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Your name: ____________________

Chemistry 342

Third Exam

November 19, 1999

$1\ \mathrm{J} = 1\ \mathrm{kg\ m^2\ s^{-2}}$ $k_B = 1.38066\times10^{-23}\ \mathrm{J\ K^{-1}}$ $R = N_{Avogadro}k_B$ 1.01325 bar = 1 atm

$R = 8.31441\ \mathrm{J\ mol^{-1}\ K^{-1}} = 1.98718\ \mathrm{cal\ mol^{-1}\ K^{-1}} = 0.082057\ \mathrm{L\ atm\ mol^{-1}\ K^{-1}}$

$p/p_0 = \exp[-(M/RT)gz]$ *barometric formula where* $g = 9.80665\ \mathrm{m\ s^{-2}}$

van der Waals equation : $(p + a/V_m^2)(V_m - b) = RT$

monatomic gas molar heat capacity: $C_V = (3/2)R$

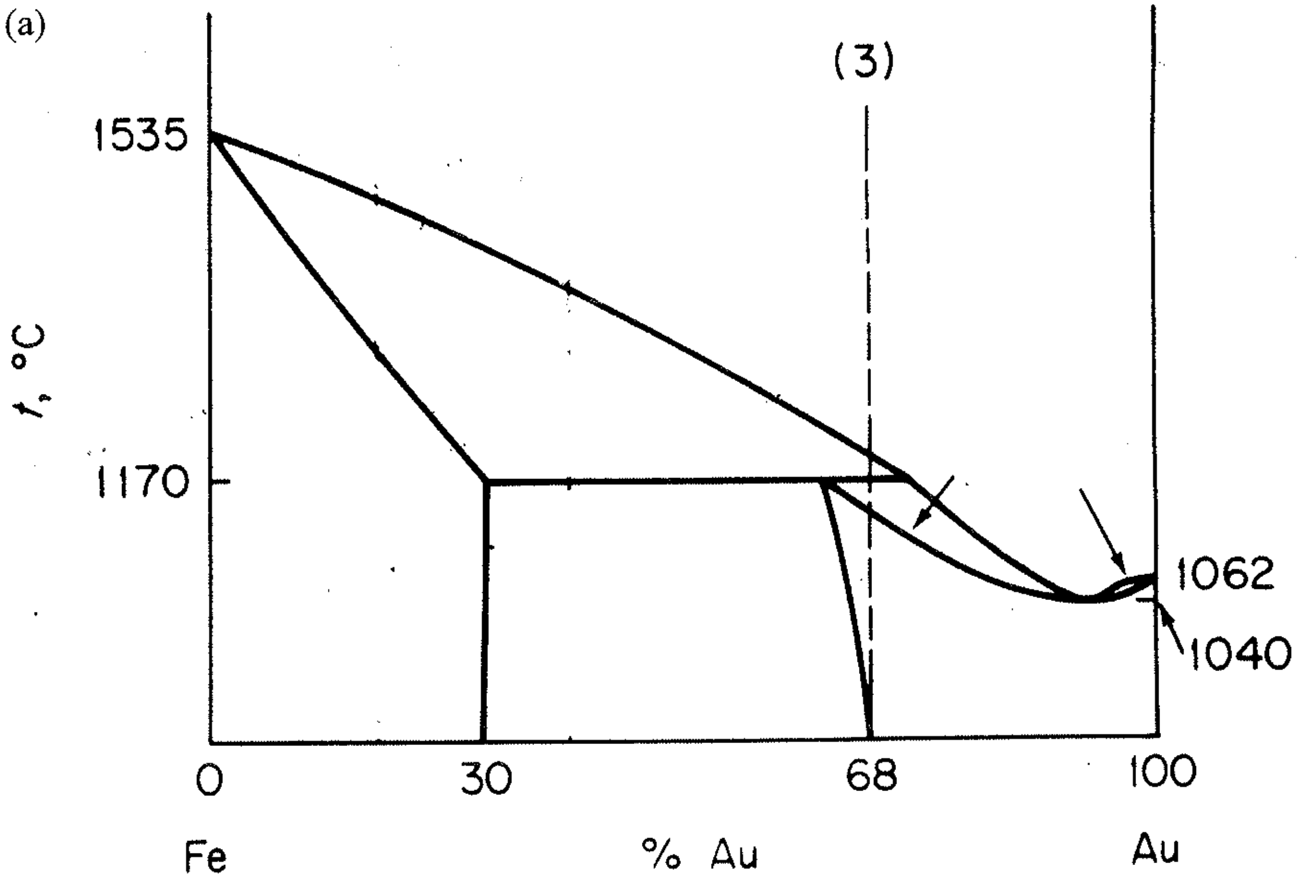
General relations for any equation of state:

