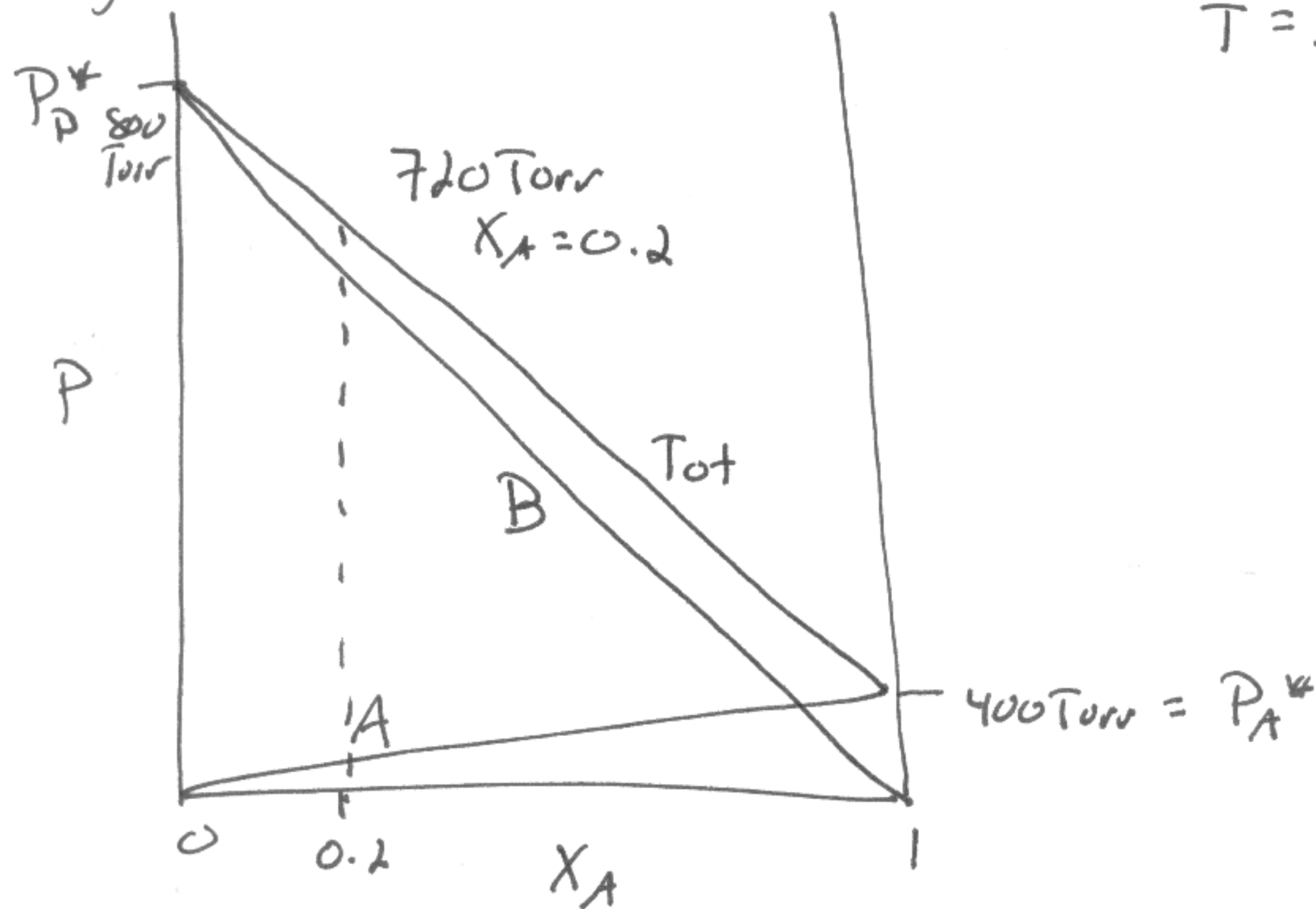


CH353 Spring 2012
HW9 Key

1. See key from HW 8.

2.



$T = 333 \text{ K}$

$$n_A = 1.0 \text{ mol}$$
$$n_B = 4 \text{ mol}$$
$$n_{\text{Tot}} = 5 \text{ mol}$$

$$X_A = 0.2$$
$$X_B = 0.8$$

$$P_{\text{Tot}} = X_A P_A^* + X_B P_B^*$$

$$P_{\text{Tot}} = (0.2)(400 \text{ Torr}) + (0.8)(800 \text{ Torr})$$

$$P_{\text{Tot}} = 720 \text{ Torr}$$

$P_{\text{Tot}} > P_{\text{ext}} (=650 \text{ Torr})$, so everything has boiled
and the mixture is all in the vapor phase.

