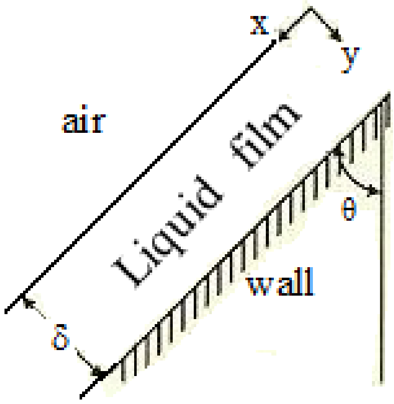
# 國立高雄大學九十八學年度碩士班招生考試試題

科目：輸送現象與單元操作
考試時間：100 分鐘

系所：化學工程及材料工程學系甲組
本科原始成績：100 分

是否使用計算機：是

**1.** Find the velocity profile, the average velocity, and the friction factor (f) for the isothermal laminar flow of a Newtonian fluid falling film in an inclined plate of length L and width W, The liquid film thickness is $\delta$, the liquid density is $\rho$, and the liquid viscosity is $\mu$, respectively.(20%)




**2.** A spheric heat generator has a radius of $R_o$, in which heat generation per unit volume and unit time is Q ($J/m^3 \cdot s$). And the surface temperature of this sphere keeps at $T_o$ ($^oK$). Using shell balance, please derive the relation between the temperature (T) and radius (r) in the heat generator sphere, where T=T(r). (Note: this system is at steady state) (20%)

**3.** (A) Derive the feed line equation for a continuous fractioning column; (B)Explain the meaning corresponding to different cases of q values and specify the orientation of feed lines in the x-y plots for the following cases: (i) $q > 1$, (ii) $q = 1$, (iii) $0 < q < 1$, (iv) $q = 0$, and (v) $q < 0$, where q is the moles of liquid flow in the stripping section for each mole of feed. (20%)

**4.** (a) Species A diffuses through a planar medium A and B following one-dimensional mass diffusion, as Figure (a) shows. Assume no homogeneous chemical reactions and at steady state. Find the concentration distribution of component A in the planar medium ($0 \leqq x \leqq W$) where $X_{A2} > X_{A1}$. (10%)

(b)Species A diffuses through a cylinder medium A and B following one-dimensional mass diffusion, as Figure (b) shows. Assume no homogeneous chemical reactions and at steady state. Find the concentration distribution of component A in the cylinder medium ($R_2 \leqq r \leqq R_1$) where $X_{A2} > X_{A1}$. (10%)

(c) Species A diffuses through a sphere medium A and B following one-dimensional mass diffusion, as Figure (c) shows. Assume no homogeneous chemical reactions and at steady state. Find the concentration distribution of component A in the sphere medium ($R_2 \leqq r \leqq R_1$) where $X_{A2} > X_{A1}$. (10%)

(d) Species A diffuses through a sphere medium A and B following one-dimensional mass diffusion, as Figure (c) shows. Homogeneous chemical reactions (reaction rate equation = $k' X_A$). Find the concentration distribution of component A in the sphere medium ($R_2 \leqq r \leqq R_1$) where $X_{A2} > X_{A1}$. (10%)

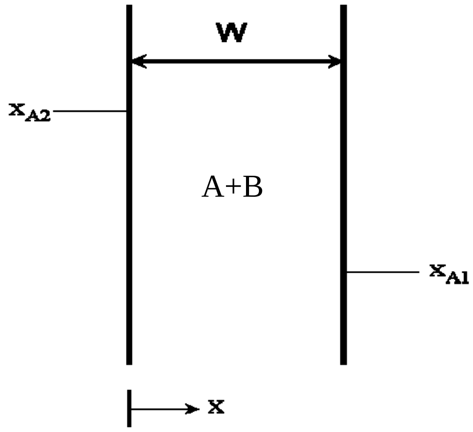



Figure (a)

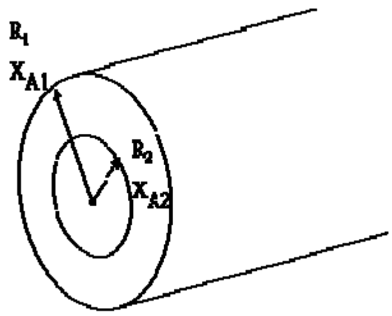



Figure (b)