$(\partial U/\partial V)_T = T(\partial p/\partial T)_V - p$ $(\partial H/\partial p)_T = -T(\partial V/\partial T)_p + V$

$C_p - C_V = \{p + (\partial U/\partial V)_T\}\cdot(\partial V/\partial T)_p$

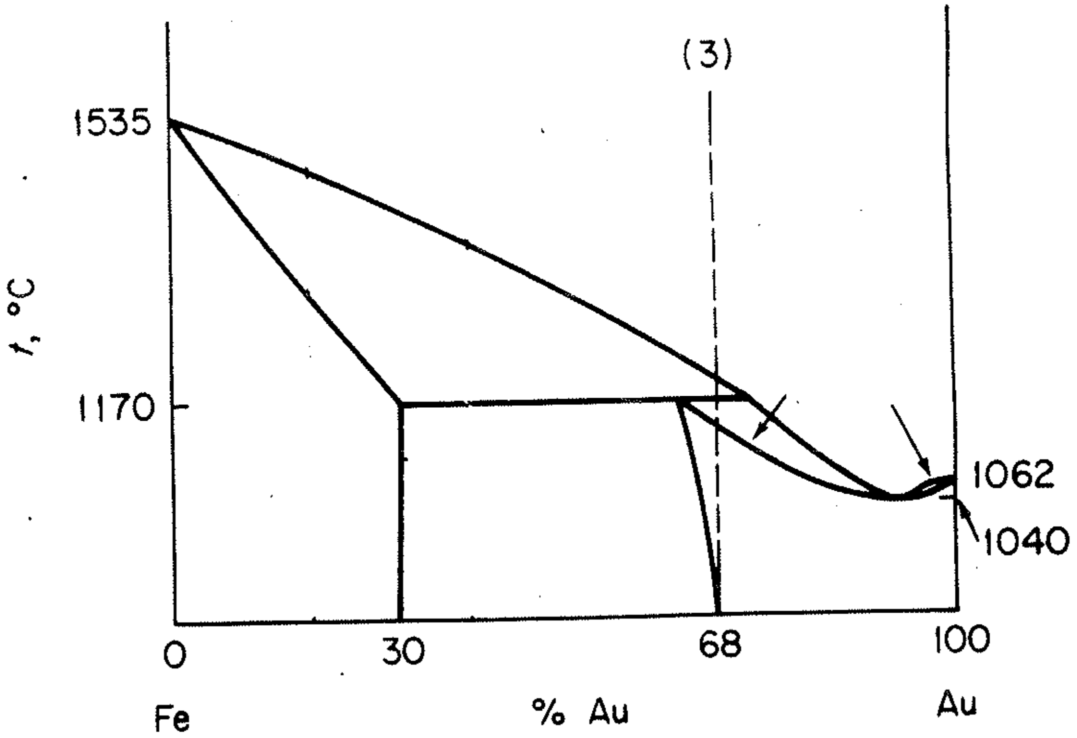
1. For the phase diagram shown below for the Fe Au system, **write the description of the phases present** in each region in diagram (a):

(a)



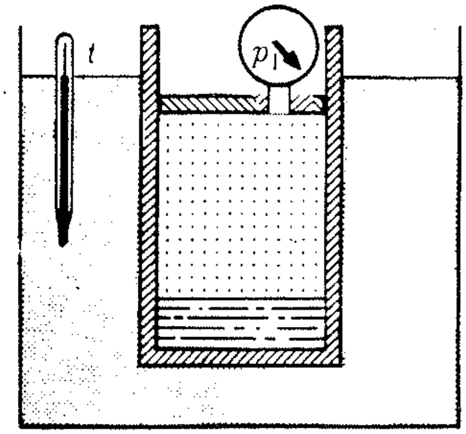
Write the number of degrees of freedom (in addition to pressure) in each region, line, intersection point in diagram (b):

(b)



Draw a labeled cooling curve for a melt of composition 68% Au , along vertical line (3) as seen above:

2. A mixture of 0.3 moles of liquid A and 0.2 moles of liquid B are placed in the container shown → and the ideal solution is allowed to come to thermal and mechanical equilibrium. The bath temperature is maintained at 21.5°C. The pressure gauge reads 0.060 atm.

