國立雲林科技大學 114 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. Water (density: 1 g/cm^3, viscosity: 1 cP) flows into a smooth, circular tube with an inside diameter of 3 cm. What is the maximum volumetric flowrate in cm^3/s that will ensure the flow remains laminar? (15%)

2. A Newtonian fluid flows between two parallel, horizontal, and infinitely long plates separated by a small distance of 2B. The upper plate moves to the right at a constant velocity of $2v_0$, while the lower plate moves to the left at a constant velocity of $-v_0$. The pressure drop in the channel is $(P_0 - P_L)/L$. Assuming that the flow is laminar and neglecting edge effects, find the momentum flux distribution τ and the velocity distribution v of the fluid by performing a shell momentum balance for the steady flow. (20%)

3. A smooth circular pipe has an inside diameter of 0.1 m and a length of 5 m. Water (density: 1000 kg/m^3; viscosity: 0.001 Pa·s) flows through the pipe with an average velocity of 8 m/s. If the friction factor is f = 0.003, calculate the friction loss in the pipe. (15%)

4. Heat transfer is a fundamental concept in thermal management systems, where the thermal resistance of a material is often used to evaluate its ability to impede heat flow. Understanding thermal resistance is crucial for designing efficient thermal systems.

(a) Please define "thermal resistance" and briefly explain its physical significance in the context of heat transfer. (5%)
(b) Derive the mathematical expressions for thermal resistance for a flat surface, a cylinder, and a sphere. Discuss how the geometry of these systems affects thermal resistance. (10%)

5. A conical section made of pyroceram has a circular cross-section where the diameter varies linearly with distance x, such that D(x) = 2x. The material has a thermal conductivity k = 3.46 W/m·K. The temperature at the larger end (x_2 = 0.25 m) is T_2 = 600 K, and at the smaller end (x_1 = 0.05 m), the temperature is T_1 = 400 K.

(a) Derive the temperature distribution T(x) along the length of the conical section. (10%)
(b) Determine the heat transfer rate q_x through the conical section. (10%)

6. 企鵝雙腳的血管採用了動脈與靜脈緊密貼合的熱交換機制，這有助於減少熱量散失。已知動脈中血液的流動方向是從身體流向腳底，而靜脈中的血液則從腳底流回身體。動脈血的初始溫度為 T_a=37°C, 而靜脈血回到身體時的最終溫度為 T_v=36°C. 假設企鵝腳底的環境溫度為 T_e=5°C 且腳底處的動脈血與靜脈血之間的熱交換效率為 η=90%。

(a) 請計算靜脈血在腳底的溫度。 (5%)
(b) 請估算熱交換過程中動脈血損失的熱量。假設血液流速為 u=0.02 m/s，動脈截面積為 $A=1\times10^{-6}$ m^2, 血液的比熱容為 c=4186 J/(kg·K) 以及血液密度為 ρ=1050 kg/m^3. (10%)

國立雲林科技大學 114 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. A tank of 0.4 m^3 contains nitrogen (ideal gas, M = 28 kg/kmol, $C_v = 5R/2$) at 2 MPa , 500°C. The tank is connected to an above vertical cylinder covered by a heavy piston weighted at 30 kN through a valve. The piston area is A = 0.1 m^2. The atmospheric pressure is 100 kPa. The whole tank-cylinder assembly is well insulated. At the beginning, the cylinder contains no nitrogen. Then the valve is opened and nitrogen flows into the above cylinder until the pressures in the cylinder and the tank equalize.

a. Find the final temperature in the cylinder if the final tank temperature is 250°C. (10%)

b. Find the mass of nitrogen that entered the above cylinder. (10%)

c. Find the piston rise in the process. (10%)

2. Air enters an adiabatic horizontal nozzle at P_1 = 30 bars, T_1 = 230°C, v_1 = 10 m/s, and at a rate of 2.0 kg/s. Assume air to be an ideal gas with constant C_p = (7R/2) and M = 29 (kg/kmol), wherein R is gas constant.

a. Find the inlet area of nozzle. (10%)

b. Find the velocity and area at a point, wherein P_2 = 20 bars, T_2 = 180°C. (10%)

國立雲林科技大學 114 學年度
碩士班招生考試試題

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3. Please demonstrate a Carnot cycle for an ideal gas using a PV program and explain how to derive Carnot's equation. (10%)

4. Please derive the equation of Raoult's law and explain why Henry's Law sometimes is necessary. (10%)

5. Please derive the fundamental residual property relations for Gibbs energy, entropy, and enthalpy, respectively, for a single-component gas under isothermal conditions (15%)

6. For a thermodynamic property M, we can know $nM = F(T, P, n_1, n_2, ..n_i...)$, and $\overline{M_i}$ a generic partial property. Please show us how to obtain $M = \sum x_i \overline{M_i}$ and $\sum x_i d\overline{M_i} = 0$ at constant temperature (T) and pressure (P). (15%)

國立雲林科技大學 114 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. The reaction $A \rightarrow 2B$ is carried out isothermally in a continuous-flow reactor. The entering volumetric flow rate and molar rate are 20 dm^3 h^{-1} and 10 mol h^{-1}, respectively. Assume the reaction rate is $-r_A = kC_A$ with $k = 0.0001$ s^{-1}.
   (a) Calculate both the CSTR and PFR reactor volumes necessary to consume 90% of A. (16%)
   (b) Calculate the time necessary to consume 99% of species A in a 1000 dm^3 constant volume batch reactor with $C_{A0} = 0.5$ mol dm^{-3}. (8%)

2. The space time necessary to achieve 70% conversion in a CSTR is 4 h. The entering volumetric flow rate and concentration of reactant A are 1.5 dm^3 min^{-1} and 2.0 mol dm^{-3}, respectively.
   (a) Determine the rate of reaction. (5%)
   (b) Determine the reactor volume. (5%)
   (c) Determine the exit concentration of A. (4%)

3. The rate law for the reaction $A + 2B \rightarrow C$ is $-r_A = kC_AC_B^2$ with $k_A = 24$ dm^6 mol^{-2} s^{-1}. What are k_B and k_C? (12%)

4. For a liquid-phase reaction operating in a 40 L CSTR, the concentrations of the A and B feed streams are 3.2 and 2.4 M before mixing, respectively. The volumetric flow rate of each stream is equal. It is known that k_1 and k_2 are 9 and 1.5 L mol^{-1} min^{-1}, respectively. Determine the total flow rate of A and B, if 75% conversion of the entering species B is required. (25%)

$$A + B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} R + S$$

5. Suppose a liquid-phase reaction ($A \rightarrow B + C$) is carried out isothermally and the data are as following:

Conversion, X	0	0.2	0.4	0.45	0.5	0.6	0.8	0.9
$-r_A$ (mol L^{-1} min^{-1})	13	21.7	65	65	65	65	16.3	11.8

The molar flow rate of A is 0.5 kmol min^{-1}.

(a) For a single CSTR, what is the volume necessary to achieve 80% conversion of the entering species A? (7%)

(b) For a single PFR, what is the volume necessary to achieve 80% conversion of the entering species A? (8%)

(c) To achieve 80% conversion of the entering species A, how to arrange the reactors to minimize the total volume of reactors? (10%)