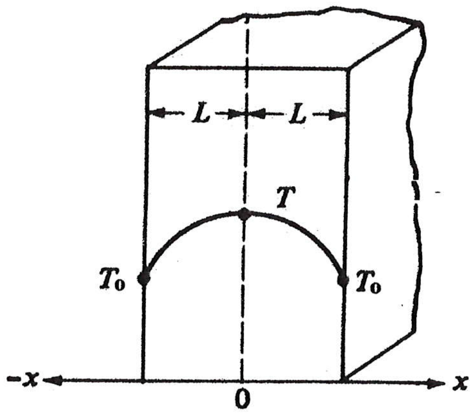
國立雲林科技大學 112 學年度 碩士班招生考試試題	系所：化材系 科目：單元操作與輸送現象

1. A thick-walled pipe of stainless steel having a $k = 21.51$ W/(m·K) with dimensions of 2.54 cm ID and 5.08 cm OD is covered with a 2.54 cm layer of asbestos (石棉) insulation, $k = 0.24$ W/(m·K). The inside wall temperature of the pipe is 800 K and the outside surface of the insulation is at 300 K. (a) Find the heat loss per unit meter length of pipe (b) the temperature at the interface between the metal and the insulation. (20%)

2. A plane wall is shown as following with internal heat generation Q per unit volume at steady state. Thermal energy is conducted only in x direction. The other walls in y, z directions are assumed to be insulated. The temperature of wall at x = L and x = －L is To. The thermal conductivity of the plane wall is k. Please derive temperature profile in the x direction T(x) as a function of x, Q, k, L, and T_0 within the plane wall. (20%)



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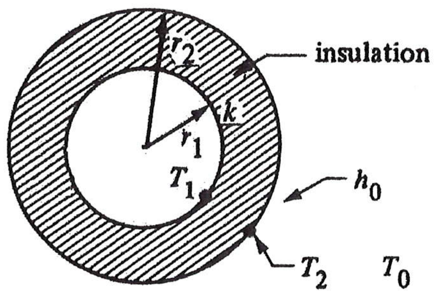
3. A cylinder, with high thermal conductivity and thin wall thickness, is insulated by a layer of insulation with thickness of $(r_2 - r_1)$, of which thermal conductivity is k. The inner temperature of the insulation is T_1 at r_1. The outer surface of the insulation at T_2 (r_2) is exposed to an environment at T_0, wherein convective heat transfer occurs with coefficient of h_0. Find the critical thickness of the insulation for the maximum heat transfer rate. (10%)



4. Please explain the physical meaning of the following dimensionless numbers: (12%)
   (a) Reynolds number
   (b) Biot number
   (c) Froude number
   (d) Schmidt number

5. For a binary mixture, find the concentration profile C_A, if A and B components are transported under equimolar counterdiffusion condition along z axis without chemical reaction. The system is controlled at constant temperature and pressure. It is known that the concentrations of A are C_{A1} and C_{A2} at $z = z_1$ and $z = z_2$, respectively. (18%)

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6. For a steady-state and laminar flow of a fluid along z axis in a vertical tube (radius R and length L), find the expressions for modified pressure $\mathcal{P}(z)$ and velocity profile $v_z(r)$ by using the following equations. Suppose the liquid flows downward under the influence of a pressure difference and gravity. The viscosity and density of fluid can be regarded to be constant in the system. (20%)

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

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

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

國立雲林科技大學 112 學年度
碩士班招生考試試題

系所：化材系
科目：材料導論

1. Describe a twin and a twin boundary. (5%).

2. Calculate the force of attraction between a K^+ and an O^{2-} ion the centers of which are separated by a distance of 1.5 nm. (15%)

3. Titanium has an HCP crystal structure ad a density of 4.51 g/cm^3. The atomic mass of Ti is 47.9 g/mol. (30%)

   (1) What is the volume of its unit cell in cubic meters?

   (2) If the c/a ratio is 1.58, compute the values of c and a.