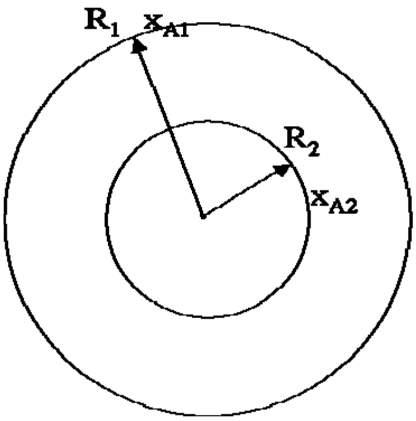



Figure (c)

科目：化工熱力學與化學反應工程　系所：化學工程及材料工程學系甲組　是否使用計算機：是
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**Table: Values of the universal gas constant**

R = 8.314 J $mol^{-1}$ $K^{-1}$ = 8.314 $m^3$ Pa $mol^{-1}K^{-1}$
= 83.14 $cm^3$ bar $mol^{-1}$ $K^{-1}$ = 8314 $cm^3$ kPa $mol^{-1}$ $K^{-1}$
= 82.06 $cm^3$ (atm) $mol^{-1}$ $K^{-1}$ = 62356 $cm^3$ (torr) $mol^{-1}$ $K^{-1}$
= 1.987 (cal) $mol^{-1}$ $K^{-1}$ = 1.986 (Btu)(lb mole)$^{-1}$ (R)$^{-1}$
= 0.7302 (ft)$^3$ (atm) (lb mol)$^{-1}$ (R)$^{-1}$ = 10.73 (ft)$^3$ (psia)(lb mol)$^{-1}$ (R)$^{-1}$
=1545 (ft)($lb_f$)(lb mol)$^{-1}$(R)$^{-1}$

1. A vessel, divided into two parts by a partition, contains 4 mol of nitrogen gas at 75℃ and 30 bar on one side and 2.5 mol of argon gas at 130℃ and 20 bar on the other. If the partition is removed and the gas mix adiabatically and completely, what is the change in entropy? Assume nitrogen to be an ideal gas with $C_v$ = (5/2)R and argon to be an idel gas with $C_v$ = (5/2)R. (20%)

2. The molar volume ($cm^3$ $mol^{-1}$) of a binary liquid mixture at T and P is given by: （20%）

$$V = 120x_1 + 70x_2 + (15x_1 + 8x_2)x_1x_2$$

(a) Find expressions for the partial molar volumes of species 1 and 2 at T and P.

(b) Show that these expressions satisfy the Gibbs/Duhem equation at constant.

(c) Show that $\left(d\bar{V}_1 / dx_1\right)_{x_1=1} = \left(d\bar{V}_2 / dx_1\right)_{x_1=0} = 0$

(d) Plot values of V, $\bar{V}_1$, and $\bar{V}_2$ calculated by the given equation for V and by the equations developed in (a) vs. $x_1$. Label points $V_1$, $V_2$, $\bar{V}_1^{\infty}$, and $\bar{V}_2^{\infty}$, and show their values.

3. What is the work (J/mol) required for the separation of air (21-mol% oxygen and 79-mol% nitrogen) at 25℃ and 1 bar in a steady-flow process into product streams of pure oxygen and nitrogen, also at 25℃ and 1 bar, if the thermodynamic efficiency of the process is 5 % and if $T_\sigma$ = 300 K? （15%）

4. The liquid phase reaction

$$A + B \longrightarrow C$$

follows an elementary rate law and is carried out isothermally in a flow system. The concentrations of the A and B feed streams are 2M before mixing. The volumetric flow rate of each stream is 5 $dm^3$/min, and the entering temperature is 300 K. The streams are mixed immediately before entering. Two reactors are available. One is a gray 200 $dm^3$ continuous-stirred tank reactor (CSTR) that can be heated to 77℃, and the other is a white 800 $dm^3$ plug-flow reactor (PFR) operated at 300 K that cannot be heated or cooled but can be painted red or black. Note k = 0.07 $dm^3$/mol.min at 300 K and E = 20 kcal/mol.

