所別：化學工程與材料工程學系碩士班 不分組　科目：輸送現象與單元操作　共 3 頁 第 1 頁
＊請在試卷答案卷（卡）內作答

第一部份：非選擇題

1. **Reynolds number** (5%)
   How is the Reynolds number defined for flow through non-circular tubes?

2. **Power-law fluid flow in tube** (25%)
   Find the velocity profile and the volumetric flow rate of the axial isothermal flow of a power-law liquid through a circular tube of radius R and length L under a pressure drop $P_0 - P_L$ (with R << L). For a power-law liquid,

$$\tau_{rz} = -m\left|\frac{dv_z}{dr}\right|^{n-1}\frac{dv_z}{dr}$$

3. Thermal radiation (15%)

(a) (5%) What is a black body?

(b) (10%) Please deduce the Wien's displacement law (the product of the maximum wavelength and temperature is a constant) from Planck distribution law,

$q = (2\pi c^2 h/\lambda^5)\,[\exp(hc/\lambda k_B T) - 1]^{-1}$,

in which λ is the wavelength, h Planck's constant, and c the speed of light.

4. Natural convection (15%)

(a)(5%) What is the definition of the coefficient of volume expansion β?

(b)(10%) Consider a free convection problem. A fluid with density ρ and viscosity μ is placed between two vertical walls a distance 2b apart. The heated wall at y=-b is maintained at a temperature T_2 and the cooled wall at y=+b is maintained at a temperature T_1. Because of the temperature gradient, the fluid near the hot wall rises and that near the cold wall descends. Please write down the equation of motion in terms of β and explain its physical meaning. Obtain the velocity distribution in terms of $\Delta T = T_2 - T_1$.

第二部份：選擇題

Choose only one answer for each question. Questions 5 to 12 are worth 3 % each. Questions 13 and 14 are worth 5 % each and Question 15 is worth 6 %. The total score is 40 %. There is no need to write down any explanations. No credits will be given to incorrect answer or no answer.

參考用

5. (3 %) If each single-phase stream containing C components, for a single adiabatic or non-adiabatic equilibrium stage with two entering streams and two exit streams, the total number of variables associated with the streams plus the heat transfer rate to or from the stage would be:
   (A) C + 4, (B) 2C + 7, (C) 4C + 16, (D) 4C + 13, (E) none of the above.

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6. (3 %) Values of an overall stage (or column) efficiency can be predicted by any of the following methods EXCEPT:
   (A) Scale-up from data obtained with laboratory or pilot plant columns,
   (B) Use of empirical efficiency models derived from data on industrial columns,
   (C) Use of semi-theoretical models based on mass and heat transfer rates,
   (D) Comparison with performance data for the same and similar systems,
   (E) None of the above.

7. (3 %) Which statement below is FALSE?
   (A) One of the possible vapor-liquid flow regimes for a contacting tray is a cellular foam,
   (B) A centrifugal contactor is an industrial equipment for absorption and stripping,
   (C) The solubility, polymorphism, crystallinity and crystal habits of an organic compound are solvent dependent,
   (D) The McCabe-Thiele method can be applied to distillation, extraction, absorption and crystallization,
   (E) None of the above.

8. (3 %) Which statement below is FALSE?
   (A) Unlike the case of a distillation column, values of a packed height equivalent to a theoretical plate (HETP) and the overall height transfer unit (HTU) may be constant throughout the packed height in the case of the absorption or stripping of dilute solutions,
   (B) Fick's law holds for transport through the polymer membrane and the largest single factor that can influence the permeability of the solute is the chemical structure of the polymer membrane for membrane separations,
   (C) For pure gases, experimental physical adsorption isotherms have shapes and they are classified into five different types,
   (D) The plait point separates the binodal curve into an extract and a raffinate,
   (E) In some ternary solvent systems, the tie lines enveloped by the bimodal curve can slope both upward and downward.