4. Please explain the following nouns(10%, 2 points per question)

a. point defect

b. quenching

c. phase law

d. eutectic point

e. ductile failure

5. Please describe the main types of metal phase changes and draw a diagram to illustrate the changes(20%)

6. What are the main methods of strain hardening in metals? Please explain the reason for strain hardening(20%)

國立雲林科技大學 112 學年度 碩士班招生考試試題

系所：化材系

科目：物理化學

1. An ideal solution is made from 3 moles of benzene and 1 mole of toluene. Please calculate ΔG_{mixing} and ΔS_{mixing} at 298 K and 1 bar pressure. Is mixing a spontaneous process? (12%)

2. Please calculate **ionic strength** (I) for (a) a 0.05 molar solution of NaCl and for (b) a Na_2SO_4 solution of the same molality. You may use the equation shown below:

   $I = \frac{1}{2}\sum_i (m_{i+}Z_{i+}^2 + m_{i-}Z_{i-}^2)$ Z_i: charge number of an ion i. m_i: molality of an ion. (12%)

3. Given the following reduction reactions and standard cell potential E^o values:

   Fe^{3+} (aq) + e^- → Fe^{2+} (aq) $E^o = +0.771$V

   Fe^{2+} (aq) + $2e^-$ → Fe (s) $E^o = -0.447$ V

   Calculate E^o for the half-cell reaction Fe^{3+} (aq) + $3e^-$ → Fe (s) (14%)

4. The decomposition of N_2O_5 is an important process in tropospheric chemistry. The half-life for the first-order decomposition of this compound is 2.05×10^4 s. How long will it take for a sample of N_2O_5 to decay to 60% of its initial value? (12%)

5. When 1.5 moles of an ideal gas are heated at a constant pressure of 2.0 bar, the temperature increases from 300 K to 325 K. Given that the molar heat capacity at constant pressure is 25.35 J mol^{-1} K^{-1}, calculate q, ΔH and ΔU. (18%)

6. 4.5 moles of He gas expand isothermally at 308 K from 48.0 cm^3 to 547.5 cm^3. Calculate ΔG and ΔA for the process. (20%)

7. The normal boiling point of isopropanol is 355.7 K, while the molar enthalpy of vaporization is 44.0 kJ mol^{-1}. Determine the vapor pressure at 298 K. (12%)

