國立臺北科技大學 101 學年度碩士班招生考試

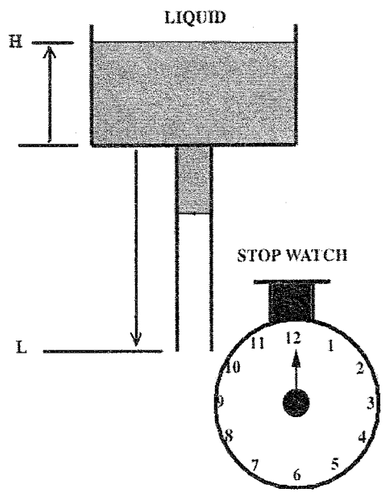
系所組別：3510 化學工程研究所甲組

第一節　單元操作與輸送現象　試題

注意事項：

1. 本試題共五題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

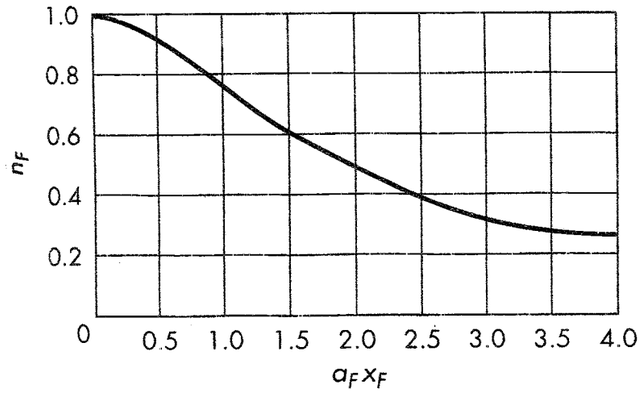
1. A capillary type of viscometer for liquid consists of a large cylindrical reservoir of radius R and with a long draining capillary tube of length L and diameter D are completely filled with a heavy oil of viscosity μ, whose value is determined by timing the fall in the surface level. At time $t = 0$ with oil height of H in the reservoir, the valve at the bottom of the capillary tube is opened to the air. (a) Derive the mathematical expression for the total time $t_{0.5\,H}$ it will take to drain the oil to half height 0.5 H. There is an air vent at the very top of the reservoir. Use the quasi-steady-state approach and neglect the exit effect; that is, use the unsteady-state mass balance along with the Hagen-Poiseuille equation for the laminar flow in the capillary tube, as shown in the following figure. (b) Given R = 1.2 cm, H = 3 cm, L = 15 cm, D = 0.2 cm, ρ = 0.86 g/cm^3, $t_{0.5\,H}$ = 25 s, find the viscosity of oil at 20°C μ =? cP
(a配分20分, b配分5分，共計25分)



2. Volatile organic compounds (VOCs) of benzene (M_A= 78) and ethylbenzene (M_B= 106) can be stripped from 6500 kg mol/h wastewater by 250 kg mol/h air at 21°C and 1 atm. A chemical analysis of the wastewater shows the composition in the amounts as in the following table, and also included are necessary thermodynamic properties. Use the Kremser's method by stripping factor S, and calculate the percent fraction of each component A and B stripped from (a) one- or (b) two-theoretical-plate tower, respectively. (c) If it is desired that at least 99% of the total VOCs be stripped, but the plate efficiency of the tower is 25%. Estimate the rates of stripping of each of the two components in the amount of kg/h? (d) What is the total number of plates required for the tower?
(a, b, c 各配分4分，d配分3分，共計15分)

VOCs	Concentration in the Wastewater, mg/L	Solubility in Water at 21°C, mole %	Vapor Pressure at 21°C, atm
Benzene	200	0.04	0.102
Ethylbenzene	30	0.0035	0.01

3. Water and air are separated by a vertical mild-steel plane wall. It is desired to increase the heat-transfer flux between these fluids by adding straight rectangular mild-steel fins of thickness y_F = 0.12 cm and height x_F = 3.0 cm and separated in 2.0 cm apart. Given the thermal conductivity of mild-steel k_m = 42.9 W/m · K, the water-side and air-side heat-transfer coefficients h_{water} = 256 W/m^2 · K, h_{air}= 11.4 W/m^2 · K, respectively. 1 m x 1 m wall surface can be loaded with 50 fins, whose value of fin efficiency η_F can be determined as a function of factor $a_F = (2h/k_m y_F)^{1/2}$ from the following figure. Calculate the percent change in the total heat resistance ΣR and the overall heat-transfer rate q when 50 fins are placed on (a) the water side or (b) the air side, as compared with (c) that of bare wall without fins on both sides at constant temperature difference between water and air.
(a, b各配分8分，c配分4分，共計20分)



注意：背面尚有試題

4. 混合氣體在一濕壁塔中被吸收出氣體 A，A 於氣相之質傳係數爲 $k_y = 1.465 \times 10^{-3}$ kg mol/(s · m^2 ·莫耳分率)，A於液相之質傳係數爲 $k_x = 1.967 \times 10^{-3}$ kg mol/(s · m^2 ·莫耳分率)，已知在 298 K，1 atm 時之亨利常數(Henry constant)爲 0.923莫耳分率/莫耳分率，試以雙膜理論(two-film theory)作爲開始，請推導出濕壁塔中氣體A分別基於(a)液相或(b)氣相的總包質傳係數K_x、K_y的關係式。若在濕壁塔中某處，A於氣相之莫耳分率爲 0.38，A於液相之莫耳分率爲 0.1，(c)求A在液體界面之莫耳分率。
(a, b, c各配分5分，共計15分)

5. 請簡要解釋下列單元操作名詞 (每小題5分，請依序作答，共計25分)

(1) 淨正吸入水頭揚程 (Net positive suction head)
(2) 拖曳係數 (Drag coefficient)
(3) 對數平均溫差 (Logarithmic mean temperature difference)
(4) 批次蒸餾瑞利方程式 (Rayleigh equation in batch distillation)
(5) 濕球溫度 (Wet-bulb temperature)