國立雲林科技大學
九十三學年度碩士班入學招生考試試題
系所：化工系
科目：化工熱力學

一、解釋名詞

1、The efficiency of the reversible carnot engine (5%)
2、Fugacity and activity (5%)
3、Heterogeneous equilibrium (4%)
4、Gibbs-Duhem equation (5 %)
5、Standard state （ideal solution） (5 %)

二、計算題

1、Suppose that 2 mol of oxygen gas, which can be regarded as ideal with Cp＝ $29.4JK^{-1}\ mol^{-1}$ (independent of temperature)in a volume of 11.2L at 273K is heated reversibly to 373K at constant volume：

a、How much work is done on the system？
b、What is the increase in internal energy U？
c、How much heat was added to the system？
d、What is the final pressure？
e、What is the final value of PV？
f、What is the increase in enthalpy H？ (12%)

2、Initially at 300K and 1 atm pressure,1 mol of an ideal gas undergoes an irreversible isothermal expansion in which its volume is doubled, and the work it performs is $500J\ mol^{-1}$,what are the values of q, $\triangle U$, $\triangle H$, $\triangle G$ and $\triangle S$？What would q and w be if the expansion occurred reversibly？ (12%)

3、The hydrolysis of adenosine triphosphate to give adenosine diphosphate and phosphate can be represented by $ATP \leftrightarrows ADP + P$

The following value have been obtained for the reaction at 37°C(standard state：1M)：

$$\triangle G^\circ = -31.0KJ\ mol^{-1}$$
$$\triangle H^\circ = -20.1KJ\ mol^{-1}$$

a、Calculate $\triangle S^\circ$
b、Calculate Kc at 37°C
c、On the assumption that $\triangle H^\circ$ and $\triangle S^\circ$ are temperature independent, Calculate $\triangle G^\circ$ and Kc at 25°C (12%)

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4、Determine whether the following process violates the laws of thermodynamics. An ideal gas of constant heat capacity（Cp=30 J/mole.K.） at 10 M Pa and 295 K enters a device which is thermally and mechanically insulated from the surroundings. One-half of the gas leaves the device at 355K and 1 M Pa , while the other half leaves at 235 K and 1 M Pa .（15%）

5、Please derive the following conditions：(10%)

（a）Equilibrium criteria of two phases of a pure substance at a constant pressure and temperature.

（b）ΔG，ΔH，ΔS of a binary ideal solution with equimolar compositions at 300 K and 1 M Pa

6、In a binary liquid-vapor equilibrium system at a constant temperature and pressure condition, the relative volatility α can be represented as the following equation：

$$\log \alpha = 1 + 0.5 (x_1 - x_2)$$

The relative volatility α is defined as $\alpha = (y_1/x_1) / (y_2/x_2)$, where y is vapor-phase mole fraction and x is liquid-phase mole fraction, Please determine the activity coefficient equation.（15%）

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請依題號作答並將答案寫在答案卷上，違者不予計分。

1. (20%) Find the first-order rate constant for the gas reaction $2A \longrightarrow R$ if the volume of the reaction mixture, starting with reactant A and 20% inert, decreases by 10% in 5 min. The total pressure stays constant at 1 atm, and the temperature is 25 °C. (R = gas constant = 0.082 atm-dm^3/mol-K = 1.987 cal/mol-K)

2. (20%) An irreversible reaction $4A + 6B \rightarrow C + 6D$ was carried out in a well-mixed flow reactor with a volume of 490 dm^3. The rate equation was expressed as $-r_A$ (mol/dm^3-s) = $kC_AC_B^2$ with $k = 1.42\times10^3\ e^{-3090/T}$ (T is absolute temperature) The reactants were each fed to the reactor in streams 1.50 dm^3/s with 4.06 mol A/dm^3 and 6.32 mol B/dm^3, respectively. The average reaction temperature was 36 °C. Find the concentrations of A and B at the reactor exit.

3. (20%) An aqueous reactant stream (4 mol A/dm^3) passes through a well-mixed flow reactor followed by a plug flow reactor. The reaction is second-order with respect to A, and the volume of the plug flow reactor is three times that of the mixed flow reactor. Find the concentration at the exit of the plug flow reactor if in the mixed flow reactor C_A = 1 mol/dm^3.