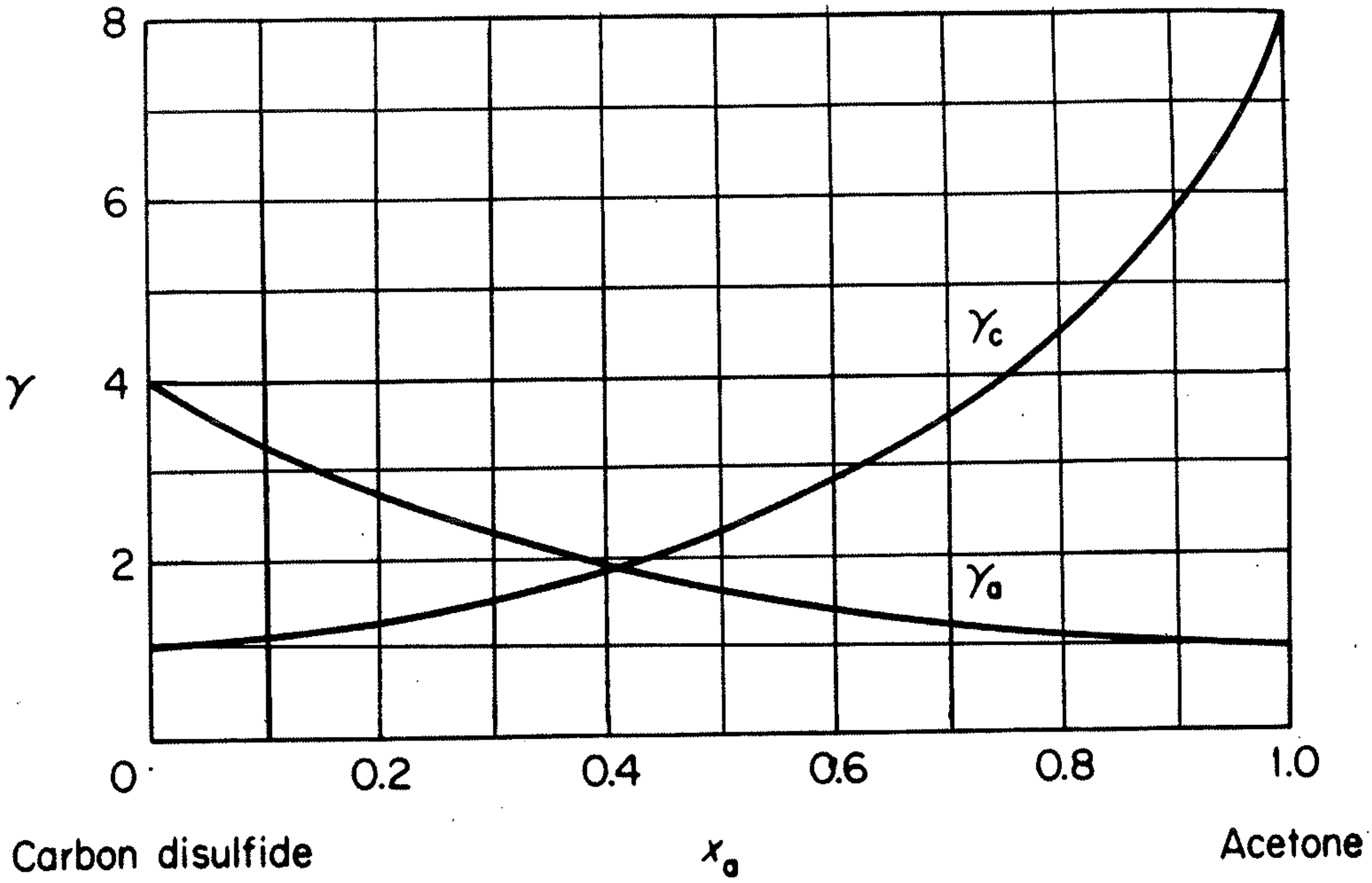


At their normal boiling points 110.6°C and 80.1 °C respectively, the enthalpies of vaporization of A and B are respectively, 34.4 and 30.8 kJ mol^{-1} and the densities of liquid A and B at this temperature are respectively 9.407 and 11.247 mol L^{-1}. **Describe the system at equilibrium** by filling in the following table with numbers (not formulas) and their corresponding units.

	numerical values and units
vapor pressure of pure liquid A at 21.5°C	
vapor pressure of pure liquid B at 21.5°C	
molefraction of B in the liquid phase	
partial pressure of A in the vapor	
molefraction of A in the vapor phase	
number of moles of liquid	
number of moles of vapor	
number of moles of A in the liquid phase	
number of moles of B in the vapor phase	

Provide the basis for your numerical answers by doing the derivations and calculations in this space and on the next page:

3. The following figure shows the activity coefficients versus composition for carbon disulfide acetone solutions at 35°C in the rational system of activities. At 35°C the vapor pressures of liquid acetone and liquid carbon disulfide are respectively, 0.46 and 0.66 atm.



