國立高雄大學 106 學年度研究所碩士班招生考試試題

科目：輸送現象
考試時間：100 分鐘

系所：化學工程及材料工程學系
（無組別）
本科原始成績：100 分

是否使用計算機：是

一、選擇題(單選，每題五分，共十題，**請在答案卷作答!**)

1. 牛頓流體(Newtonian fluid)中，剪切應力(Shear stress)與何種單位長度的物理量成正比?
(A)壓力差 (B)速度差 (C)溫度差 (D)濃度差

2. 白努力方程式(Bernoulli equation)為何種輸送現象的平衡式?
(A)能量守恆 (B)質量守恆 (C)動量守恆 (D)以上皆非

3. 水在一圓管中以層流狀態流動，請問其最小的摩擦因數(Friction factor)約為?
(A) 0.01 (B) 0.02 (C) 0.03 (D) 0.04

4. 在進行流體動量平衡時，不含下列何種作用力?
(A)壓力 (B)剪切應力 (C)重力 (D)努力

5. 水在室溫(20ºC)下，在直徑 5 公分圓管中，以每秒 20 公尺流動，請問其流動狀態為?
(A)層流 (B)紊流 (C)過渡狀態 (D)以上皆非

6. 無旋性流(irrotational flow)不須滿足下列何種條件?
(A) $\nabla P=0$ (B) $\nabla \cdot V=0$ (C) $\nabla^2\phi=0$ (D) $\nabla^2\psi=0$

7. 熱傳的方式，不含下列何者?
(A)傳導 (B)對流 (C)輻射 (D)擴散

8. 在進行流體熱量平衡式的無因次化時，不含下列何種無因次數?
(A) Eu (B) Pr (C) Nu (D) Re

9. 在類比動量及熱傳時，若使用 Reynolds 類比法，Pr 的數值須具備以下何種條件?
(A) <1 (B) =1 (C) >1 (D)無關

10. 兩同心球體直徑分別為 24 及 36 公分，請問此時從內球看外球的視因數(view factor)為?
(A) 0.22 (B) 0.33 (C) 0.44 (D) 0.66

二、計算/證明題 (每題十分，共五題，**請在答案卷作答!**)

11. High pressured nitrogen gas at 298 K is contained in a 2 m spherical natural rubber container whose wall is 5 cm thick. The concentrations of nitrogen in the rubber at the inner and outer surfaces are 0.08 kg/m^3 and 0.01 kg/m^3, respectively. The diffusion coefficient of nitrogen through rubber is 1.5 x10^{-10} m^2/s. Please find the mass flow rate of nitrogen diffused through this container.

12. Please derive the effectiveness (ε) of a parallel-flow heat exchanger from energy balance.

13. A large plane wall of thickness 2L experience a uniform heat generation. Determine the expression for the variation of temperature within the wall, if the temperature on the surface $T_2>T_1$.

14. Please find the velocity profile of a Bingham fluid in a circular tube with an angle (α) to the ground. (Hint: $\tau=\tau_0+\mu\cdot dv/dy$)

15. An incompressible Newtonian liquid is confined between two concentric cylinders of infinite length; the radii of the inner solid (with angular velocity, ω_i) and the stationary outer hollow are R_i and R_o, respectively. Please find the velocity profile in the liquid and the shear stress on the outer cylinder and list your assumptions.

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Cylindrical coordinates (r, θ, z):

$$\rho\left(\frac{\partial v_r}{\partial t}+v_r\frac{\partial v_r}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_r}{\partial \theta}+v_z\frac{\partial v_r}{\partial z}-\frac{v_\theta^2}{r}\right)=-\frac{\partial p}{\partial r}+\mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(rv_r)\right)+\frac{1}{r^2}\frac{\partial^2 v_r}{\partial \theta^2}+\frac{\partial^2 v_r}{\partial z^2}-\frac{2}{r^2}\frac{\partial v_\theta}{\partial \theta}\right]+\rho g_r$$

$$\rho\left(\frac{\partial v_\theta}{\partial t}+v_r\frac{\partial v_\theta}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta}+v_z\frac{\partial v_\theta}{\partial z}+\frac{v_r v_\theta}{r}\right)=-\frac{1}{r}\frac{\partial p}{\partial \theta}+\mu\left[\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial}{\partial r}(rv_\theta)\right)+\frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2}+\frac{\partial^2 v_\theta}{\partial z^2}+\frac{2}{r^2}\frac{\partial v_r}{\partial \theta}\right]+\rho g_\theta$$

$$\rho\left(\frac{\partial v_z}{\partial t}+v_r\frac{\partial v_z}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_z}{\partial \theta}+v_z\frac{\partial v_z}{\partial z}\right)=-\frac{\partial p}{\partial z}+\mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2}+\frac{\partial^2 v_z}{\partial z^2}\right]+\rho g_z$$

