國立成功大學
115學年度碩士班招生考試試題

編　號：52

系　所：化學工程學系

科　目：化工熱力學

日　期：0203

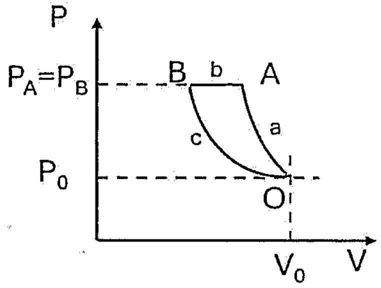
節　次：第 2 節

注　意：1.可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

1. **(15%)** One mole of an ideal diatomic gas, initially at standard temperature and pressure (STP: $T_0 = 273\ K$; $P_0 =$ 1 atm), is taken through a reversible process such that $V = aP$ and a =22,400 (cm^3/atm) to final pressure of 0.5 atm.
   (1) (2%) Calculate the final volume and temperature of the gas.
   (2) (5%) express the heat (Q) of gas expansion as function of $Cp, Cv, P,\ and\ V$.
   (3) (8%) Calculate the amount of heat that must be extracted from the system to perform this process.

2. **(15%)** An ideal monoatomic gas undergoes the following sequence of mechanically reversible process in a closed system:
   (1) From an initial state of T_0 and P_0, it is compressed adiabatically to T_A.
   (2) It is then cooled from T_A to T_B at constant pressure.
   (3) Finally, it is expected to be isothermally to its original state, as shown in the figure below.

   Express $W, Q, \Delta U, \Delta H,$ and ΔG as functions of $\frac{P_A}{P_0}$ and T_0 for each of the three processes.



3. **(15%)**
   (1) **(8%)** Please show that $C_P - C_V$ is the function of T, V, volume expansivity (β) and isothermal compressibility (κ).
   (2) **(7%)** Calculate $C_P - C_V$ of iron at 1,500 K and atmospheric pressure. $\beta = 6.8 \times 10^{-6}\ K^{-1}$, $\kappa = 5.9 \times 10^{-12}\ Pa^{-1}$, $M_w = 55.8\ g/mol$, and density $= 7.87\ g/cm^{-3}$.

4. **(5%)** Please draw a P-x_2 plot of the L-V phase diagram for a two-component system that meets the following conditions: (also provide the corresponding equations for the curves in the plot.)
   (1) The two components are completely miscible; (2) The boiling point of component 1 is higher than that of component 2; (3) The mixture is an ideal solution.

5. **(10%)** Please derive to obtain $\left(\frac{\partial P}{\partial T}\right)_V = \frac{\beta}{\kappa}$ where β is the volume expansivity and κ is the isothermal compressibility. [Note] You MUST list the expressions of β and κ.

6. (16%) For the figure as shown in Fig. 1 (constant T, P), please derive to obtain the following.

(1) (10%) $\lim_{x_1 \to 0} \dfrac{G^E}{x_1 x_2 RT} = \ln\gamma_1^{\infty}$

(2) (6%) The slope of the $\ln\gamma_1$ curve is everywhere in opposite sign of the $\ln\gamma_2$ curve.

7. (24%, 3% each) Answer true or false. **Each incorrect answer will be a 1% deduction. The lowest possible score for this section (problem 7) is 0** (no negative final score).

(1) On the figure of M^E vs. x_1 (at constant T, P, for a mixture solution of two species), the profile must exist a point so that $V^E = \bar{V}_1^E = \bar{V}_2^E$

(2) For a binary mixture, on the figure of P vs mole fraction (liquid (x_i) or vapor (y_i)), the P vs x_i curve is always located above of P vs y_i curve.

(3) For the figure **(Fig. 1)** as shown below, it is always correct that there is one point such that $G^E/RT = \ln\gamma_1 = \ln\gamma_2$

(4) Gibbs/Duhem equation is $\sum_i x_i d\bar{M}_i = (\frac{\partial M}{\partial P})_{T,x} dP + (\frac{\partial M}{\partial T})_{P,x} dT$

(5) For an irreversible flow process of constant enthalpy, pressure decreases.

(6) For steady-state adiabatic flow in a horizontal pipe of constant cross-sectional area, $\frac{dP}{dx} < 0$ and $\frac{du}{dx} > 0$, accordingly, $\frac{d\rho}{dx} > 0$ when $u < c$ (sonic velocity). The following equations are provided for your reference. [Note] $M \equiv u/c$

$$u\frac{du}{dx} = T\cdot\left(\frac{\beta u^2/C_P + M^2}{1-M^2}\right)\cdot\frac{dS}{dx} \qquad \frac{dP}{dx} = -\frac{T}{V}\cdot\left(\frac{1+\beta u^2/C_P}{1-M^2}\right)\cdot\frac{dS}{dx}$$

(7) For the operation of a turbine, the pressure always increases.

(8) For the H (molar enthalpy of binary mixture solution) vs x_1 (molar fraction of species 1 in liquid) diagram as shown in **Fig. 2**, then, the mixing is exothermic.