國立雲林科技大學 113 學年度
碩士班招生考試試題

系所：化材系
科目：單元操作與輸送現象

1. Please explain the following terms: (12%)
(a) viscosity
(b) kinematic viscosity
(c) turbulent viscosity
(d) volume viscosity

2. If one wants to measure the viscosity of glycerol by flowing through a horizontal tube 0.3 m long and with 0.8 cm inside radius at 25 °C. The pressure drop is 330 Pa, and the volumetric flowrate is 75 cm^3/min. The density of glycerol is known as 1.261 g/cm^3. Use Hagen-Poiseuille equation to estimate the viscosity of glycerol in centipoise (cp). (18%)

3. Carburization is a key process in making low alloy steels. This process involves the absorption of carbon into steel in a high temperature environment, and the simplest model can be obtained by considering one-dimensional diffusion of carbon into a steel plate at a fixed temperature. Suppose the initial carbon level in steel is C_0, and the surface concentration of carbon is fixed as C_S. The diffusion coefficient D for the carbon-steel binary is assumed to be constant. Start with the Fick's second law ($\frac{\partial C(x,t)}{\partial t} = D\frac{\partial^2 C(x,t)}{\partial x^2}$) to find the carbon concentration in steel as a function of distance x and time t from the surface at $x = 0$. Note that the results can be expressed in terms of error function ($\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-\eta^2} d\eta$) given the properties of $\mathrm{erf}(0) = 0$ and $\mathrm{erf}(\infty) = 1$. (20%)

4. In a plane wall, thermal energy is conducted only in x direction at steady state. The other walls in y, z directions are assumed to be insulated. The temperature of wall is T_1 ($x = x_1$) and T_2 ($x = x_2$). The thermal conductivity of the plane wall is $k = k_0(1 + \alpha\theta)$, wherein α, k_0 are constants and $\theta = T - T_0$ with the defined reference temperature of T_0. Please derive temperature profile in the x direction $\theta(x)$ as a function of x, x_1, x_2, α, θ_1 and θ_2 within the plane wall. (20%)

5. A sphere with the radius of R is suspended in the fluid. Thermal energy is conducted radially at steady state from the sphere into the fluid (thermal conductivity k) and convectional heat transfer is neglected. The surface temperature of sphere is Ts and bulk fluid temperature is To. Please derive temperature profile of the fluid in the radial direction T(r) as a function of r, R, To, Ts. (15%)

6. A hollow cylinder, with the inner radius of r_1 and outer radius of r_2, possesses thermal conductivity of $k = k_0(1 + \beta\theta)$, wherein β, k_0 are constants and $\theta = T - T_0$ with the defined reference temperature of T_0. The inner temperature of the cylindrical wall is T_1 at r_1. The outer surface of the cylindrical wall is T_2 at r_2. Find the heat transfer rate per unit length of the cylinder at steady state. (15%)

題目共二頁

國立雲林科技大學 113 學年度 碩士班招生考試試題

系所：化材系

科目：物理化學

1. A van der Waals gas has a molar volume of $5.42\times10^{-3}\ m^3\ mol^{-1}$ at 440 K. The van der Waals parameters a and b are $18.45\ bar\ dm^6\ mol^{-2}$ and $4.2\times10^{-2}\ dm^3\ mol^{-1}$, respectively. (a) Calculate the pressure exerted by the gas. (6%) (b) What is the compression factor of the gas? (5%) (c) What kind of force dominates? (3%)

2. 0.5 mole of ethane at 1 bar and 350 K expanded reversibly and adiabatically to 0.4 bar. Assume ethane is an ideal gas with $C_{p,m}/C_{V,m}$=1.38. (a) What are the initial volume, final volume, and final temperature of the ethane? (13%) (b) Calculate the work done, ΔU, and ΔH for the process. (11%)

3. Calculate ΔS, ΔS_{sur}, and ΔS_{tot} when three moles of a perfect gas were compressed isothermally and reversibly to half its initial volume. (12%)

4. A and B form an ideal solution at 298 K, with $x_A = 0.320$, $P_A^* = 84.3$ Torr, and $P_B^* = 41.2$ Torr. (a) Calculate the partial pressures of A and B in the gas phase. (8 %) (b) A portion of the gas phase is removed and condensed in a separate container. Calculate the partial pressures of A and B in equilibrium with this liquid sample at 298 K. (8 %)