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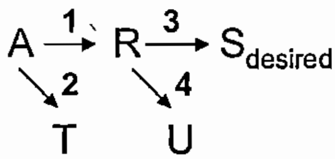
4. (20%) For an irreversible first-order liquid-phase reaction (C_{A0} = 10 mol/liter), conversion is 90 % in a plug flow reactor. If two-thirds of the stream leaving the reactor is recycled to the reactor entrance, and if the throughput to the whole reactor-recycle system is kept unchanged, what does this do to the concentration of reactant leaving the system?

5. (20%) The first-order reactions



$k_1 = 10^9 e^{-6000/T}$
$k_2 = 10^7 e^{-4000/T}$
$k_3 = 10^8 e^{-9000/T}$
$k_4 = 10^{12} e^{-12000/T}$

are to be run in two mixed flow reactors in series anywhere between 10 and 90℃. If the reactors may be kept at different temperatures, what should these temperatures be for maximum fractional yield of S? Find this fractional yield.

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科目：輸送現象

1. Using the Navier-Stokes equations for a steady, viscous, incompressible flow, obtain an expression for the velocity profile between two flat, parallel plates (see, Fig. 1). (20%)

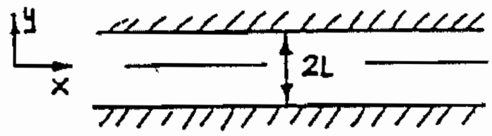

Fig. 1 Flow in two parallel plates

2. Show an analytical solution of the one-dimensional heat conduction equation for the case of the semi-infinite wall (see, Fig. 2). (20%)

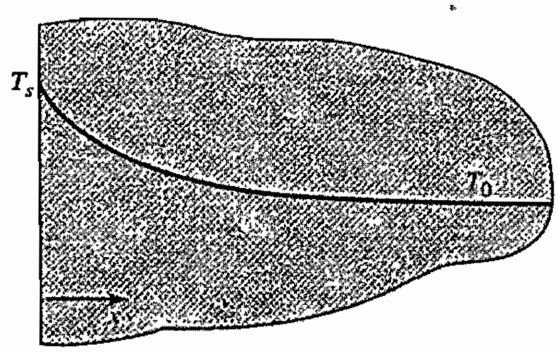

Fig. 2 Temperature distribution in a semi-infinite wall at time t

3. Under the pseudo-steady-state diffusion for the Arnold diffusion cell (see, Fig. 3), show the equation commonly used to evaluate the gas diffusion coefficient D_{AB}. (20%) (Hint: the molar flux $N_{A,z}$ is related to the amount of A leaving the liquid by $N_{A,z} = \frac{\rho_{A,L}}{M_A}\frac{dz}{dt}$, where $\frac{\rho_{A,L}}{M_A}$ is the molar flux of A in the liquid phase)

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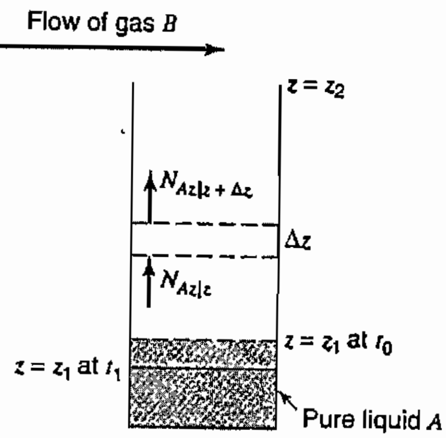

Fig. 3 Arnold diffusion cell with moving liquid surface

4. A heat source is located within a hollow sphere with an internal radius κR and external radius R. Conditions are such that the internal surface temperature is constant at T_i and the external surface temperature is T_0. The thermal conductivity of the shell is *k*.
   (a) What is the steady state temperature distribution in the spherical shell as a function of *r*? (10%)
   (b) What is the total heat rate? (10%)

5. Determine $v_\theta(r)$ between two coaxial cylinders of radii R and κR rotating at angular velocities Ω_0 and Ω_i, respectively. Assume that the space between cylinders is filled with an incompressible isothermal fluid in laminar flow. (20%)