Demonstrate that you can plot the corresponding vapor pressure diagram *from the above given information* by **calculating the following**:

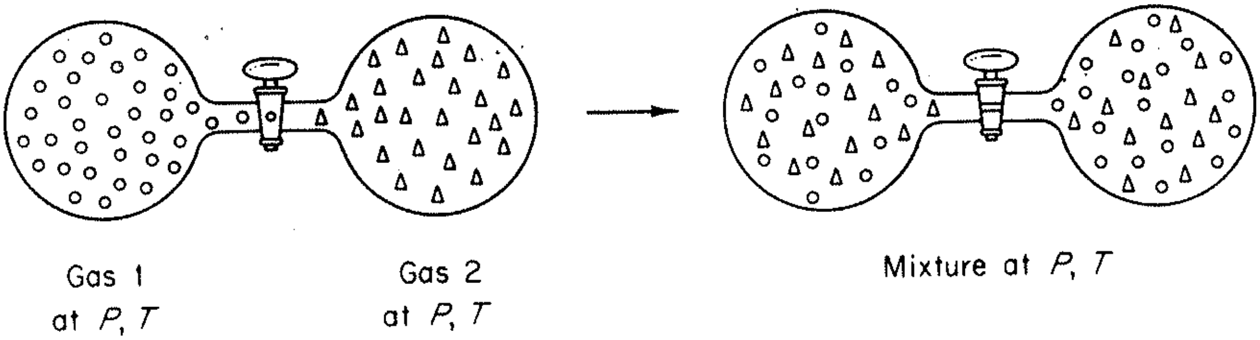
Henry's Law constant for carbon disulfide

Henry's law constant for acetone

partial pressure contributed by carbon disulfide to the vapor pressure of a solution that has 15 mole percent carbon disulfide

partial pressure contributed by acetone to the vapor pressure of a solution that has 75 mole percent carbon disulfide

4. Consider two ideal gases: n_1 moles of molecules of type 1 and n_2 moles of molecules of type 2. The initial and final conditions are shown below.



Write an equation that expresses the chemical potential of the gas in the left bulb at the initial conditions. From this **find** G_1 the Gibbs free energy for the gas in the left bulb at initial conditions.

Write an equation that expresses the chemical potential of the gas in the right bulb at the initial conditions. From this **find** G_2 the Gibbs free energy for the gas in the right bulb at initial conditions.

In a mixture of ideal gases, where p_i is the partial pressure of the ith species,
$(\partial\mu_i/\partial p)_T = \partial/\partial p(\partial G/\partial n_i)_{p,T} = \partial/\partial n_i(\partial G/\partial p)_T = (\partial V/\partial n_i)_{p,T} = RT/p_i$
or $d\mu_i = RT\, d(\ln p_i)$

Write an equation that expresses the chemical potential of the molecules of type 1 in the gas mixture at the final conditions.

Write an equation that expresses the chemical potential of the molecules of type 2 in the gas mixture at the final conditions.

Write an equation that expresses the Gibbs energy of the gas mixture at the final conditions.

Write an equation that expresses the ΔG for the process pictured above (in terms of molefractions x_1 and x_2).

5. In each of the following systems, it is desired that equilibrium be maintained between the two sides $\mathcal{A}$ and $\mathcal{B}$ by adjusting one variable (***bold***). **Calculate the value** that this variable has to be set to in each case, so as to maintain equilibrium.

$\mathcal{A}$	$\mathcal{B}$	Equilibrium condition, answers
fresh water semi mem $T = 298$ K $p = 0.0313$ atm	sea water permeable brane 35000 ppm of dissolved salts (MW=58.5 g mol^{-1}) by weight $T = 298$ K **$p = ?$**	❀ μ ( ) = μ ( )
liquid D density 55 mol L^{-1} $T = 298$ K $p = 200$ atm	ideal vapor D + insoluble gas E, $T = 298$ K $p_D + p_E = 200$ atm **$p_D = ?$**	$p^*_D = 0.60$ atm ❀ μ ( ) = μ ( )
water with dissolved CO_2 (0.1 mole %) $T = 278$ K	CO_2 gas $T = 278$ K **$p_{CO2} = ?$**	$K_H = 1.25 \times 10^6$ atm at 278 K ❀ μ ( ) = μ ( )
liquid water density 55.55 mol L^{-1} **$T = ?$**	water vapor $p = 0.20$ bar T = same	$\Delta_{vap}H = 40.7$ kJ mol^{-1} at 373 K ❀ μ ( ) = μ ( )

Write the derivations here, leading from the completed equilibrium statement(❀) to the working equation used for the calculating the answers.

5. continued

Write the derivations here, leading from the completed equilibrium statement(❀) to the working equation used for the calculating the answers.