東海大學 104 學年度碩士班招生考試試題

考試科目：單元操作與輸送現象　　應考系組：化材系　　科目代碼：31011

考試日期：104 年 03 月 08 日第 3 節　　使用計算機：可　　

本次考試之試題共 3 題，試卷有兩頁，總分 100 分。

1. (40 points) Velocity distribution of a steady and fully developed flow of a Newtonian fluid in a section of circular pipe is described as $v = v_{max}[1-(\frac{r}{R})^2]$, where v is the axial component of the velocity at the radial position of r ; v_{max} is the velocity at the axis of the pipe and R is the inner radius of the pipe.

(a) Show that the average velocity across the circular cross section of the pipe, v_{avg} , is equal to $v_{max}/2$ (8 points)

(b) The shear stress at pipe wall τ_w, is equal to $2\mu v_{max}/R$. (6 points)

(c) By force or momentum balance, show that the pressure drop Δp across the length of the pipe L, is equal to $2(L/R)\tau_w$. (12 points)

(d) Combining the derivations in (a), (b) and (c), show that $\Delta p=4(L/R)(\mu v_{max}/R)$. (8 points)

(e) The Fanning friction factor f is defined by $f = 2\tau_w / \rho v_{avg}^2$ with ρ represents the density of the Newtonian fluid. Show that $f=16/Re$, with the Reynolds number defined as $Re = (\rho v_{avg} D/\mu)$ and D is the inner diameter of the pipe. (6 points)

2. (30 points) A furnace wall consisting of 0.25 m of fire clay brick, 0.20 m of kaolin, and a 0.10 m outer layer of masonry brick, respectively, is exposed to furnace gas at 1370 K inside and with air at 300 K adjacent to outside wall. The thermal conductivities of clay, kaolin, and masonry are 1.13, 1.34, and 0.66 W/m-K, respectively. The inside and outside convective heat transfer coefficients are 115 and 23 W/m^2-K, respectively.

(a) Determine the flux of heat loss of the wall. (10 points)

(b) Determine the temperature of the inside wall surface. (5 points)

(c) Determine the temperature between clay and kaolin. (5 points)

(d) Determine the temperature between kaolin and masonry. (5 points)

(e) Determine the temperature of the outside wall surface. (5 points)

3. (30 points) As shown in the following figure, helium gas is steadily diffusing in the positive z direction through a stagnant column of air. At 25°C and 1 bar, the diffusivity of helium though air D_{ha} is 0.6 cm^2/s.

(a) (10 points) Show that the molar flux of helium with respect to stationary axes, $N_h = -\frac{CD_{ha}}{(1-x_h)}\frac{dx_h}{dz}$, where x_h is the local molar fraction of helium and for simplicity, x_h is assumed depending on z only. C is the total molar concentration of the mixture.

(b) (5 points) By regarding the mixture is an ideal gas find the total molar concentration of the mixture C

(c) (15 points) At the point z = 0 cm, the molar fraction of helium is equal to 0.03, while at the top of the column where z =100 cm, x_h=0.01, find the molar flux of helium.