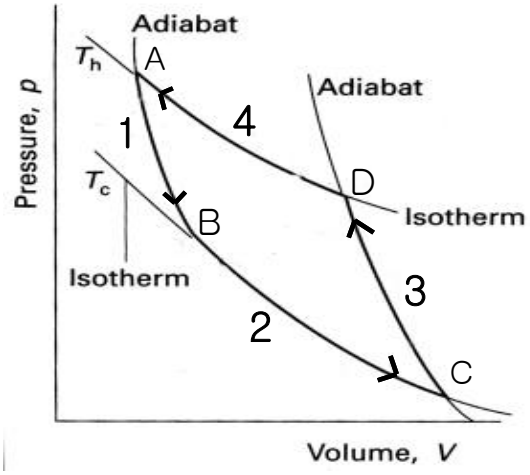
PHYSICAL CHEMISTRY
EXAM II (5/15/2014) Dept. Chem. & Biol. Eng., Korea Univ. Prof. D. J. Ahn

1(45). A modified Carnot cycle uses 1.00 mol of ammonia gas which follows EOS ($P=\frac{nRT}{V-nb}$) as the working substance from an initial state (point A) of 10.0 atm and 600 K. It expands adiabatically to a temperature of 300K (Step 1), and then isothermally to a pressure of 1.00 atm (Step 2). This expansion is followed by an adiabatic compression (Step 3), and then an isothermal compression (Step 4) back to the initial state.

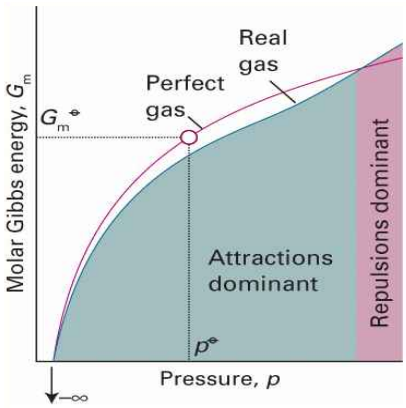


(a:10) Based on conceptual thermodynamic consideration on heat flow between two temperatures (T_h and T_c), justify whether pumping heat from cold source to hot sink is possible.

(b:15) Determine the values of q, w, ΔU and ΔS for each stage of the cycle and for the cycle as a whole. Express your answer as a table of values. ($C_{V,m}=\frac{3}{2}R$, $b=3.71\times10^{-2}dm^3mol^{-1}$)

(c:10) In case we use this heat pump for the purpose of indoor cooling, estimate the coefficient of performance COP. How much work is needed to remove 10 kJ of heat? Suggest an energy-saving way of using this heat pump.

(d:10). Find values of fugacity coefficient Φ at points A and C. Discuss whether the gas follows ideal gas behavior. ($\ln\phi=\int_0^p\frac{Z-1}{p}dp$; 이 식을 유도할 경우 추가점수 부여)



2(10). The volume of an aqueous solution of NaCl at 25℃ was measured at a series of molalities b, and it was found that the volume fitted the expression $v=1003+16.62x+1.77x^{3/2}+0.12x^2$ where $v=V/cm^3$, V is the volume of a solution formed from $1.000\,kg$ of water, and $x=b/b^{\ominus}$. Calculate the partial molar volume of the components in a solution of molality $0.100\,mol/kg$.

3(20). 순수한 물질에 대하여 P-T phase diagram을 구축하려고 한다.

(a:5) Phase boundary에서 $\frac{dp}{dT}=\frac{\Delta_{trs}S}{\Delta_{trs}V}$임을 보이고 이를 이용하여 phase boundary의 기울기가 S/L, S/G, L/G의 순으로 됨을 설명하시오.

(b:10) (a)의 결과를 이용하여 benzene의 triple point(4.8 kPa, 278.7 K) 근처에서 P-T phase diagram을 구축하시오. ($\Delta_{fus}H=10.6\,kJ/mol$, $\Delta_{vap}H=30.8\,kJ/mol$, $\rho(s)=0.891\,g/cm^3$, $\rho(l)=0.879\,g/cm^3$)

(c:5) Phase Rule을 유도하시오. (상의 수 π개, 화학종의 수 C개) 각 영역과 boundary에서 DOF를 구하시오.

4(10). 순수한 액체에 다른 물질을 소량 용해시켰을 때, 어는점과 끓는점의 변화를 chemical potential (μ)의 개념을 활용하여 도시하고 설명하시오.