(a) Which reactor and what conditions do you recommend? Explain the reason for your choice. Back up your reasoning with the appropriate calculations. （8%）

(b) How long would it take to achieve 90 % conversion in a 200 $dm^3$ batch reactor with $C_{A0} = C_{B0}$ = 1M after mixing at a temperature of 77℃? （7%）

(c) What conversion would be obtained if the CSTR and PFR were operated at 300 K and connected in series? In parallel with 5 mol/min to each? （10%）

5. Ozone is a reactive gas that has been associated with respiratory illness and decreased lung function. The following reactions are involved in ozone formulation.

$$NO_2 + h\nu \rightarrow NO + O$$
$$O_2 + O + M \rightarrow O_3 + M$$
$$O_3 + NO \rightarrow NO_2 + O_2$$

$NO_2$ is primarily generated by combustion in the automobile engine.

(a) Show that the steady-state concentration of ozone is directly proportional to $NO_2$ and inversely proportional to NO. (5%)

(b) Drive an equation for the concentration of ozone in solely in terms of the initial concentration $C_{NO,0}$, $C_{NO2,0}$, and $O_{3,0}$ and the rate law parameters. (5%)

(c) In the absence of NO and $NO_2$, the rate law for ozone generation is $-r_{O3} = \dfrac{k(O_2)(M)}{(O_2)(M) + k^{'}(O_3)}$

Suggest a mechanism. (10%)

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(15%)

1. Figure 1 shows the first three peaks of the x-ray diffraction pattern for α-iron, which has a BCC crystal structure; monochromatic x-radiation having a wavelength of 0.1542 nm was used.

(a) Index (ie. Give *h*, *k*, and *l* indices) for each of the peaks.

(b) Determine the interplanar spacing for each of the peaks.

(c) Determine the atomic radius for α-iron.

(Note: $\sin 22.3 \cong 0.379$ ; $\sin 32.5 \cong 0.537$ ; $\sin 41.0 \cong 0.656$ ; $\sqrt{2} \cong 1.414$ ; $\sqrt{3} \cong 1.732$)

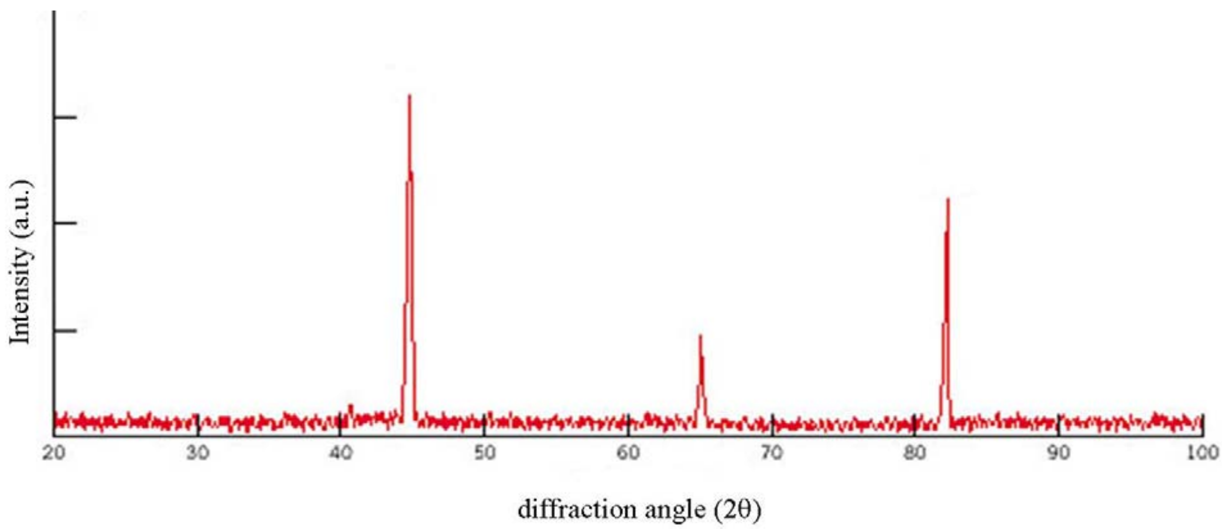


Figure 1. Diffraction patterns for poly-crystalline α-iron

(10%)

2. For an FCC single crystal, would you expect the surface energy for a (100) plane to be greater or less than that for a (111) plane? Why?

