國立中央大學 107 學年度碩士班考試入學試題

所別： 化學工程與材料工程學系 碩士班 甲組(一般生) 共 3 頁 第 1 頁

科目： 輸送現象與單元操作

本科考試可使用計算器，廠牌、功能不拘 ＊請在答案卷(卡)內作答

This 100-minute examination consists of 5 overall questions, each of which contain further sub-questions. A perfect score is 100%. Please state your question numbers and steps clearly and indicate your final answers in the given answer booklet.

1. (35%) As a biomedical engineer, you are dedicated to studying the characteristics of blood flows surrounding blood clots, the massive formation of which would lead to heart attacks, strokes, etc. To better investigate the fluid mechanics of blood surrounding the clots, you decide to build a scaled-up mock system which reproduces the flow pattern of blood under the blood pressure of P_B. It is assumed that the blood flows surrounding blood clots are continuum, whereby the continuum mechanics applies, and that the clots are of spherical shape with the diameter D. You begin the designing of this mock system with a dimensionless analysis.
   (a) (5%) At what condition is the continuum assumption valid?
   (b) (6%) Identify the minimally needed scaling factors and define the dimensionless variables.
   (c) (6%) Identify the initial and boundary conditions and express them in the dimensionless form.
   (d) (6%) Derive the dimensionless equations of change.
   (e) (6%) Determine the factors/dimensionless groups that affect the dimensionless velocity and pressure profiles of the flows. How would the flow velocity be affected by D?
   (f) (6%) Water is to be used as a mock-up of blood in the model system. Given that blood flows at 40 cm/s in aorta, the kinematic viscosity of blood is $\sim 3 \times 10^{-6}$ m^2/s, and the clot size is ~1 mm in diameter, what flow velocity of water must be maintained to reproduce in the mock system the flow pattern of blood if the mock-up of clot is 10 cm in diameter (the kinematic viscosity of water is $\sim 1 \times 10^{-6}$ m^2/s at 20 °C)?

2. (10%) Please answer the following question
   (a) (2%) Consider Wiedemann, Franz, Lorenz equation. Among iron, copper, water, engine oil, how is the thermal conductivity of these materials? Please write the correct order of the thermal conductivity at ambient temperature. (Answer example: Water > Copper > Engine oil > Iron)

參考用

注意:背面有試題

(b) (4%) Consider the conductivity of monatomic gases. Are the following sentences correct or incorrect?

(i) (2%) Thermal conductivity of a gas is independent of pressure.

(ii) (2%) Thermal conductivity varies as the 1/2 power of the absolute temperature.

(c) (2%) There are several parameters to analyze energy transfer. Among these parameters, what is the parameter describing the ratio of the molecular diffusivity of momentum to the molecular diffusivity of heat?

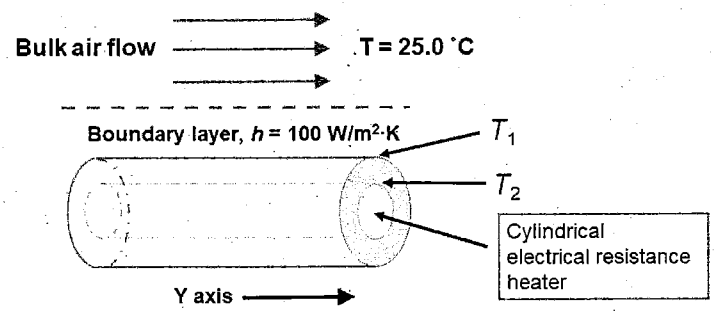
(d) (2%) There are two nondimensional parameters in the lumped-parameter solution for transient conduction. What are these parameters?

3. (20%) A cylindrical iron tube of 20.0-cm thick and inside diameter = 80 cm (thermal conductivity of iron (k_s) = 50W/m·K in this case) rests on electrical resistance rod, which is maintained at 200°C (T_2, See below figure). Consider the both end is sealed with insulator. Air flows over the top surface of the cylinder tube to provide a convective heat-transfer coefficient of h = 100 W/m^2·K. The air temperature is maintained at 25°C.

