國立中央大學101學年度碩士班考試入學試題卷

所別：化學工程與材料工程學系碩士班 甲組(一般生)　科目：輸送現象與單元操作　共 2 頁 第 1 頁

本科考試可使用計算器，廠牌、功能不拘　　*請在試卷答案卷（卡）內作答

Momentum Transport (#1 &#2: 35%)

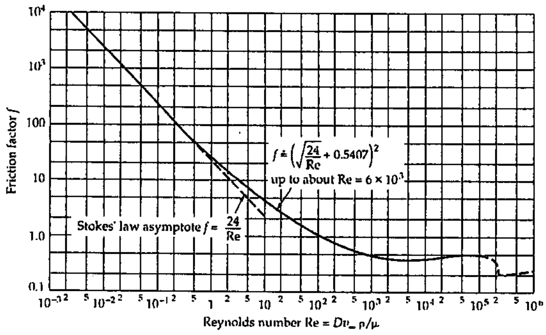

Figure A: Friction factor (or drag coefficient) for spheres moving relative to a fluid with a velocity u_∞.

1. (20%)

It is desired to design an experiment to test the friction factor chart in **Figure A** for flow around a sphere of diameter D (radius R).

(a) (7 %) Derive formulae that give the form drag and wall drag for creeping flow passing the sphere.

(b) (5 %) Derive the formula f=24/Re that gives the friction factor f as a function of Reynolds number Re in the creeping flow region (Re< 0.1).

(c) (5 %) Derive a formula that gives the required diameter as a function of f, Re, g, μ, ρ, ρ_{sph} for terminal velocity conditions.

(d) (3 %) You want to test the plotted value f=1 at Re=100. This is to be done by dropping bronze spheres (ρ_{sph}=8g/cm^3) in water (ρ=1g/cm^3, μ=10^{-2}g/cm·s). What sphere diameter must be used?

[hint: $P = P_o - \rho g z - \frac{3}{2}\frac{\mu u_\infty}{R}(\frac{R}{r})^2\cos\theta$

$$\tau_{r\theta} = \frac{3\mu u_\infty}{2R}(\frac{R}{r})^4\sin\theta \qquad \tau_{rr} = -2\tau_{\theta\theta} = -2\tau_{\phi\phi} = \frac{3\mu u_\infty}{R}[-(\frac{R}{r})^2 + (\frac{R}{r})^4]\cos\theta$$

2. (15%) A Newtonian fluid (density ρ and viscosity μ) is in a laminar flow in a narrow slit (dimension: L×W) formed by two parallel walls a distance 2B part. It is understood that B<<W, so that edge effects are unimportant. Make a different momentum balance, and obtain the expressions for the momentum-flux, velocity distributions, the average velocity <u>, maximum velocity u_{max}, and Renolds number as a function of ρ, μ, D_h(hydrulic diameter) and <u>.

Mass Transport (#3: 35%)

3. (35%)

Drug diffusion coefficients across membranes, ***D***, of model drugs, ***1***, such as lidocaine and dihydroquercetin from hydrogels, were measured using a Franz diffusion cell thermostated at 37°C. The cell consists of two well-stirred volumes separated by a cellulose acetate membrane or a rat skin. To measure a diffusion coefficient with this cell, both the upper (or donor) and lower (or receptor) compartments are originally filled with distilled water. At time t = 0, a certain amount of ***1*** is placed in the donor compartment, $C^0_{1,donor}$. After a known time, both donor and receptor compartments are sampled and their concentrations, $C_{1,donor}$ and $C_{1,receptor}$, are measured respectively by high performance liquid chromatography. Assuming the flux across the membrane quickly reaches a steady state value, ***A*** is the area available for diffusion, δ is the membrane thickness, V_{donor} and $V_{receptor}$ are volumes of the donor and receptor compartments respectively:

(a) (7%) calculate the flux across the membrane,

(b) (7%) write an overall mass balance on the two adjacent compartments,

(c) (7%) obtain the differential equation by combining (a) and (b),

(d) (7%) integrate (c) to achieve the desired result, and

(e) (7%) explain how to use the result in (d) to determine, ***D***, graphically.

注意：背面有試題

Heat Transport (#4 and #5: 30 %)

4. (15%)

(a) (8%) For the analogy equation between heat and mass transfer, what dimensionless numbers in heat transfer correspond to the Sherwood number and Schmidt number in mass transfer? Please also give the definitions of those dimensionless numbers in heat transfer. (Note: you have to specify which one corresponds to Sherwood number, and which one corresponds to Schmidt number.)

(b) (7%) For non-isothermal forced-convection and free-convection flow system, what dimensionless numbers influence the dimensionless velocity and temperature profiles? (Note: the definitions of these dimensionless numbers are not required for part (b))

5. (15%)

(a) (12%) For heat transfer between the fluid inside tube and the fluid outside tube, please derive the relationship for the overall heat-transfer coefficients based on the outside and inside tube surface areas in terms of the inside heat-transfer coefficients h_i, the outside heat-transfer coefficients h_o, the thermal conductivity of wall k_w, the inside tube radius r_i, and the outside tube radius r_o.

(b) (3%) Which tube surface area is the overall heat-transfer coefficient for outside finned tube usually based on, the outside or the inside tube surface area? Please explain the reason.