國立雲林科技大學
95學年度碩士班入學招生考試試題

系所：化工系
科目：化工熱力學

1.(35%)

Helium enters a reversible isothermal compressor at 540°R and 12atm and is continuously compressed to 180atm. The kinetic and potential energy changes in the compressor will be assumed to be negligible. Calculate the work (Btu/lb-mole) per mole of helium needed to run the compressor and the amount of heat (Btu/lb-mole) per mole of helium that must be removed from the compressor if helium behaves according to the equation of state

$$PV = RT - a(P/T) + bP$$

where $a = 11.13\ ^{\circ}R\text{-}ft^3/lb\text{-}mole$

$b = 0.2445\ ^{\circ}R\text{-}ft^3/lb\text{-}mole$

$\ln(180/12) = 2.708$

Unit conversions for Problem 1: 1 atm = 14.7 psia, 1 ft^3–psia = 5.4 Btu

2.(15%)

In order to achieve the maximum change in entropy of mixing, what the amount (g) of benzene (78 g/g-mole) should be mixed ? If 1 g of ethylbenzene (106 g/g-mole) is in the ideal mixture (benzene and ethylbenzene).

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3. (30%)

In a closed system, 1 mole of ideal gas undergoes the following sequence of mechanically reversible processes:

(a) From an initial state of 70°C and 1 bar, it is compressed adiabatically to 150°C.

(b) It is then cooled from 150 to 70°C at constant pressure.

(c) Finally, it is expanded isothermally to its original state.

Calculate *work*, *heat*, *internal energy change*, and *enthalpy change* for each of the three processes and for the entire cycle. Take $C_v = (3/2)R$ and $C_p = (5/2)R$. R is gas constant.

Hint: $1.2331^{2.5} = 1.689$, $\ln 1.689 = 0.524$

4. (20%)

The activity coefficients (γ) of a binary A-B equilibrium system can be expressed as a function of species mole fraction (x).

$$\ln \gamma_A = 0.5\, x_B^2$$

$$\ln \gamma_B = 0.5\, x_A^2$$

The vapor pressures of A and B at 80°C are 900 mmHg and 600 mmHg, respectively. There is an azeotrope when the system operates at 80°C. Calculate

(a) The azeotrope pressure (*mmHg*)? (10%)

(b) The azeotrope mole fraction composition? (10%)

Hint: $\ln 3 = 1.0986$, $\ln 2 = 0.6931$, $e^{0.0045} = 1.0045$

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[Data: $ln\ 2 = 0.693$, $ln\ 3 = 1.099$, $ln\ 5 = 1.609$]

1. (25 %) The reaction S $\longrightarrow$ R, $-r_S = kC_S^2$, takes place in CSTR with 90 % conversion. If $k = 0.5$ dm^3/(mol-min), $C_{So} = 2$ mol/dm^3, and flow rate $v = 5$ dm^3/min, what residence time and reactor volume will be required?

2. (25 %) A gas-phase reaction A $\longrightarrow$ B + C is to be conducted in a 10 dm^3 (initially) isothermal batch reactor at 25 ^oC at constant pressure. The reaction is second-order with respect to A and rate constant $k_A = 0.023$ dm^3/(mol-s). Determine the time required for 75 % conversion of 2 mol A.

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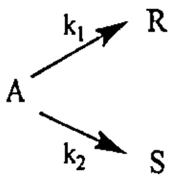
3. Liquid reactant A decompose as follows:



$r_R = k_1 C_A^2$, $k_1 = 0.4\ m^3/mol.min$

$r_S = k_2 C_A$, $k_2 = 2\ min^{-1}$

A feed of aqueous A ($C_{AO} = 40\ mol/m^3$) enters a reactor, decomposes, and a mixture of A, R, and S leaves.

Find C_R, and C_S and τ (space time) for $X_A = 0.9$ in a plug flow reactor.

