# Quiz 4

CH 353 Sumer 2009

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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.

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

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

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

$$\frac{dP}{dT} = \frac{\Delta S}{\Delta V} = \frac{\Delta H}{T\Delta V} \qquad \ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

$$\left(\frac{\partial \mu}{\partial P}\right)_T = V_M \qquad \left(\frac{\partial \mu}{\partial T}\right)_P = -S_M$$

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

$$F = C - P + 2$$

**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 One way to "break" an azeotrope is to increase the temperature.

T F If a liquid A is mixed in a binary solution and the vapor pressure is less than $X_A P_A^*$ then then, A has a stronger attraction for B than it does for itself.

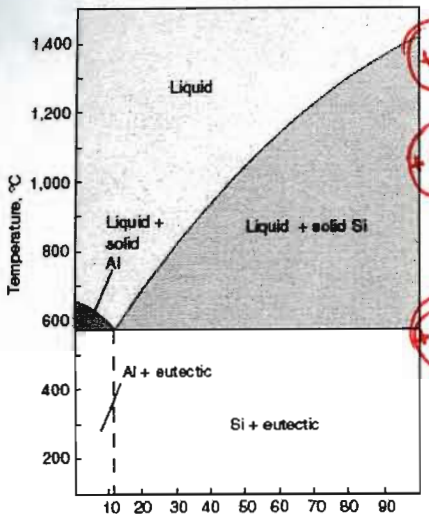
T F A 1 M solution of NaCl in liquid water at a pressure of 1 atm has 1 degree of freedom.

T F If $P_A^* > P_B^*$ then $X_A > X_B$ always.

T F Binary liquid mixtures boil over a range of temperatures

2A. (25 points)

This is a phase diagram for a mixture of Al and Si.




+5 A. The axis at the bottom shows the percentage of what ?

Si

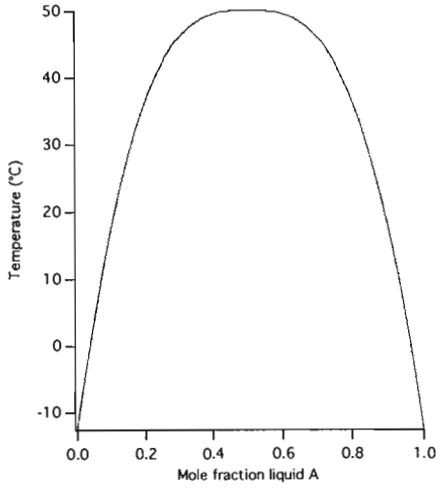
+10 B. At 1000°C and an overall composition of 80% Silicon what is present at equilibrium?

Solid Si and Liquid ($x_{Si} \approx 0.5$)

+10 C. Why is the solid region at the bottom labeled in two parts, Al + eutectic & Si + eutectic?

Bl cas the liquid cools either Al(s) or Si(s) forms until the remaining liquid is eutectic composition Below ~575°C this freezes

2B. (25 points)




A liquid-liquid phase diagram is shown on the left.

If a liquid mixture made of 50g of A (M.W. 50 g mol$^{-1}$) + and 200 g of B (100 g mol$^{-1}$) is held at a temperature of 20°C what are the composition(s) and number of moles of the phase(s) that exist at equilibrium?

1 mol A, 2 mol B

(5) $x_A = 0.33$

+10 Two liquids

2.143 mols ↑ $x_{A_1} = 0.1$ $x_{A_2} = 0.9$ → 0.857 mols

+10

$n_{tot} = 3$

$n_2 + 2.5n_2 = 3$

$n_2 = 0.857$

$n_1 = 2.143$

$n_1(x_{A_1} - 0.33) = n_2(0.33 - 0.9)$

$n_1(0.1 - 0.33) = n_2(0.33 - 0.9)$

$\frac{n_1}{n_2} = \frac{0.57}{0.23} \approx 2.5$

3A. (25 Points)

A mixture has 1 mole of benzene and 2 moles of toluene. At 60° the vapor pressure of pure benzene is 51.3 kPa and pure toluene is 18.5 kPa.
If the pressure is reduced at what pressure will the first bubble form?
What will the composition of the bubble be?

$$P = P_{Benzene} + P_{Towene} = X_B P_B^* + (1-X_B) P_T^*$$

$$P = 0.333(51.3) + 0.667(18.5) = 29.43 \text{ kPa}$$

$$Y_A = \frac{P_A}{P_{tot}}$$

(5) $X_{Benzene} = 0.333$

(10) $Y_{Benzene} = 0.58$

(10) $P_{tot} = 29.43$ kPa

$$Y_{benzene} = \frac{(0.333)(51.3)}{(29.43)} = 0.58$$

3B. (25 points)

The following is data for a mixture of ethanol (EtOH) and ethylacetate

| Temp | 77.15 | 75.00 | 71.60 | 76.40 | 78.30 |
|---|---|---|---|---|---|
| $X_{EtOH}$ | 0 | .1 | .462 | .942 | 1 |
| $Y_{EtOH}$ | 0 | .164 | .462 | .880 | 1 |

A. Which has a higher pure vapor pressure ethanol or ethylacetate? Explain (+10)
Ethylacetate. Boils at lower T

B. This mixture forms an azeotrope at what composition? (+10)
$X_{EtOH} = 0.462$

C. Are the intermolecular forces between ethanol/ethylacetate stronger (more attractive) or weaker (less attractive) than ethanol for itself? (+5)
Weaker - low BP azeotrope

4. (50 points)

At a particular temperature, the vapor pressure of pure acetone is 37.7 kPa and the vapor pressure of pure ether is 86.1 kPa.

You have a mixture that is 1 mole of acetone mixed with 9 moles of ether at high pressure. You can assume the vapor pressure of ether is given by Raoult's Law, but that the vapor pressure of the acetone is given by Henry's Law. The Henry's Law constant for acetone in ether is 78.5 kPa.

A. At 80 kPa, if the system was in a two phase equilibrium what would the mole fractions be in the liquid and vapor phases?

B. If the mixture above (9:1) was reduced to a pressure of 10 kPa, how many moles of liquid would there be? How many moles of vapor?

C. Given the data, would this system form a low boiling or high boiling point azeotrope? Or is it ideal?

Let A = Acetone, B = ether

A. $P = P_A + P_B$

$P = \chi_A K + \chi_B P_B^*$

$80 = \chi_A(78.5) + (1-\chi_A)(86.1)$

$80 = 78.5\chi_A + 86.1 - 86.1\chi_A$

$\chi_A = \frac{-6.1}{-7.6} = 0.8$ (+15)

$y_A = \frac{(0.8)(78.5)}{80} = 0.785$ (+10)

B. $z_A = 0.1 = \frac{1}{1+9}$

At equil and 80 kPa, $\chi_A = 0.8$ and $y_a = 0.785$, so all vapor

$n_{tot} = n_{vap} + n_{liq} = 10$

C. $K > P^*_{acetone}$, Low BP azeotrope