PHYSICAL CHEMISTRY

EXAM II (5/14/2012) Dept. Chem. & Biol. Eng., Korea Univ. Prof. D. J. Ahn

1(10). 강의시간에 "현대냉동기술"에 관한 동영상을 관람하였다. 냉동기술이 여러 가지 이로운 점을 제공하고 있으며, 예로 초전도체를 부양시키기도 하고 생체를 냉동하여 생명을 보존 연장하는 시도도 행해지고 있다. 이 동영상에서 제시된 내용 중에서 (a) 에너지 고갈문제와 (b) 환경문제를 극복 개선하는 사례를 기술하시오.

2(20). Answer the followings:

(a) Describe the dependences of the Gibbs energy on pressure and temperature, respectively, and draw the corresponding diagrams including solid, liquid, and gas phases.

(b) Explain the relations among Figs. 1-3 given below.

(c) Derive an mathematical relation between compression factor Z and fugacity coefficient ϕ ($\equiv f/P$).

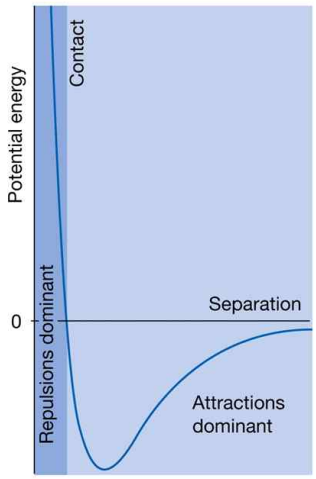


Fig. 1

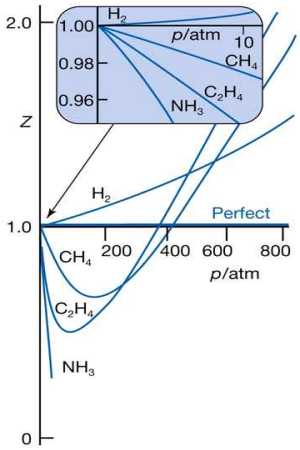


Fig. 2

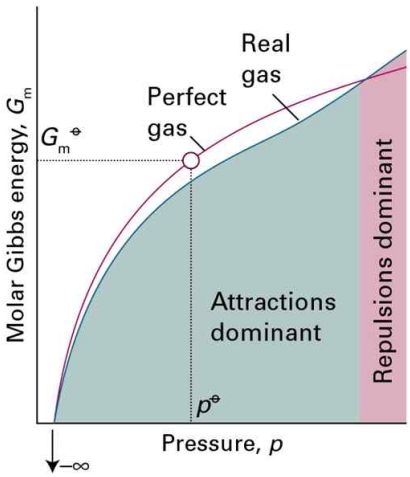


Fig. 3

3(15). This following table lists the values of the vapour pressures measured from the binary mixtures consisting of benzene and acetic acid, at 50 ℃.

$x_{\text{acetic acid}}$	0	0.2	0.4	0.6	0.8	1.0
$p_{\text{acetic acid}}$/kPa	0	2.7	4.0	5.1	6.7	7.3
p_{benzene}/kPa	35.2	30.4	25.3	20.0	12.4	0

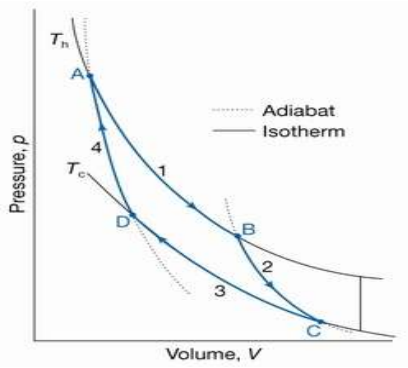
(a) Calculate the values of total pressure with the mole fraction of acetic acid.

(b) Find out the Henry's constant of both components assuming ideal-dilute solution.