($\ln 5 = 1.61$; $\ln 2 = 0.693$)

(25%)

4. Enzyme E catalyses the fermentation of substrate A (the reactant) to product R. Find the size of mixed flow reactor needed for 95% conversion of reactant in a feed stream (25 liter/min) of reactant (2 mol/liter) and enzyme. The kinetics of the fermentation at this enzyme concentration are given by

$$A \xrightarrow{\text{enzyme}} R \qquad -r_A = \frac{0.1C_A}{1 + 0.5C_A} \left(\frac{\text{mol}}{\text{liter.min}}\right)$$

(25%)

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系所：化工系
科目：輸送現象

1. A variation of a device used to measure the viscosity of very viscous materials such as asphalt, plastics, etc. is shown in Fig.1. A force, F, is applied to a rod to pull it through a tube immersed in the viscous liquid. The radii of rod and tube are R_1 and R_2, respectively. The tube is stationary and full of liquid. The rod pulls some liquid up through the tube, and the excess runs over the side and back into the pool of liquid. Develop an equation that relates the viscosity to the measured force and velocity. You may ignore end effects, the effect of gravity and assume the liquid is Newtonian. (25%)

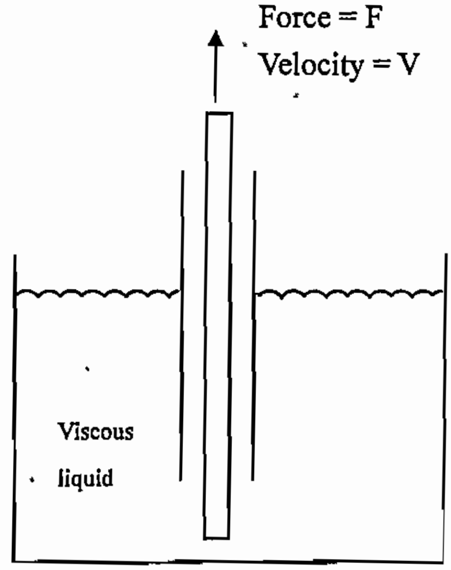
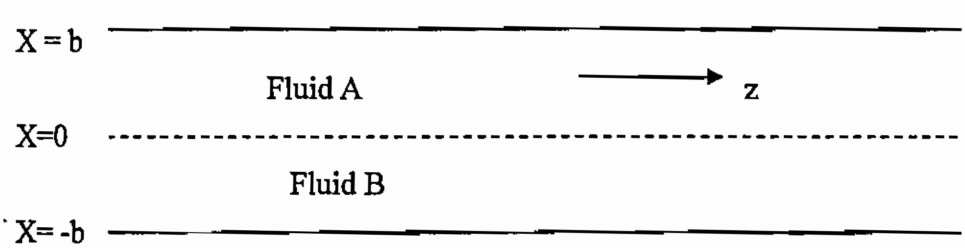


Fig. 1

2. Two immiscible liquids are flowing adjacently in a rectangular channel. The laminar steady state flow is horizontal with a pressure drop per unit length of $\frac{p_o - p_L}{L}$. Assume $v_x=0$, $v_y=0$, $\rho_A<\rho_B$, $\mu_A<\mu_B$.



(a) Derive an equation for the shear stress profile. (10%)

(b) Derive equations for velocity profiles of both liquids. (10%)

(c) What is the value of $\tau_{xz}|_{x=0}$ when $\mu_A \ll \mu_B$, such as when A is a gas and B is a liquid? (5%)

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3. According to Fig. 2, a long solid tube is considered, insulated at the outer radius r_2 and cooled at the inner radius r_1, with heat generation $\dot{q}$ (W/m^3) within the solid.