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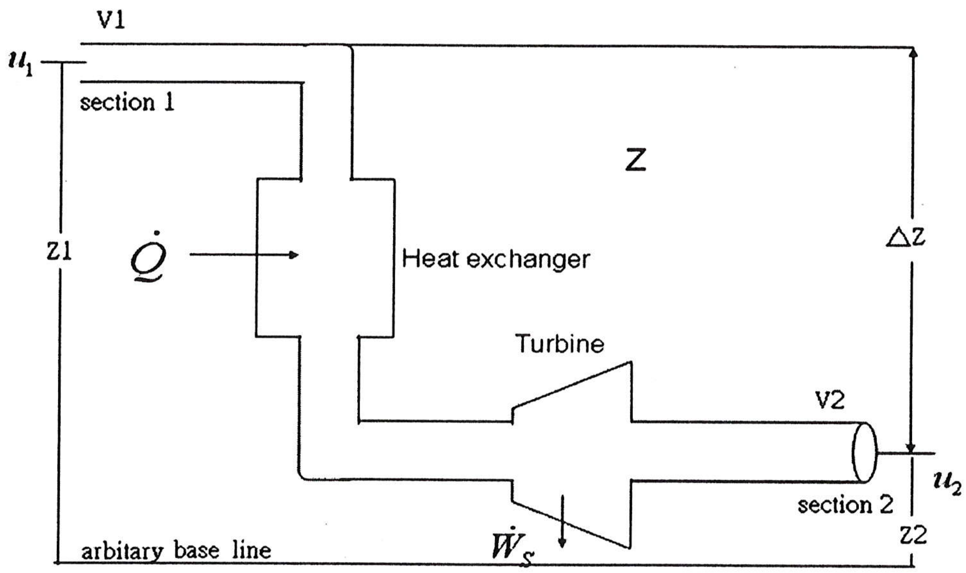
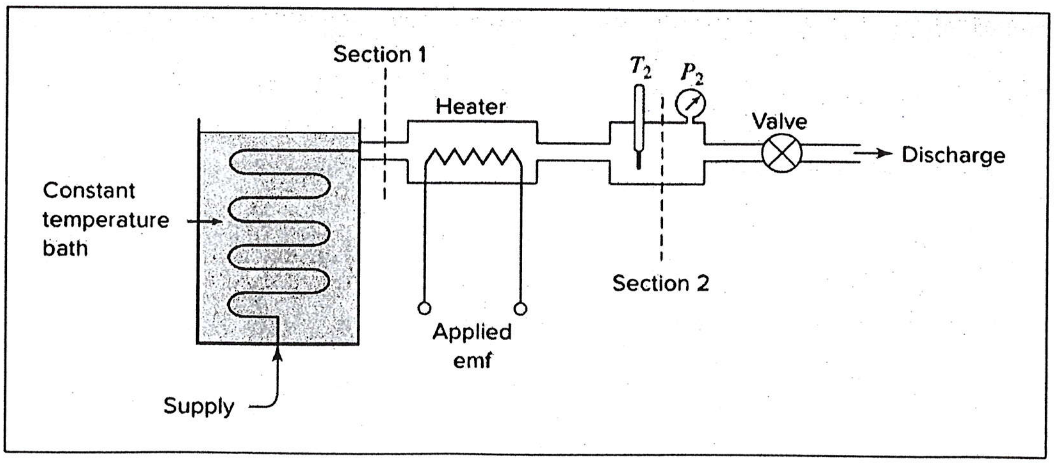
碩士班招生考試試題
系所：化材系
科目：化工熱力學

1. (20%)
   Express properly the four laws of thermodynamics?

2. (20%)
   (a) Write the energy balance for the steady-state flow process as illustrated below. (10%)

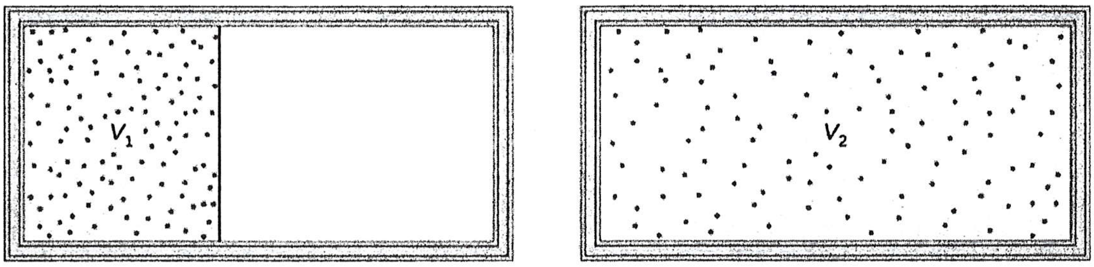


   (b) A flow calorimeter for enthalpy measurements is illustrated schematically below. The design provides for minimal velocity and elevation changes from section 1 to section 2, making kinetic- and potential- energy changes of the fluid negligible. Q is the heat added per unit mass of water flowing determined from the resistance of the heater and the current passing through the fluid. With no shaft work entering the system, what will be the reduced energy balance for this laboratory processes. (10%)



3. (10%)

An ideal gas occupies a partitioned volume V_1 inside a box whose walls are thermally insulating, as shown below. When the partition is removed, the gas expands and fills the entire volume V_2 of the box(i.e., adiabatic free expansion). What is the entropy change of the universe (the system plus its environment)?



(a) (b)

4. (15%)

A chemical engineer claims to have devised a heat engine that produces power of 95,000 kW by taking heat of 135,000 kW from steam at 750 K and discarding heat to cooling water at 300 K. Show whether or not the engine is possible.