(a) (6%) What is the temperature gradient on the direction of air flow (y direction) at the surface contacting to the insulator (dT/dy)?

(b) (7%) What is the temperature at the top surface, T_1, of the cylindrical iron tube?

(c) (7%) What is the heat flux through the cylindrical iron tube, in W/m^2?



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4. (12%) Helium and nitrogen gas are present in a tube 7 mm in diameter and 8 cm long at 340 K and a uniform constant pressure of 1.0 atm abs. The partial pressure of He at one end of the tube is 0.055 atm and at the other end is 0.012 atm. The diffusivity is 0.894 cm^2/s. Calculate the following and state your assumptions:

   ($R = 8.314\ m^3 \cdot Pa \cdot K^{-1} \cdot mol^{-1} = 0.082\ L \cdot atm \cdot K^{-1} \cdot mol^{-1} = 0.7302\ ft^3 \cdot atm \cdot R^{-1} \cdot lbmol^{-1}$)

   (a) (6%) Flux of He in kg mol/s·m^2.

   (b) (6%) Flux of N_2 in kg mol/s·m^2.

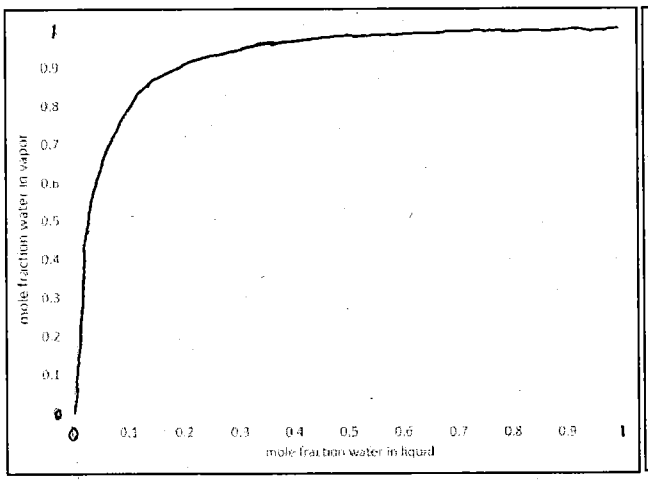
5. (23%) A vertical flash drum is used to separate 100 kmol/hr of a water and ethylene glycol mixture. The feed is 40% water at 300 kPa and 150℃. If the drum is operated at 30.4 kPa and 33% of the feed is vaporized,

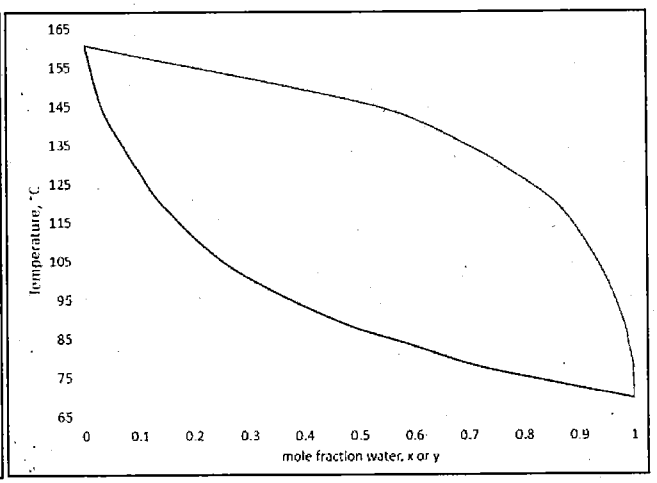
   (a) (10%) What is the temperature of the drum?

   (b) (13%) How much heat should be added or removed to the feed before the valve?

   (Enthalpy info: $h_F = 33$ kJ/mol, $h_V = 52$ kJ/mol, $h_L = 27$ kJ/mol)

   Use the diagrams below to work out your solution.





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