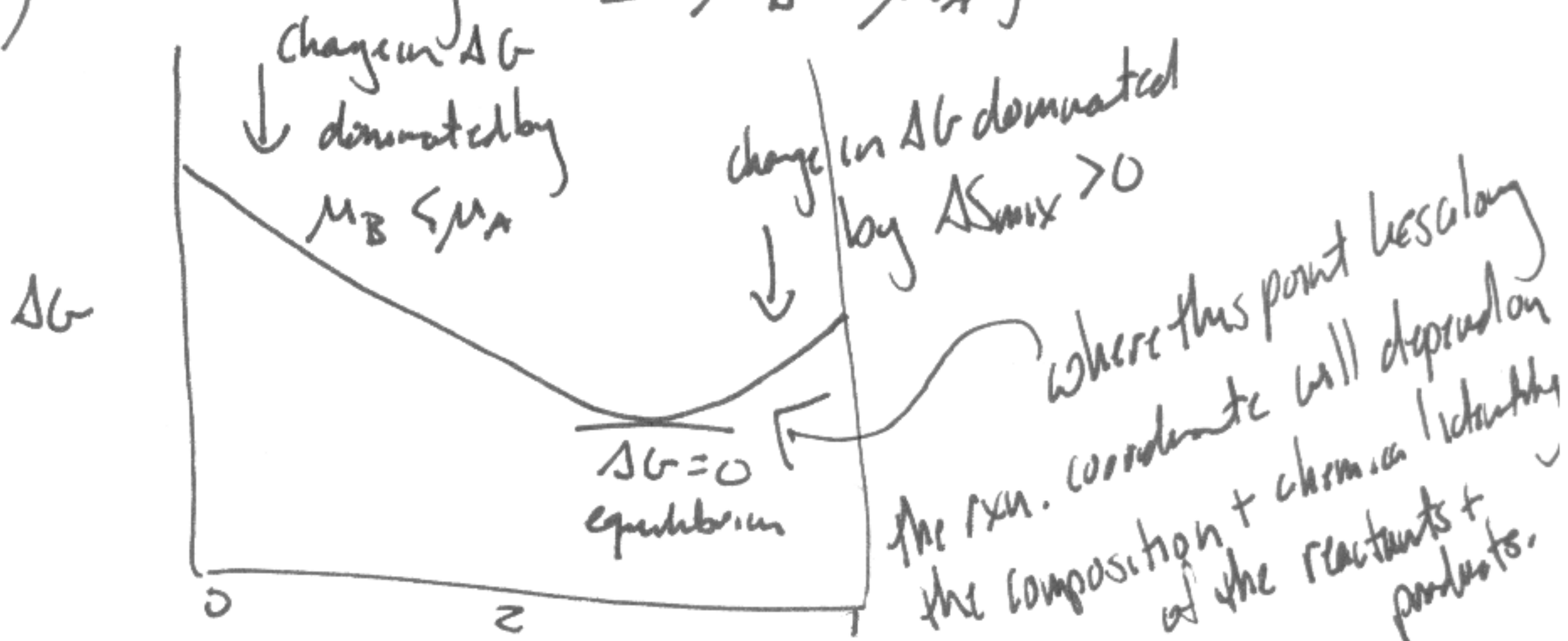
3. The driving force that causes a reaction to go to equilibrium is movement towards lower chemical potential, which lowers the Gibbs free energy of all species in solution. For the reaction $A \rightarrow B$,

$$\left(\frac{\partial G}{\partial z}\right) = \Delta G_{\text{rxn}} = \mu_B - \mu_A.$$

If B has lower chemical potential than A, $\mu_B - \mu_A < 0$, $\Delta G_{\text{rxn}} < 0$, and the reaction is spontaneous. Even very favorable reactions do not go 100% to completion because there is also a free energy associated with mixing reactants and products. This is described by:

$$\Delta G_{\text{mix}} = nRT (X_A \ln X_A + X_B \ln X_B)$$

and will be at a minimum when $X_A = X_B$. There comes a point in any reaction when it becomes too energetically unfavorable to decompose reactants and products. Graphically this shown by: (if $\mu_B < \mu_A$)