5. (20%)

Saturated liquid water at 1,000 kPa (enthalpy 762.6 kJ/kg) flows adiabatically through an orifice, without any appreciable change in kinetic or potential energy, and immediately into a large flash tank that operates at 101.325 kPa (enthalpy of 419.1 kJ/kg for saturated liquid and of 2676.0 kJ/kg for saturated vapor).

(a) What is the steam quality (%) inside the tank? (10%)

(b) Does the temperature of the steam after flash increase or decrease? Explain why. (10%)

6. (15%)

An ideal gas (constant-volume heat capacity 12.471 J/mol-K) at 1 bar and 70°C is compressed adiabatically and reversibly to 150°C in a closed system. Determine

(a) The minimum compression work? (5%)

(b) The heat transferred and actual work, if the process has a work efficiency of 80%, accomplishing exactly the same changes of state? (10%)

國立雲林科技大學 112 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 show how to obtain the designed equations for batch reactor, continuous stirred-tank reactor (CSTR), and tubular flow reactor, respectively. (21%)

2. 100 moles of B are to be produced hourly from a feed consisting of a saturated solution of A (C_{A0}= 0.1 mol/liter) in a mixed flow reactor. The reaction is

$$A \rightarrow B, \text{ and}$$

$$\text{reaction rate of B } r_B = (0.2/hr) \bullet C_A$$

Cost of reactant at C_{A0}= 0.1 mol/liter is

NT$ 0.5/mole A.

Cost of reactor including instillation, auxiliary equipment, instrumentation, overhead, labor, etc., is

NT$ 0.01/(hr·liter).

What reactor size, feed rate, and conversion shall be used for optimum operations? What is the unit cost of B for these conditions if unreacted A is discarded? (19%)

3. Acetaldehyde vapor is decomposed in an ideal tubular-flow reactor according to the reaction:

$$CH_3CHO \rightarrow CH_4 + CO$$

The reactor is 3.3 cm ID and 80 cm long and maintained at a constant temperature 518℃. The acetaldehyde vapor is measured at room temperature and slightly above atmospheric pressure. For consistency, the measured flow rate is corrected to the standard condition (0℃, 1atm). In one run, 35% of the acetaldehyde is decomposed in the reactor. The second-order specific rate constant is 0.33 liter/(s)(g mol) at 518 ℃, and the reaction is irreversible. The pressure is essential atmospheric. Calculate the actual residence time. (10%)

4. Consider the following complex reactions in a reactor:

$3A \rightarrow B + 2C \qquad -r_{1A} = k_{1A}C_A$

$A + 2B \rightarrow 3D \qquad r_{2D} = k_{2D}C_AC_B^2$

What are the net rates of reaction for A, B, C, and D (r_A, r_B, r_C, and r_D)? (16 %)

5. A liquid-phase irreversible reaction $A \rightarrow B, -r_A = kC_A^n$, was carried out in a constant-volume batch reactor where the variation of concentration was recorded as follows:

t, min	0	10	20	30	40
C_A, M	1	0.16	0.0625	0.0331	0.0204

Determine the reaction order (n) and the rate constant (k). (20%)

6. Substance A in a liquid-phase reactor produces B and C by the following parallel reactions:

$$A \rightarrow B, \quad r_B = k_1C_A, \quad k_1 = \alpha_1 e^{-\frac{E_1}{RT}}$$

$$A \rightarrow C, \quad r_C = k_2C_A, \quad k_2 = \alpha_2 e^{-\frac{E_2}{RT}}$$

where $\alpha_1 = 10^{15}\ s^{-1}$, $\alpha_2 = 5 \times 10^{16}\ s^{-1}$, $E_1 = 89\ \frac{kJ}{mol}$, and $E_2 = 100\ \frac{kJ}{mol}$. What temperature makes that $r_B = r_C$? (14%)