(15 %)

3. Tin bronze has a composition of 89 wt% Cu and 11wt % Sn, and consists of two phases at room temperature: an α phase, which is copper containing a very small amount of tin in solid solution, and an ε phase, which consists of approximately 37 wt% Sn. The electrical resistivities and densities of the two phases are given in the below table.

| phase | Electrical resistivity (Ω-m) | Density ($g/cm^3$) |
|---|---|---|
| α | $1.88 \times 10^{-8}$ | 8.94 |
| ε | $5.32 \times 10^{-7}$ | 8.25 |

(a) What are the weight fractions of the two phases?
(b) What are the volume fractions of the two phases?
(c) Compute the room temperature conductivity of this alloy.

(20%)

4. Consider 3.0 kg of austenite containing 0.35 wt % C , cooled to below 727℃.
(a) What is the proeutectoid phase?
(b) How many kilograms each of total pearlite and cementite form?
(c) How many kilograms each of pearlite and the proeutectoid phase form?
(d) Schematically sketch and label the resulting microstructure.
(Note: the solubility limit of C in iron is around 0.022 wt % at 727℃)

(10%)

5. (a) Calculate the room-temperature electrical conductivity of silicon that has been doped with $10^{23}$ $m^{-3}$ of As atoms. (b) Is this material n-type or p-type? Why?
(Note: The electron mobility at an impurity concentration of $10^{23}$ $m^{-3}$ is 0.065 $m^2$/V-s )

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(10 %)

6.Gallium arsenide (GaAs) and gallium phosphide (GaP) are compound semiconductors that have room-temperature band gap energies of 1.42 and 2.25 eV, respectively, and form solid solutions in all proportions. Furthermore, the band gap of the alloy increases approximately linearly with GaP additions (in mol%). Alloys of these two materials are used for light-emitting diodes wherein light is generated by conduction band-to-valence band electron transitions. Determine the composition of a GaAs–GaP alloy that will emit red light having a wavelength of 0.62 mm.

(10 %)

7. In your own words describe briefly the phenomenon of (a) luminescence (b) superparamagnetism

(10%)

8. A cylindrical rod of brass originally 0.40 in (10.2 mm) in diameter is to be cold worked by drawing. The circular cross section will be maintained during deformation. A cold-worked tensile strength in excess of 55,000 psi (380 MPa) and a ductility of at least 15 %*EL* are desired. Furthermore, the final diameter must be 0.30 in (7.6 mm). Figures. 2 (a)~(c) show the dependence of yield strength, tensile strength, and ductility of brass on percent cold work. Explain how this may be accomplished.