4. $\Delta T = -0.1 \text{ K}$ $\frac{\Delta P}{\Delta T} = \frac{\Delta H_{\text{fus}}}{T_{\text{fus}} \Delta V_{\text{fus}}}$

$$\rho_{\text{ice}} = 0.92 \text{ g/cm}^3 \left(\frac{1000 \text{ cm}}{1 \text{ m}} \right)^3 = 9.2 \times 10^5 \text{ g/m}^3 \left(\frac{1}{18 \text{ g/mol}} \right) = 5.0 \times 10^4 \frac{\text{mol}}{\text{m}^3}$$

$$\rho_{\text{water}} = 1.0 \text{ g/mL} \left(\frac{1000 \text{ mL}}{1 \text{ L}} \right) \left(\frac{1 \text{ L}}{0.001 \text{ m}^3} \right) = 1.0 \times 10^6 \text{ g/m}^3 \left(\frac{1}{18 \text{ g/mol}} \right) = 5.6 \times 10^4 \frac{\text{mol}}{\text{m}^3}$$

$$\Delta V = V_{\text{L}} - V_{\text{S}} = \frac{1}{\rho_{\text{L}}} - \frac{1}{\rho_{\text{S}}} = -2.0 \times 10^{-6} \text{ m}^3/\text{mol}$$

$$\Delta P = P_{\text{f}} - P_{\text{atm}} = \frac{\Delta H_{\text{fus}} \Delta T}{T_{\text{fus}} \Delta V_{\text{fus}}}; \quad P_{\text{f}} = \frac{\Delta H_{\text{fus}} \Delta T}{T_{\text{fus}} \Delta V_{\text{fus}}} + P_{\text{atm}}$$

$$P_{\text{f}} = \frac{(6010 \text{ J/mol})(-0.1 \text{ K})}{(275 \text{ K})(-2.0 \times 10^{-6} \text{ m}^3/\text{mol})} + 1.01 \times 10^5 \text{ Pa}$$

$$P_{\text{f}} = 1.10 \times 10^6 \text{ J/m}^3 + 1.01 \times 10^5 \text{ Pa}$$

$$\boxed{P_{\text{f}} = 1.2 \times 10^6 \text{ Pa}}$$

this is the pressure necessary to lower T_{fus} by -0.1 K

$$\text{Pressure exerted by ice skater: } = \frac{F}{A} = \frac{(70 \text{ kg})(10 \text{ N/kg})}{(0.3 \text{ m})(0.003 \text{ m})}$$

$$\boxed{P_{\text{skate}} = 7.8 \times 10^5 \text{ Pa}}$$

lower by $\times 2$, so this force will not melt the ice.

(4)

$$b) P(\text{needed}) = \frac{F}{A} = \frac{(\text{mass})(10 \text{ N/kg})}{\text{Area}} = 1.20 \times 10^6 \text{ Pa}$$

$$\text{mass} = \frac{PA}{10 \text{ N/kg}} = \frac{(1.20 \times 10^6 \text{ Pa})(0.3 \text{ m})(0.003 \text{ m})}{10 \text{ N/kg}}$$

$\text{mass} = 108 \text{ kg}$

minimum mass needed.

c) Ice maintained at 1 atm and 273 K is near its thermodynamic triple point where solid, liquid, and vapor are all in equilibrium.

Solid ice under these conditions always has a thin film of water covering it, which is why you can slip on ice, even when not wearing skates.

5. 1-propanol = (1) 2-propanol = (2)