5. For the half-cell reaction $\mathrm{Hg_2Cl_2}(g) + 2e^- \rightarrow 2\mathrm{Hg}(l) + 2\mathrm{Cl}^-(aq)$, $E° = +0.27$ V. Using this result and $\Delta G_f^\circ(\mathrm{Hg_2Cl_2}, s) = -210.7\ \mathrm{kJ\ mol^{-1}}$, determine $\Delta G_f^\circ(\mathrm{Cl}^-, aq)$. (14 %)

6. A certain reaction is first order, and 540 s after initiation of the reaction, 32.5% of the reactant remains. (a) What is the rate constant for this reaction? (10%) (b) At what time after initiation of the reaction will 10% of the reactant remain? (10%)

國立雲林科技大學 113 學年度 碩士班招生考試試題

系所：化材系

科目：材料導論

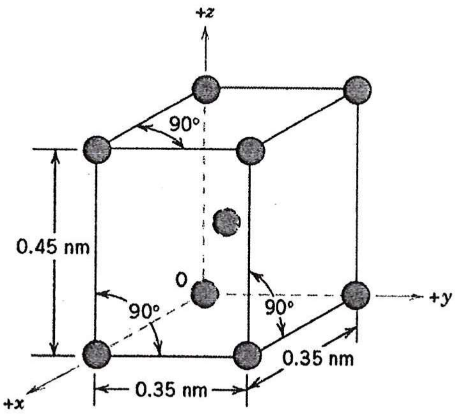
1. Show that the atomic packing factor for HCP is 0.74. (10%)

2. The accompanying figure shows a unit cell for a hypothetical metal. (30%)

(a) To which crystal system does this unit cell belong?

(b) What would this crystal structure be called?

(c) Calculate the density of the material, given that its atomic weight is 141 g/mol.



3. What is the composition of Pb and Sn, respectively, **in atom percent**, of an alloy that consists of 5.5 wt% Pb and 94.5 wt% Sn? (the atomic weights of Pb = 207.2 g/mol. the atomic weights of Sn = 118.71 g/mol) (10%)

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4. Please explain the following nouns: (10%)

(a) Annealing(4%)

(b) Binary-Eutectic Systems(3%)

(c) Ductility(3%)

5.What are stages of moderately ductile failure?(20%)

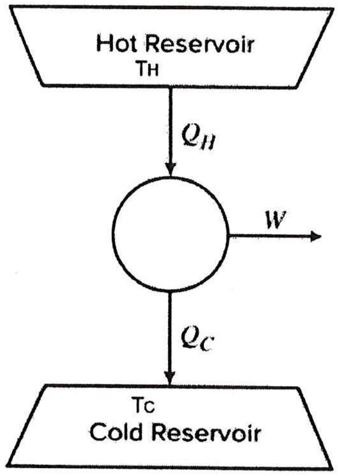
6.What is criterion for crack propagation? (20%)

國立雲林科技大學 113 學年度
碩士班招生考試試題

系所：化材系
科目：化工熱力學

1. (20%)
Air in the ideal-gas state (constant-volume heat capacity 12.471 J/mol-K) is compressed from 1 bar and 70°C to 1.7 bar and 150°C in a closed system which is placed inside a constant-temperature bath at 30°C.
(a) The compression process operates adiabatically in a mechanically reversible manner. Calculate the work required, enthalpy change and entropy change. (10%)
(b) The compression process has a work efficiency of 70% and accomplishes exactly the same changes of state. Calculate the work required, heat transferred and total entropy change. (10%)

2. (15%)
A central power plant operates with a heat engine by taking heat of 158000 kW from a hot reservoir at 350°C and discards heat to a cold reservoir at 30°C. It has a thermal efficiency equal to 55% of the maximum possible value.
(a) Calculate the thermal efficiency, work produced, and heat discarded. (10%)
(b) Show whether or not this plant operation is thermodynamically possible. (5%)



3. (15%)
Steam at 8600 kPa and 500°C (enthalpy H=3391.6 kJ/kg, entropy S=6.6858 kJ/kg-K) is fed at a rate of 59 kg/s into a steam turbine with rated capacity of 56400 kW. Exhaust from the turbine enters a condenser at 10 kPa (saturated vapor: S=8.1511 kJ/kg-K, H=2584.8 kJ/kg; saturated liquid: S=0.6493 kJ/kg-K, H=191.8 kJ/kg).
Calculate
(a) the maximum work output and correspondingly the quality of the steam at discharge. (10%)
(b) the turbine efficiency. (5%)

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4. (20%)

A device operates adiabatically and without moving parts, splitting a feed of compressed air into two streams: chilled and warm air. The feed air enters at 30°C and 7.5 bar, and the device produces chilled air at 10°C and 1.5 bar and warm air at 50°C and 1.5 bar. Assuming the device operates adiabatically and the air behaves as an ideal gas with $C_p=(7/2)R$, determine the ratio of the mass flow rate of the chilled air to warm air.