(c) Based on the Raoult's law, calculate the activity a_i ($\equiv P_i/P_i^* = \gamma_i x_i$) and activity coefficient γ_i of both components.

4(15). Calculate the difference in molar entropy (a) between liquid water and ice at −7 ℃, (b) between liquid water and its vapour at 93 ℃ and 1.00 atm. The differences in heat capacities on melting and on vaporization are 37.3 J/K·mol and −41.9 J/K·mol, respectively. Distinguish between the entropy changes of the sample, the surroundings, and the total system, and discuss the spontaneity of the transitions at the two temperatures.

5(20). A Carnot cycle uses 2.00 mol of a diatomic perfect gas as the working substance from an initial state of 15.0 atm and 650 K. It expands isothermally to a pressure of 5.00 atm (Step 1), and then adiabatically to a temperature of 350 K (Step 2). This expansion is followed by an isothermal compression (Step 3), and then and adiabatic compression (Step 4) back to initial state. Determine the values of q, w, ΔU, ΔH, ΔS, ΔS_{tot}, and ΔG for each stage of the cycle and for the cycle as a whole. Express your answer as a table of values.



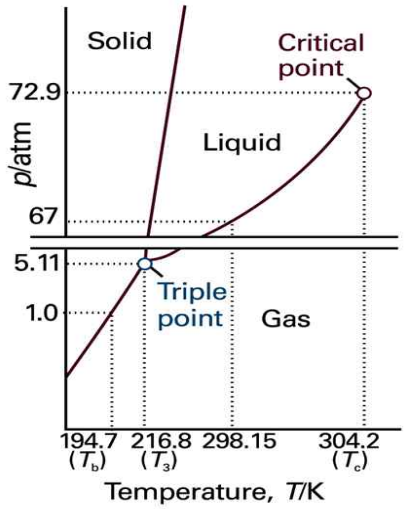
6(20). 아래 그림은 순수한 이산화탄소에 대한 P-T 상평형도이다. 아래 질문에 답하시오.

(a) 일반적으로 상의 수 Π개, 화학종의 수 C개, 독립된 반응의 수 r개가 있을 때, Phase Rule을 유도하시오.

(b) 삼중점에서의 DOF를 구하고 그 의미를 설명하시오.

(c) Phase boundary의 기울기가 [L/G] < [S/G] 임을 설명하시오.

(d) 이산화탄소 기반의 초임계 유체기술이 산업적 응용성이 높은 이유를 설명하시오.



7(30). Answer the followings:

(a) Based on the standard-state data of each reaction at 298 K given in the box below,

$4NH_3\ (g) + 5O_2\ (g) \rightarrow 4NO\ (g) + 6H_2O\ (l)$ $\quad \Delta_rH^\ominus = -1170$ kJ/mol

$2NO\ (g) + O_2\ (g) \rightarrow 2NO_2\ (g)$ $\quad \Delta_rH^\ominus = -114$ kJ/mol

$3NO_2\ (g) + H_2O\ (l) \rightarrow 2HNO_3\ (l) + NO\ (g)$ $\quad \Delta_rH^\ominus = -72$ kJ/mol

(at 298 K)	NH_3 (g)	O_2 (g)	HNO_3 (l)	H_2O (l)
$S^\ominus_m$ (J/K·mol)	192.45	205.14	155.60	69.91
$C^\ominus_{p,m}$ (J/K·mol)	35.06	29.36	109.87	75.29

Find out $\Delta_rH^\ominus$, $\Delta_rS^\ominus$ and $\Delta_rG^\ominus$ at 398 K of the reaction $NH_3\ (g) + 2O_2\ (g) \rightarrow HNO_3\ (l) + H_2O\ (l)$.

(b) When the reaction temperature is changed and maintained from 298 K to 398 K in a reactor, explain the temperature effect on the changes in product yield and reaction speed by consideration of the energy diagram which depicts the values of energy level as the reaction progresses.

[총점 130점]