國立高雄大學 106 學年度研究所碩士班招生考試試題

科目：化工動力學
考試時間：100 分鐘

系所：化學工程及材料工程學系
（無組別）
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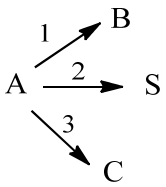
1. To explain the following proper nouns. (20%)
   (A) Chemical equilibrium, (B) Heterogeneous reaction, (C) Catalyst, (D) Elementary reaction, (E) Membrane reactor
2. To derive the design equation of the reactor. (30%)
   (A) Batch reactor
   (B) Continuous-stirred tank reactor (CSTR)
   (C) Plug-flow tubular reactor (PFR)
3. In a homogeneous isothermal liquid polymerization, 20% of the monomer disappears in 20 minutes for initial monomer concentration of 0.02 and also for 20 mol/liter. What rate equation represents the disappearance of the monomer? (20%)
4. A liquid reactant stream (1 mol/liter) passes through two continuous-stirred tank reactors (CSTR) in a series. The concentration of A in the exit of the first reactor is 0.5 mol/liter. Find the concentration in the exit stream of the second reactor. The reaction is second order with respect to A and $V_2/V_1=2$. (20%)
5. For a given feed stream having C_{A0} should we use a plug-flow tubular reactor (PFR) or a continuous-stirred tank reactor (CSTR) and should we use a high or low conversion level for the exit stream if we wish to maximize instantaneous fractional yield of S? The reaction system is



Where $n_1=3$, $n_2=1$, and $n_3=2$ are the reaction orders of reactions 1, 2, and 3. (10%)

國立高雄大學 106 學年度研究所碩士班招生考試試題

科目：材料科學導論
考試時間：100 分鐘

系所：化學工程及材料工程學系
（無組別）
本科原始成績：100 分

是否使用計算機：是

1. Please describe and define the following terms: (25%)
   (a) annealing
   (b) calcination
   (c) creep
   (d) diffusion flux
   (e) dislocation line

2. Please calculate the atomic packing factor (APF) for the face-centered cubic (FCC) crystal structure. (10%)

3. Consider the tensile stress-strain curves in Figure 1 labeled A and B and answer the following questions. These curves are typical of metals. Consider each part as a separate question that has no relationship to previous parts of the question. (15%)
   (a) Which sample has the larger work hardening exponent: A or B? How do you know?
   (b) Assume that the two stress-strain curves represent successive tests of the same sample. The sample was loaded, then unloaded before necking began, and then the sample was reloaded. Which sample represents the first test: A or B? How do you know?
   (c) Sample A and B have the same composition and were processed identically, except that one of them was cold worked more than the other. The stress-strain curves were obtained after the samples were cold worked. Which sample has the lower recrystallization temperature: A or B? How do you know?

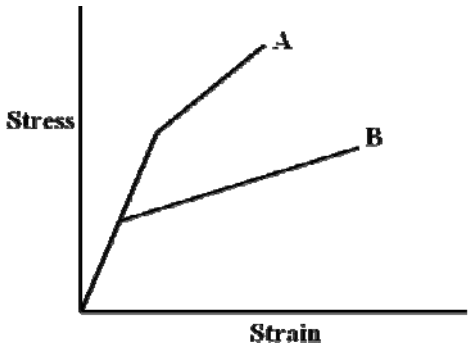


Figure 1

4. What are the major differences between martensitic and pearlitic transformations? (10%)

5. Please describe the main differences between wrought and cast alloys, and briefly indicate their manufacturing principles. (10%)

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6. Figure 2 shows the Mg–Pb phase diagram, please answer the following questions: (15%)
   (a) A 50 wt% Mg–50 wt% Pb alloy is slowly cooled from 700°C to 400°C. (i) At what temperature does the first solid phase form? What is the composition of this solid phase? (ii) At what temperature does the liquid solidify? What is the composition of this last remaining liquid phase?
   (b) A 55 wt% Mg–45 wt% Pb alloy is rapidly quenched to room temperature from an elevated temperature in such a way that the high-temperature microstructure is preserved. This microstructure is found to consist of the α phase and Mg_2Pb, having respective mass fractions of 0.65 and 0.35. Determine the approximate temperature from which the alloy was quenched.

