Quiz 4
CH 353 Sumer 2010
Vanden Bout
Name: _KEY_

You can use anything to answer the following except someone else.
Carefully read all the problems. The exam should have 4 questions on 6 pages. The first page
has potentially useful information. The last page is for extra writing space.

$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ $R = 8.314 \times 10^{-2} \text{ L bar K}^{-1} \text{ mol}^{-1}$ $R = 8.206 \times 10^{-2} \text{ L atm mol}^{-1} \text{ K}^{-1}$

$1 \text{ atm} = 1.01325 \text{ bar}$ $T/K = T/°C + 273.15$ $1 \text{ atm-L} = 101.325 \text{ J}$ $1 \text{ bar-L} = 100 \text{ J}$

$g = 9.8 \text{ m s}^{-2}$ $\Pi = \rho g h$

$$\Delta T = K X_B \quad K \equiv \frac{R T_b^{*2}}{\Delta_{VAP} H} \quad \Delta T = K_b m \quad \Delta T = K' X_B \quad K' \equiv \frac{R T_m^{*2}}{\Delta_{FUS} H} \quad \Delta T = K_f m$$

$$\Pi = \frac{n_B}{V} RT = [B]RT$$

$$P_A = X_A P_A^* \quad P_A = Y_A P \quad P_A = X_A K$$

$$F = C - P + 2$$

Please sign at the bottom to certify that you have worked on your own.
I certify that I have worked the following exam without the help of others, and that
the work I am turning in is my own.

Signed: --
                    Signature   Date

1. True/False   Circle either T or F for each statement   (10 points each)

T (F)   If you put a biological cell in pure water it will dehydrate as the water will flow out of
cell via osmosis.   cell will "fill up"

T (F)   Positive deviations from Raoult's law indicate that the solvent and solute have identical
intermolecular forces.   Ideal ⟶ Same IMF ⟶ Raoult's Law

T (F)   Assuming ideal solutions, a 0.1 molal solution of sucrose (mw 342 g mol^{-1}) in water
will have a lower freezing point than a 0.1 molal solution of fructose (mw 180 g mol^{-1})
in water.   Same

(T) F   If two liquids A and B are found in a liquid vapor equilibrium, and $P_A^* > P_B^*$ then $Y_A > X_A$.

(T) F   For an a non-ideal mixture of two liquids, $Y_A = \dfrac{P_A}{P}$

Definition of Y_A

2A. (25 points)   Below is a temperature phase diagram (vs. % mass) for a binary mixture of
water and nitric acid.
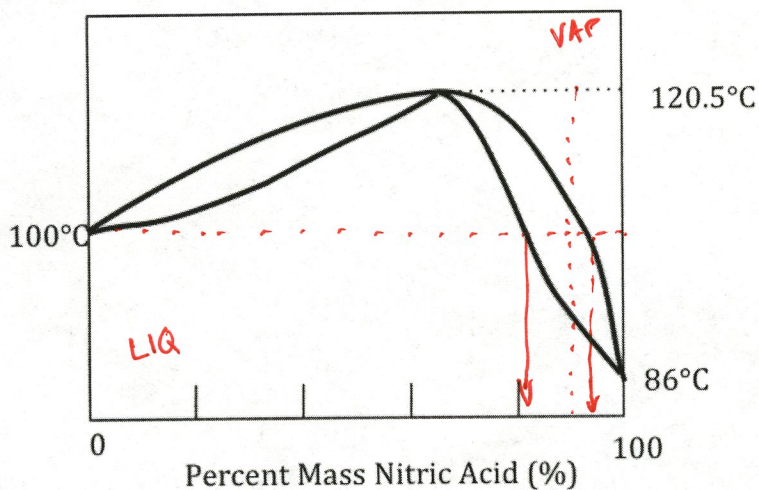
A solution that has composition that is 90% nitric acid at 50°C is heated to the boiling
temperature of water.

If the systems in a 2 phase equilibrium, what are the approximate concentrations of the two
phases (in % mass)? (
If not, what phase is the system? $X_{Nitric\ Acid} = 80\%$ $Y_{Nitric} = 95\%$

Are the intermolecular forces (IMF) between water and nitric acid stronger and weaker than the
IMF the two have for themselves? (explain)

stronger. High boiling point Azeotrope

negative deviations from Raoult's Law.

2B. (25 points)

Given that the freezing point depression constant for water if 1.858 K molal^{-1}, what is the
freezing point of a solution made from 2 g of NaCl (MW 58.44 g mol^{-1}) and 5 g of KCl (74.55 g
mol^{-1}) in 100 mL of water (density 1 g mL^{-1}).

$$\frac{2}{58.44} = 0.0342 \times 2 = 0.0684 \text{ moles ions from NaCl}$$

ims per NaCl

$$\frac{5}{74.55} = 0.067 \times 2 = 0.134 \text{ mole ims from KCl}$$

total mole = 0.2025   molality $= \frac{.2025}{.1} = 2.025$

$$\Delta T = (1.858)(2.025) = 3.763 \quad \boxed{T_m = -3.76°C}$$

3. (50 Points)

You have an ideal binary mixture that contains 4 mole of compound A and 1 moles of compound B. The system is held a constant temperature at which the vapor pressure of pure A is 200 Torr and the vapor pressure of pure B is 100 Torr. The system is initially at a pressure 400 Torr and is all liquid. The pressure is then lowered.

