國立雲林科技大學 系所：化材系

101 學年度碩士班暨碩士在職專班招生考試試題 科目：單元操作與輸送現象

1. A liquid flows through a capillary with an inside radius $R=10^{-3}$ m and a length L=0.4 m. The viscosity of the liquid is 1.5×10^{-3} Pa·s. The velocity distribution inside the capillary is

$$v = 0.3\left[1-\left(\frac{r}{R}\right)^2\right] \text{ m/s,} \quad \text{where } r \text{ is the radial coordinate.}$$

(a) What is the volumetric flow rate? (10%)

(b) What is the pressure drop Δp across the capillary during flow? (10%)

Hint: the flux of r-momentum in the flow direction $\tau = \frac{\Delta p}{2L} r$

2. An oil with heat capacity $c_p = 2.5\,\text{kJ/kg}\cdot\text{K}$ is flowing through a double-pipe heat exchanger at a rate of 7500 kg/h and is to be cooled from 373 K to 343 K. Cooling water ($c_p = 4.187\,\text{kJ/kg}\cdot\text{K}$) entering at 298 K and flowing **counterflow** at a rate of 3500 kg/h is available.

(a) Calculate the outlet temperature of the cooling water (5%)

(b) Calculate the overall heat transfer coefficient in $\text{W/m}^2\cdot\text{K}$ if the heat-transfer area inside the heat exchanger is 6.5 m^2 (10%)

3. A Newtonian fluid is confined between two parallel infinite plates with a distance B apart. The lower plate is moving leftward at a constant velocity v_0 and the upper plate is moving rightward at a constant velocity $2v_0$. The pressure gradient in the flow is $\frac{P_0 - P_L}{L}$ Assuming that the flow is steady-state and laminar and gravity is negligible, find the velocity distribution (15%)

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4. 利用逆流式套管熱交換器(countercurrent double-pipe heat exchanger)，以 105 °C 凝結水蒸汽(condensing steam)將空氣自 30 °C 加熱至 80 °C。假設主要熱傳阻力控制在空氣熱對流部份。已知空氣熱對流的熱傳係數(h)經驗式為 $Nu = 0.023\,\mathrm{Re}^{0.8}\,\mathrm{Pr}^{0.4}$，式中 Nu 為納瑟數(Nusselt number)、Re 為雷諾數(Reynolds number)、Pr 為普蘭多數(Prandtl number)。若改用 120 °C 凝結水蒸汽加熱空氣同樣自 30 °C 加熱至 80 °C，試問所加熱空氣的流量為原所加熱空氣流量的多少倍？ (15 分)

5. 有一液珠懸浮於靜止不動氣體中，液珠成分為 A，氣體為 A 和 B。若 B 不溶於 A，而 A 自液珠表面蒸發，然後擴散至氣相中。因液珠很小可視為球狀，假設液體之蒸發速率緩慢，液珠的半徑 R 可視為不變。試推導出計算液珠蒸發速率的方程式。 (20 分)

6. 在298K及1atm下，一填料塔(packing tower)中利用有機胺溶液吸收二氧化碳。氣體進入時含 1.26 mol% 的二氧化碳，離去時含 0.04 mol%。假設在操作條件範圍，二氧化碳與有機胺溶液間平衡關係遵守亨利定律(Henry's law)，亦即 $y_{CO2}=1.575x_{CO2}$。氣體流速為 2.3 g-mol/s，液體流速為 4.8 g-mol/s。已知填料塔直徑為 40 cm，總體質傳係數(overall mass transfer coefficient) 與單位體積的表面積的乘積 K_ya 為 5.0×10^{-5} mol/(cm^3-s)，試計算填料塔高為多少 m? (15 分)