$$P_1^* = 20.9 \text{ Torr}$$

$$P_2^* = 45.2 \text{ Torr}$$

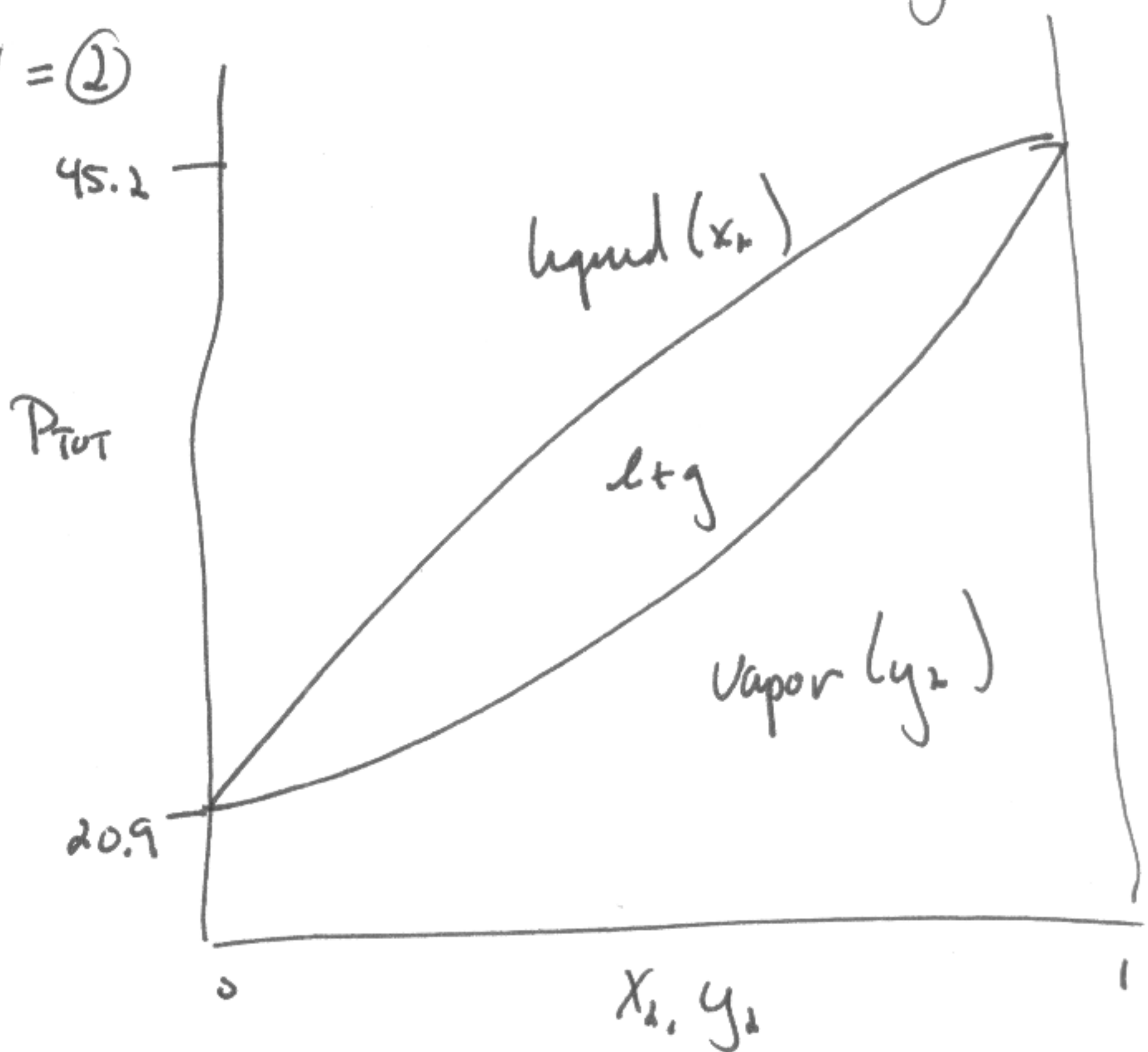
$$x_2 = 0.6 \Rightarrow x_1 = 0.4$$

$$P_{\text{TOT}} = x_1 P_1^* + x_2 P_2^*$$

$$P_{\text{TOT}} = 35.5 \text{ Torr}$$

$$y_2 = \frac{P_2}{P_{\text{TOT}}} = \frac{x_2 P_2^*}{P_{\text{TOT}}}$$

$y_2 = 0.76 \Rightarrow y_1 = 0.24$



6. conc. H_2SO_4 : 98% by mass H_2SO_4 (solute)
2% by mass H_2O (solvent)

$$FW(\text{H}_2\text{O}) = 18 \text{ g/mol}$$

$$FW(\text{H}_2\text{SO}_4) = 98 \text{ g/mol}$$

$$\rho_{\text{sol}} = 1.84 \text{ g/ml}$$

assume 1 L of soln:

$$m_{\text{sol}} = m_1 + m_2 = \rho V_{\text{sol}} = 1840 \text{ g}$$

$$m_2 = 0.98(m_{\text{sol}}) = 1803 \text{ g}$$

$$m_1 = 0.02(m_{\text{sol}}) = 36.8 \text{ g}$$

$$n_2 = \frac{m_2}{FW_2} = 18.4 \text{ moles}$$

$$C_2 = \frac{18.4 \text{ moles}}{1 \text{ L}} = 18.4 \text{ mol/L}$$

concentrated H_2SO_4 is
said to be "18M"