國立臺北科技大學 109 學年度碩士班招生考試

系所組別：3510 化學工程與生物科技系化學工程碩士班甲組

第一節　單元操作與輸送現象　試題

注意事項：

1. 本試題 5 題，第 1 題 5 分，第 2 題 20 分，第 3 題 20 分，第 4 題 30 分，第 5 題 25 分，共 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
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. If the sphericity is defined as the surface-volume ratio for a sphere of diameter D_p divided by the surface-volume ratio for the particle whose nominal size is D_p, its equation is $\emptyset_s = \frac{6/D_p}{S_p/V_p}$. For a sphere, $S_p = \pi D_p^2$ and $V_p = \frac{1}{6}\pi D_p^3$. Please write down the sphericity of a sphere. (5 分)

2. It is proposed to pump 10000 kg/h of toluene at 114℃ and 1.1atm abs pressure from the reboiler of a distillation tower to a second distillation unit without cooling the toluene before it enters the pump. If the friction loss in the line between the reboiler and pump is 7kN/m² and the density of toluene is 866 kg/m³, how far above the pump must the liquid level in the reboiler be maintained to give a net positive suction head of 2.5m? [Hint: the vapor pressure of toluene is 1.1 atm because of the reboiler] (20 分)

3. In unit operations we frequently use g_c, called Newton's law proportionality factor for the gravitational force unit. For example, we have Bernoulli equation as

$$\frac{p_a}{\rho} + \frac{gz_a}{g_c} + \frac{u_a^2}{2g_c} = \frac{p_b}{\rho} + \frac{gz_b}{g_c} + \frac{u_b^2}{2g_c}.$$ Please

a) write down the value and the unit of g_c in international system. (10 分)

b) write down the value and the unit of g_c in English system. (10 分)

4. A steady stream of liquid in turbulent flow is heated by passing it through a long, straight, heated pipe. The temperature of the pipe is assumed to be greater by a constant amount than the average temperature of the liquid. If a theoretical equation for this problem exists and it can be written in the general form $\frac{q}{A} = \Psi(\overline{V}, \rho, \mu, Cp, k, \Delta T)$. Please conduct the dimensional analysis to discover the dimensionless groups! It is required to write down the dimensionless group explicitly. [You could find useful information on Table 1.] (30 分)

Table 1

Quantity	Symbol	Dimensions
Heat flow per unit area	$\frac{q}{A}$	$\overline{H}\ \overline{L}^{-2}\ \overline{t}^{-1}$
Average velocity of liquid	$\overline{V}$	$\overline{L}\ \overline{t}^{-1}$
Density of liquid	ρ	$\overline{M}\ \overline{L}^{-3}$
Viscosity of liquid	μ	$\overline{M}\ \overline{L}^{-1}\ \overline{t}^{-1}$
Specific heat, at constant pressure, of liquid	C_p	$\overline{H}\ \overline{M}^{-1}\ \overline{T}^{-1}$
Thermal conductivity of liquid	k	$\overline{H}\ \overline{L}^{-1}\ \overline{t}^{-1}\ \overline{T}^{-1}$
Temperature difference between wall and fluid	ΔT	$\overline{T}$

5. Methyl alcohol flowing in the inner pipe of a double-pipe exchanger is cooled with water flowing in the jacket. The inner pipe is made from 1-in. Schedule 40 steel pipe. For an 1-in. Schedule 40 steel pipe, the outside diameter is 1.315 inches and the inside diameter is 1.049 inches. The thermal conductivity of steel is 26 Btu/ft·h·°F. The individual coefficients and fouling factors are given in the Table below. What is the overall coefficient, based on the outside area of the inner pipe? (25 分)

	Btu/ft²·h·°F
Alcohol coefficient h_i	180
Water coefficient h_o	600
Inside fouling factor h_{di}	1,000
Outside fouling factor h_{do}	500