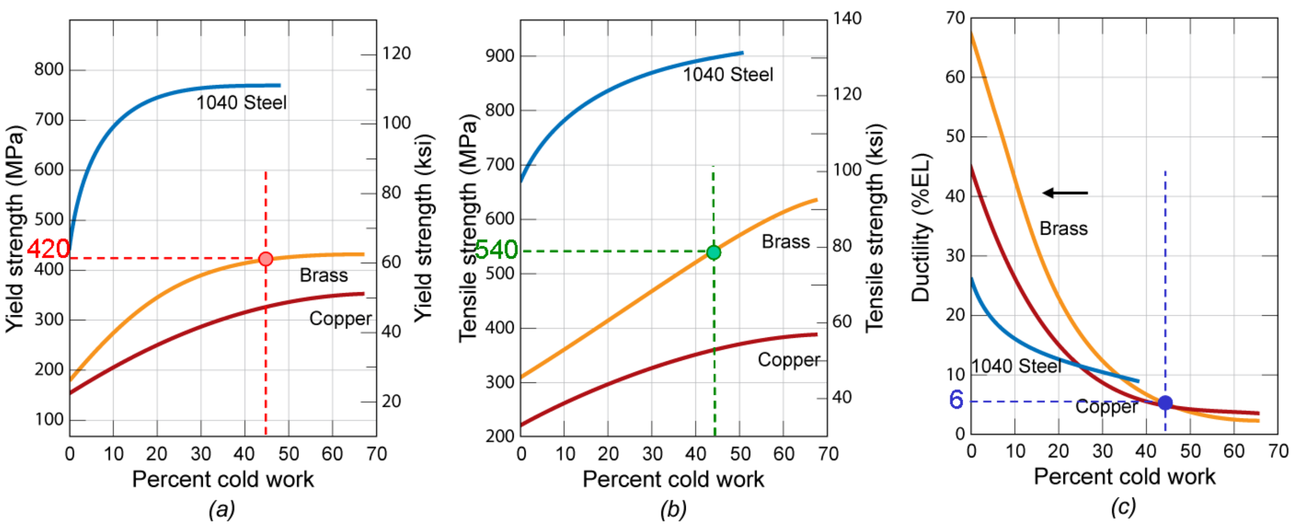


Figure. 2 The dependence of (a) Yield strength (b) tensile strength (c) ductility of brass on percent cold work

科目：材料熱力學
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本科原始成績：100 分

1. What is the van der Waals equation? Please explain the meanings of correction terms in van der Waals equation. (10 %)

2. What is the relationship between Henry's and Raoul's laws? Please derive their relationship and explain by a binary A-B solution. (10 %)

3. Graphite is the stable form of 298K and 1 atm pressure, and increasing the pressure on graphite at temperature less than 1440K causes the transformation of graphite to diamond. Calculate the pressure which, when applied to graphite at 298K, causes the transformation of graphite to diamond, given (10%)
$H_{298K,\ (graphite)} - H_{298K,\ (diamond)} = -1900J$
$S_{298K,\ (graphite)} = 5.74\ J/K$
$S_{298K,\ (diamond)} = 2.37\ J/K$
$D_{298K,\ (graphite)} = 2.22\ g/cm^3$
$D_{298K,\ (diamond)} = 3.515\ g/cm^3$

4. The partial pressure of hydrogen in the atmosphere is such that an Fe-C-Ti melt containing 1 wt% C and 3 wt% Ti contains 5 parts per million (by weight) of hydrogen at 1600℃. Calculate the vacuum, which is required to decrease the hydrogen content of the melt to 1ppm, given that $e_H^{Ti} = -0.08$, that $e_H^{C} = 0.06$, and that hydrogen in pure iron obeys Henry's law up to a solubility of 0.0027 wt% under a pressure of 1 atm of hydrogen at 1600℃. (15%)

5. What is "chemical sink"? Please explain why it is impossible to obtain an absolutely pure substance? (10 %)

6. By establishing the equilibrium

$$PCl_{5(g)} = PCl_{3(g)} + Cl_{2(g)}$$

at 500 K in a mixture of $PCl_5$ and $PCl_3$ a gas is obtained at 1 atm total pressure in which the partial pressure of $Cl_2$ is 0.1 atm. In what ratio were $PCl_5$ and $PCl_3$ mixed to obtain this equilibrium gas? ($PCl_{3(g)} + Cl_{2(g)} = PCl_{5(g)}$, $\Delta G^\circ = -95{,}600 - 7.94\,T \ln T + 235.2\,T$ J) (10%)

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7. During the chlorination of $NiO_{(s)}$ in a reactor at 900K it is required that 90% conversion of the chlorine gas be achieved during a single pass through the reactor. Calculate the required total gas pressure. (10%)

The reaction is $NiO_{(s)} + Cl_{2(g)} = NiCl_{2(s)} + \frac{1}{2} O_{2(g)}$ , $\Delta G^{o}_{900K} = -15{,}490J$

8. The EMF of the cell $Ag_{(s)}|AgCl_{(s)}|Cl_{2(g,\ 1atm)}$, Pt is found to be

$$E(\text{volts}) = 0.977 + 5.7\times10^{-4}(350-t) - 4.8\times10^{-7}(350-t)^2$$

in the temperature range $t$ = 100℃ to $t$ = 450℃. Calculate the value of $\Delta C_p$ for the cell reaction. (10%)

9. Please explain the following terms:
   (1) fugacity. (4%)
   (2) intensive properties. (3%)
   (3) state function. (4%)
   (4) spinodal curve. (4%)

log2 = 0.301, log3=0.477, log5 = 0.699, log7=0.845
$e^2 = 7.389$, $e^3 = 20.086$, $e^{0.02} = 1.02$, $e^{0.05} = 1.05$