5. (10%)

Evaluate the spontaneity of a chemical reaction at both low and high temperatures for each possible combination of signs (positive or negative) for the enthalpy change (ΔH) and the entropy change (ΔS) of the system. Discuss your predictions in the context of the Gibbs free energy equation.

(a) ΔH negative, ΔS positive (5%)

(b) ΔH negative, ΔS negative (5%)

6. (20%)

A vessel is divided into two parts by a partition. One part contains 3 mol of nitrogen gas at 85°C and 25 bar, and the other contains 2 mol of argon gas at 120°C and 15 bar. If the partition is removed, allowing the gases to mix adiabatically and completely, determine:

(a) The final temperature and pressure in the vessel. (10%)

(b) The change in the entropy of the system. (10%)

Assume nitrogen to be an ideal gas with $C_v = (5/2)R$ and argon to be an ideal gas with $C_v = (3/2)R$.

國立雲林科技大學 113 學年度 碩士班招生考試試題

系所：化材系

科目：化工動力學

1. Please present the general mole balance equation and utilize it to derive the designed equations for the batch reactor, continuous stirred-tank reactor (CSTR), and plug-flow reactor, respectively, considering a first-order reaction occurring in these reactors. (20%)

2. The homogenous gas decomposition of phosphine:

$$4PH_{3(g)} \rightarrow P_4 + 6H_2,$$

proceeds at 1200°F with first-order rate,

$$-r_{PH3} = (10/hr)\, C_{PH3}\,.$$

What size of plug-flow reactor (PFR), operating at 1200°F and 4 atm, is necessary to attain a 70% conversion of a feed comprising 5 lb-mol of pure phosphine per hour? Furthermore, if a continuous stirred-tank reactor (CSTR) is employed instead of a PFR, which reactor incurs a higher cost under the assumption of the same material cost per unit volume? (14%)

3. To produce 100 million pounds per year of ethylene glycol by hydrolyzing ethylene oxide (A), two continuous stirred-tank reactors (CSTRs) are employed and operated isothermally. Please demonstrate how to calculate the conversions for the two CSTRs arranged in series and in parallel, respectively, considering a first-order chemical reaction, and include the variables for the reactor volume (V) and the volumetric flow rate entering the reactor (v_0). (16%)

4. Substance A reacts to produce D (desired) and U (undesired), which reaction system is

$A \rightarrow D,\ r_D = k_D C_A$

$A \rightarrow U,\ r_U = k_U C_A^2$

In the viewpoint of the increase of the r_D/r_U ratio, which reactor, CSTR or PFR, should be chosen? Explain the reasons and suggest other ways to increase the r_D/r_U ratio besides the choice of the reactors. (15%)

5. A liquid-phase irreversible reaction ($-r_A = kC_A^n$) was carried out in a CSTR. Pure substance A enters the reactor at a concentration of 1.5 M. The space time (τ) was varied and the effluent concentrations of substance A were recorded as followings: at $\tau = 10$ min, $C_A = 1$ M and at space $\tau = 20$ min, $C_A = 0.5$ M. Find n and k. (15%)

6. The liquid-phase reaction

$A \rightarrow n\,B,\quad r_B = kC_A{}^2$

reacts in two CSTRs in series (space time of the first CSTR $\tau_1 = 10$ min, space time of the second CSTR $\tau_2 = 7.5$ min, k = constant). The change in volumetric flow rate is negligible. The pure A ($C_{A0} = 1$ M and $C_{B0} = 0$ M) is fed into the first CSTR and the compositions flowing out from the first CSTR and flowing into the second CSTR are $C_A = 0.5$ M and $C_B = 0.25$ M. What is the n value? What are C_A and C_B in the effluent flow from the second CSTR? (20%)