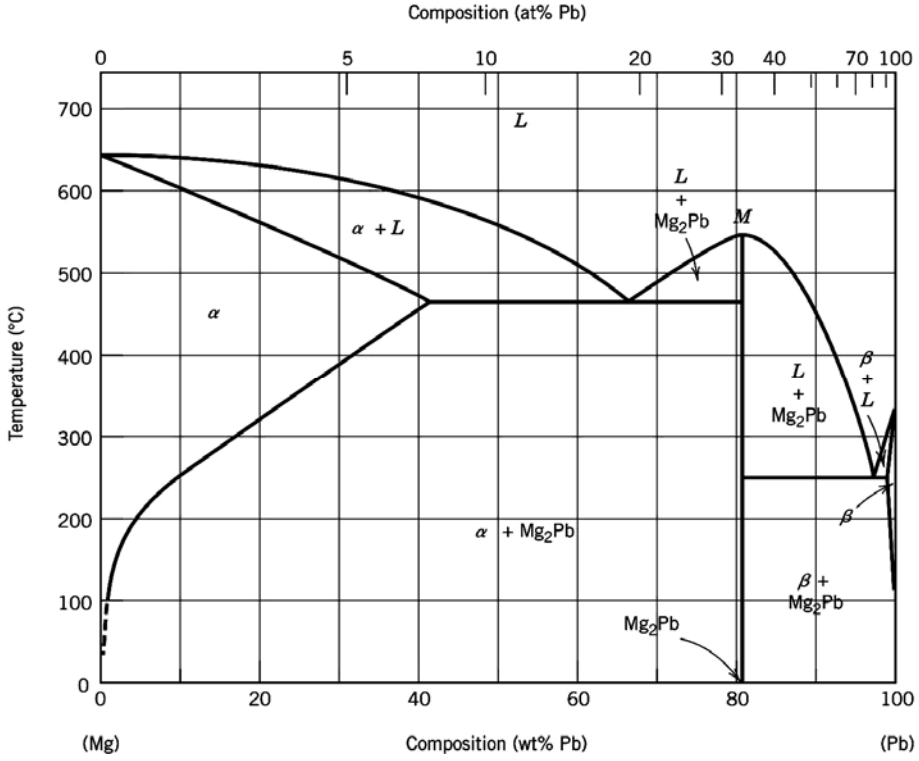

Figure 2

7. Two sheets of a 1040 steel are joined together with an aluminum rivet, as shown in Figure 3. Discuss the possible corrosion cells that might be created as a result of this joining process, such as composition cells, stress cells, and concentration cells. Recommend a joining process that might minimize corrosion of these cells. (15%)

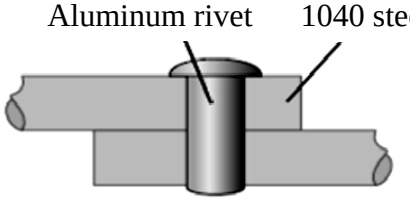

Figure 3

國立高雄大學 106 學年度研究所碩士班招生考試試題

科目：普通化學
考試時間：100 分鐘

系所：化學工程及材料工程學系
（無組別）
本科原始成績：100 分

是否使用計算機：是

1. Nitrogen gas can be prepared by passing gaseous ammonia over solid copper (II) oxide at high temperatures. The other products of the reaction are solid copper and water vapor. If a sample containing 18.1 g of NH_3 is reacted with 90.4 g of CuO, which is the limiting reactant? How many grams of N_2 will be formed? If 6.63 g of N_2 is actually produced, what is the percent yield of nitrogen? (atomic mass: N, 14.01; O, 16.00; H, 1.008; Cu, 63.55) (10%)
2. Write Lewis structures and predict the molecular structures of $COCl_2$, SO_3, BrF_3, and PCl_5. Which of these compounds are polar? (15%)
3. Use the molecular orbital model to predict the magnetism and bond order of B_2 and NO^+. (8%)
4. Draw all resonance structures for SCN^-. Which resonance structure is the most stable one? Explain why. (5%)
5. Give the systematic name for each of the following compounds: (10%)
   (a) Fe_2O_3 (b) GaI_3 (c) $Mn(OH)_2$ (d) Na_2SO_4 (e) P_4O_{10}
6. Maleic acid is an organic compound composed of 41.39% C, 3.47% H, and the rest oxygen. If 0.129 mole of maleic acid has a mass of 15.0 g, what are the empirical and molecular formulas of maleic acid? (atomic mass: C, 12.01; O, 16.00; H, 1.008) (10%)
7. A solution is prepared by mixing 0.0300 mole of CH_2Cl_2 and 0.0500 mole of CH_2Br_2 at 25 °C. Assuming the solution is ideal, calculate the vapor pressure of the resulting solution and the composition of the vapor (in terms of mole fractions) at 25 °C. At 25 °C, the vapor pressures of pure CH_2Cl_2 and pure CH_2Br_2 are 133 and 11.4 torr, respectively. (10%)
8. Draw energy plots for a catalyzed and an uncatalyzed pathway for a given reaction. Use a same plot (or draw two plots) to illustrate the effect of a catalyst on the number of reaction-producing collisions (effective collisions) for a catalyzed and an uncatalyzed pathway for a given reaction at a given temperature. (8%)
9. Predict which substance in each of the following pairs would have the greater intermolecular forces. Explain why. (6%)
   a. CO_2 or OCS b. CH_3OH or H_2CO
10. Calculate the $[H^+]$ of a 1.0 L solution that contains 0.25 M NH_3 (K_b=1.8 x 10^{-5}) and 0.40 M NH_4Cl. Then, calculate the $[H^+]$ of the solution after the addition of 0.10 mole of gaseous HCl? (10%)
11. Describe the cell based on the following half-reactions: (8%)

    $VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$ $\varepsilon^0 = 1.00$ V

    $Zn^{2+} + 2e^- \rightarrow Zn$ $\varepsilon^0 = -0.76$ V

    Where T = 25 °C, $[VO_2^+]$ = 2.0 M, $[H^+]$ = 0.50 M

    $[VO^{2+}] = 1.0 \times 10^{-2}$ M, $[Zn^{2+}] = 1.0 \times 10^{-1}$ M

    Write the balanced cell reaction and calculate the cell potential at 25 °C (log 4=0.602).