   i) Two partially-miscible liquid phases can be formed: γ (rich in component 1) and δ (rich in component 2).
   ii) The normal boiling point of component 1 is 100°C, which differs by 20°C from component 2’s boiling point.
   iii) γ, δ, and vapor co-exist at 50°C and 1 atm with the following composition: \( x_1^γ = 0.75, x_2^δ = 0.80, y_1 = 0.40 \).

b) Draw the process of cooling a gaseous mixture of 1 and 2, initially \( y_1 = 0.30 \), from 100°C to 20°C. Label the initial point as A and final point as D.

As the gaseous mixture is cooled, the first liquid phase formed is the _______ phase. Let’s call this point B.

The composition of the dew is _______ mole% component 1. This occurs at approximately _____°C.

When this mixture is cooled further, three phases co-exist at __________°C. (Point C). The compositions in the phases are _________________________________.

When the mixture is cooled further, the ________________ disappears and ______________ is formed.

c) For the same process as in b):

At 50.1°C, there are more ______ phase than the ______ phase. In fact, we can calculate the ratio of the amounts of the two phases: ___________________ / ___________________ = ___________

At 49.9°C, there are more ______ phase than the ______ phase. In fact, we can calculate the ratio of the amounts of the two phases: ___________________ / ___________________ = ___________
2) (adapted from Final Exam Fall 1999)

Consider the reaction of CO$_2$ gas with liquid water containing small amount of Ca(OH)$_2$ to form CaCO$_3$ as pure solid precipitate:

$$\text{Ca(OH)}_2 \text{(aq)} + \text{CO}_2 \text{(g)} \rightarrow \text{CaCO}_3 \text{(s)} + \text{H}_2\text{O} \text{(l)}$$

This process that takes place in the oceans is believed to be a major contributor to the removal of CO$_2$ from the Earth’s atmosphere.

a) What is the equilibrium constant for the reaction at 25°C? You can use the information in steam tables and appendix C. If heat capacities are required, assume that they are constant at their values at 25°C.

b) Find another expression for the equilibrium constant at 25°C that is a function of the partial pressure of CO$_2$ in the gas phase and the molal concentration of Ca(OH)$_2$ in the aqueous phase. We are considering the process described above: atmospheric pressure, dilute Ca(OH)$_2$(aq). Assume that the species only exist in the phase specified in the reaction.

c) For a CO$_2$ fraction of 0.01 mole% in the Earth’s atmosphere, what must the concentration of Ca(OH)$_2$(aq) be when the reaction above is at equilibrium? Assume that the sea temperature is 25°C.