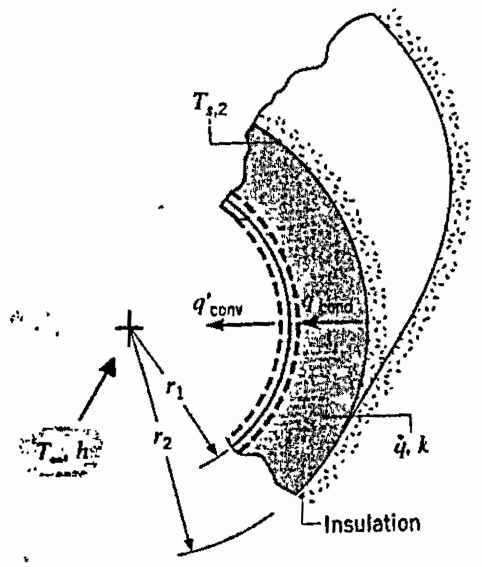

Fig. 2

(a) If the solution for temperature distribution $T(r)$ is obtained, which the following assumptions are appropriate. (5%)

(A) unsteady-state conditions
(B) one-dimensional axial conduction
(C) outer surface adiabatic
(D) uniform volumetric heat generation
(E) constant properties

(b) To determine the general solution $T(r)$ (5%)

4. According to Fig. 3, the thermal boundary layer for laminar flow past a flat surface.

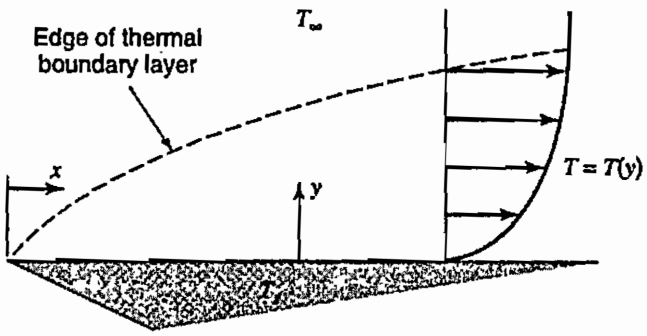

Fig. 3

(a) If the dimensionless temperature $T^*(y) = (T - T_s)/(T_\infty - T_s)$, which the boundary conditions are appropriate. (5%)

(A) $T^*(0) = 1$
(B) $T^*(0) = 0$
(C) $T^*(\infty) = 1$
(D) $T^*(\infty) = 0$
(E) $T_\infty = T_s$

(b) If the surface temperature gradient $dT^*/d\eta|_{\eta=0} = 0.32 Pr^{1/3}$, where the similarity variable $\eta = y\sqrt{u_\infty / vx}$, please determine local Nusselt number Nu_x. (5%)

5. For fully developed conditions with uniform surface heat flux ($q_s'' = \text{constant}$), a laminar flow in circular tubes is considered.

(a) In fully developed region, please choose the correct answers: (5%)

(A) $\frac{\partial T}{\partial x} = \frac{dT_m}{dx}$, where T_m is mean temperature.

(B) The axial temperature gradient depends on the radial coordinate

(C) $\frac{dT_s}{\partial x} = \frac{dT_m}{dx}$, where T_s is surface temperature.

(D) The temperature profile is treated as being parabolic.

(E) Nusselt number is a constant

(b) If the mean temperature is found to be

$$T_m = T_s - 0.0573\left(\frac{u_m D^2}{\alpha}\right)\left(\frac{dT_m}{dx}\right)$$

where u_m is mean velocity of flow and α is thermal diffusivity. Please determine Nusselt number. (10%)

6. A thin liquid film flows along the wall (x-direction) while in contact with a gas mixture. The time of contact between the two phases (from x=0 to x=L) is relatively short for normal operation of absorption. If the maximum velocity u_{max} will be at the age of the falling film where $y = \delta$, the velocity profile of flow is expressed by

$$u_x = 2u_{max}\left[\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^2\right]$$

(a) According to Fig. 4, if solute A penetrates only a short distance into the liquid film because of a slow rate of diffusion or a short time of exposure, please write the appropriately differential equation. (5%)

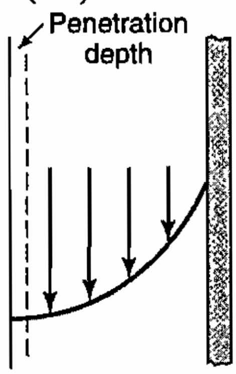

Fig. 4

(b) Under the penetration theory model, please determine the convective mass-transfer equation. (10%)