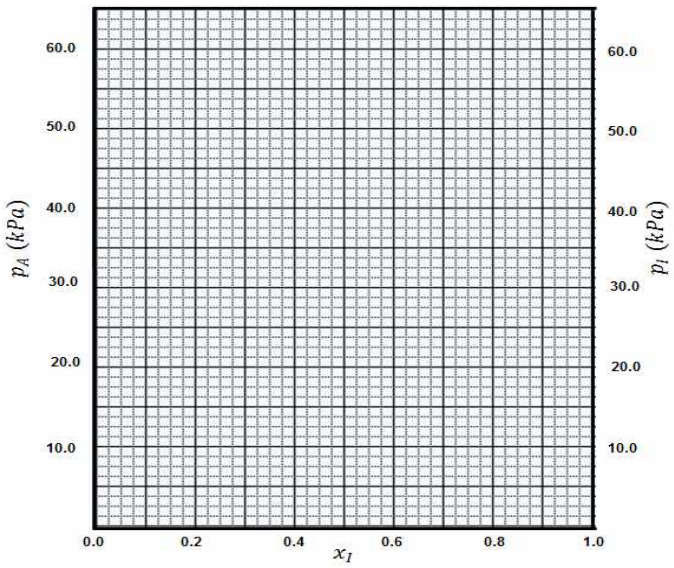
5(35). The table below lists the vapor pressures of mixtures of iodoethane (I) and ethyl acetate (A) at 50℃.

x_I	0.000	0.0579	0.1095	0.1918	0.2353	0.3718	0.5478	0.6349	0.8253	0.9093	1.000
p_I/kPa	0.000	3.73	7.03	11.7	14.05	20.72	28.44	31.88	39.58	43.00	47.12
p_A/kPa	37.38	35.48	33.64	30.85	29.44	25.05	19.23	16.39	8.88	5.09	0.000

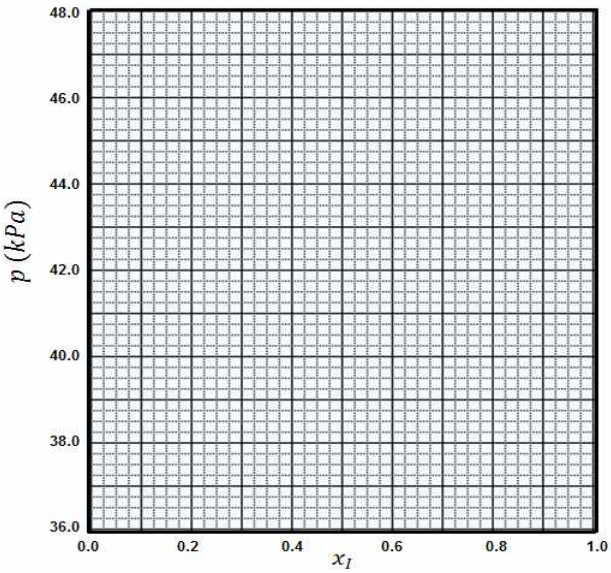
(a:5) Which component is more volatile when pure? State the reason why mixed state has different volatility compared to pure states.
(b:5) Based on Raoult's and Henry's laws, find activity coefficients of both components as we consider iodoethane as solute.
(c:5) Complete the diagram 'C' using the data given. Evaluate the validity of using Raoult's and Henry's laws.
(d:10) Provided that iodoethane and ethyl acetate obey Raoult's law, derive equations describing bubble-point line and dew-point line in Pxy phase diagram.
(e:10) Using the resulting equations in (d), construct Pxy diagram 'E' and its corresponding Txy diagram conceptually.

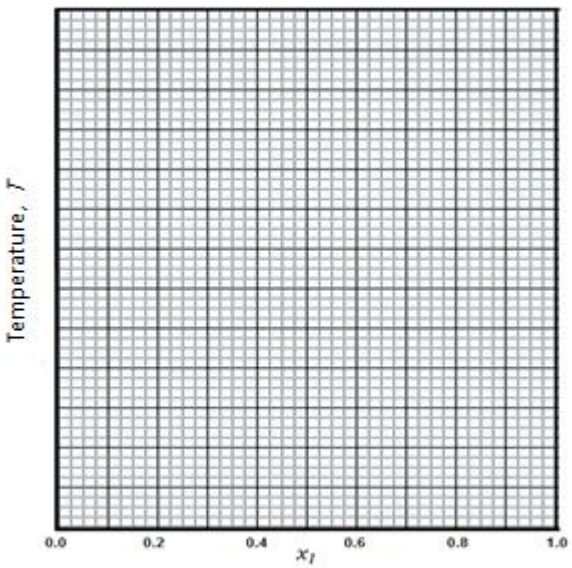
[총점 120]

C


$p_A\ (kPa)$
$p_I\ (kPa)$
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.2
0.4
0.6
0.8
1.0
x_I

E


$p\ (kPa)$
48.0
46.0
44.0
42.0
40.0
38.0
36.0
0.0
0.2
0.4
0.6
0.8
1.0
x_I


Temperature, T
0.0
0.2
0.4
0.6
0.8
1.0
x_I