9. (3 %) Which term below does NOT apply to extraction or leaching?
   (A) Janecke diagram, (B) Fenske equation, (C) Marangoni effect, (D) minimum reflux ratio, (E) solutropy.

10. (3 %) Which factors below do NOT influence the design or analysis of BOTH a binary distillation operation and a ternary liquid-liquid extraction?
    (A) feed flow rate, composition, temperature and pressure, (B) operating pressure, (C) phase-density difference, (D) minimum reflux ratio, (E) number of equilibrium stages.

11. (3 %) Which statement below is FALSE?
    (A) The equilibrium curve has to be above the operating line for a binary

distillation operation,

(B) The equilibrium curve has to be below the operating line for an absorber,

(C) The operating line could be curved,

(D) When the overall number of transfer units (NTU) is less than the number of equilibrium (theoretical stages), the slope of the operating line is less than the equilibrium curve in a countercurrent-flow packed adsorption column,

(E) A perfect separation of a binary mixture that does not form an azeotrope requires an infinite number of stages in both sections of the column.

12. (3 %) A mixture of N_2 and O_2 gases contains equal weight of each gas. The absolute velocities are given as: $\vec{v}(N_2) = -7\vec{i}$ m/sec and $\vec{v}(O_2) = +7\vec{i}$ m/sec, where $\vec{i}$ is a unit vector in the x direction. Obtain the mass and molar average velocities.

(A) $0\vec{i}$ and $-0.42\vec{i}$ m/sec, (B) $14\vec{i}$ and $0.8\vec{i}$ m/sec, (C) $0.42\vec{i}$ and $0\vec{i}$ m/sec, (D) $28\vec{i}$ and $32\vec{i}$ m/sec, (E) none of the above.

13. (5 %) Benzene (B) and iso-pentane (P) are mixed at 1.5 atm, and 110°F. Determine the compositions of the liquid and vapor using Raoult's law. The vapor pressure data are: vapor pressure of benzene at 110°F = 212 mm Hg, vapor pressure of iso-pentane at 110°F = 1273 mm Hg.

(A) $x_B = 0.02$, $x_P = 0.98$, $y_B = 0.87$ and $y_P = 0.13$

(B) $x_B = 0.98$, $x_P = 0.02$, $y_B = 0.13$ and $y_P = 0.87$

(C) $x_B = 0.13$, $x_P = 0.87$, $y_B = 0.98$ and $y_P = 0.02$

(D) $x_B = 0.13$, $x_P = 0.87$, $y_B = 0.02$ and $y_P = 0.98$

(E) $x_B = 0.87$, $x_P = 0.13$, $y_B = 0.98$ and $y_P = 0.02$

14. (5 %) Four gallons of gasoline (A) is poured on a surface area of 20 ft^2. Determine the time necessary for the gasoline to evaporate into still dry air (B). The diffusivity is $D_{AB} = 6.5$ ft^2/hr. Evaporation occurs through a 6 in. film at 65°F. The gasoline has a vapor pressure of 2 psia and a mean gasoline density of 6 lb/gallon.

(A) 8 hours, (B) 2 hours, (C) 30 mins, (D) 18 hours, (E) none of the above

15. (6 %) A cylindrical vessel of diameter 7.0 ft is filled to 2.5 ft below the open top with pure n-butanol. Inside the tank, the air is stationary, but currents above it maintain a small enough concentration of n-butanol there to allow it to be neglected. The system is at 77.0°C and 1 atm. The diffusivity of n-butanol in air at these conditions is 0.438 ft^2/hr. Determine the rate of evaporation of n-butanol from the vessel at steady state conditions. Vapor pressure of n-butanol at 77.0°C = 144 mm Hg, universal gas constant, R = 0.7302 ft^3 atm/lbmole-R°, and T(°F) = T(°R) - 459.67.

(A) 0.00803 lb moles/hr, (B) 0.00038 lb moles/hr, (C) 0.00308 lb moles/hr, (D) 3.803 lb moles/hr, (E) none of the above.

參考用

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