At what pressure will the first bubble of gas form? (give your answer in Torr)

If the pressure is then lowered another 10 Torr, will the system be in a liquid vapor equilibrium?

If so, what are the composition of the two phases and how many moles is in each phase?
If not, what phase is the system?

$$P = P_A^* + P_B^* = X_A P_A^* + X_B P_B^* = .8(200) + .2(100)$$

@ bubble line $X_A = Z_A = .8$ $= \boxed{180 \text{ Torr}}$

if $P = 170$ Torr

$$P = P_A + P_B = X_A P_A^* + (1-X_A) P_B^*$$

$$\boxed{X_A = \frac{P - P_B^*}{P_A^* - P_B^*} = \frac{170-100}{200-100} = \frac{70}{100} = .7}$$

$$\boxed{Y_A = \frac{P_A}{P} = \frac{(.7)(200)}{(170)} = 0.82}$$

$Z_A = 0.8$ $n_{liq}(.8-.7) = n_{vap}(.82-.8)$

$$\frac{n_{vap}}{n_{liq}} = 5 \qquad n_{vap} = 5 n_{liq}$$

$$n_{liq} + n_{vap} = 5 = n_{liq} + 5n_{liq} \qquad \boxed{n_{liq} = \frac{5}{6} \qquad n_{vap} = \frac{25}{6}}$$

4. (50 points)

You make a solution of two compounds by dissolving 10 g of compound B in 100 mL of compound. Given the data below answer the following.

Compound	MW (g mol^{-1})	density (g mL^{-1})	$\Delta_{fus}H°$ (kJ mol^{-1})	T_m (K)
A	89	0.8	28.9	260.0
B	56	1.2	35.0	390.2

$n_B = \dfrac{10}{56} = 0.178$ $n_A = \dfrac{(100)(.8)}{89} = .899$ $X_B = \dfrac{.178}{.178 + .899} = 0.165$

A. What is the freezing point of the solution you would find using the freezing point depression constant you would find for use with the mole fraction of solute (K'_f). (give an answer with 4 significant figures)

$\Delta T = K'_f \, X_B$

$K'_f = \dfrac{RT_m^*}{\Delta_M fus} = \dfrac{(8.314)(260)^2}{28,900} = 19.45$

$\Delta T = 19.45(.165)$
$= 3.21$
$T_m = 260 - 3.21 = \boxed{256.8 \, K}$

B. The freezing point depression should really be calculated based on the activity of the solution using

$$\ln a_A = \frac{\Delta_{fus}H°}{R}\left[\frac{1}{T_m^*} - \frac{1}{T_m}\right]$$

$a_A = X_A = 1 - X_B = .835$

$\ln(.835) = \dfrac{28,900}{8.314}\left[\dfrac{1}{260} - \dfrac{1}{T_m}\right]$ $\boxed{T_m = 256.5}$

What do you get for a freezing point using this formula assuming the solution is ideal? (give an answer with 4 significant figures)

C. Finally you discover the actual freezing point of the solution is 258.3 K. What is the vapor pressure of this solution given that the vapor pressure of pure A is 75 Torr.

$a_A = \dfrac{P_A}{P_A^*}$ $P_A = a_A P_A^* = (.915)(75)$

$\ln(a_A) = \dfrac{28,900}{8.314}\left[\dfrac{1}{260} - \dfrac{1}{258.3}\right]$ $\boxed{= 68.7 \, Torr}$

$a_A = 0.915$

schvent→

Bonus question (10 points)
No partial credit and its not worth much so don't waste time if you don't know how to do it.

A solvent has a $\Delta_{vap}H° = 34.9$ kJ mol^{-1} and a standard boiling point of 80°C.

You use this solvent to make a solution with an unknown solute. You measure the vapor pressure of the solution at 25°C and find it to be 80 Torr. What is the osmotic pressure of the solution?

$$P_A^* @ 353.15 = 1 \text{ bar}$$

$$\ln\left(\frac{P_{A_{298}}^*}{1}\right) = \frac{-34,900}{8.314}\left[\frac{1}{298.15} - \frac{1}{353.15}\right]$$

$$P_{A_{298.5}}^* = 0.112 \text{ bar}$$

$$a_A = \frac{P_A}{P_A^*} = \frac{80}{.112(750)} = 0.952$$

$$\ln a_A = \frac{-\bar{V}\Pi}{RT}$$

$$\boxed{\Pi = \frac{-RT \ln a_A}{\bar{V}}}$$

NEED $\bar{V}$ for solvent!