國立雲林科技大學 113 學年度
碩士班招生考試試題

系所：化材系
科目：單元操作與輸送現象

1. Please explain the following terms: (12%)
(a) viscosity
(b) kinematic viscosity
(c) turbulent viscosity
(d) volume viscosity

2. If one wants to measure the viscosity of glycerol by flowing through a horizontal tube 0.3 m long and with 0.8 cm inside radius at 25 °C. The pressure drop is 330 Pa, and the volumetric flowrate is 75 cm^3/min. The density of glycerol is known as 1.261 g/cm^3. Use Hagen-Poiseuille equation to estimate the viscosity of glycerol in centipoise (cp). (18%)

3. Carburization is a key process in making low alloy steels. This process involves the absorption of carbon into steel in a high temperature environment, and the simplest model can be obtained by considering one-dimensional diffusion of carbon into a steel plate at a fixed temperature. Suppose the initial carbon level in steel is C_0, and the surface concentration of carbon is fixed as C_S. The diffusion coefficient D for the carbon-steel binary is assumed to be constant. Start with the Fick's second law ($\frac{\partial C(x,t)}{\partial t} = D\frac{\partial^2 C(x,t)}{\partial x^2}$) to find the carbon concentration in steel as a function of distance x and time t from the surface at $x = 0$. Note that the results can be expressed in terms of error function ($\text{erf}(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-\eta^2} d\eta$) given the properties of $\text{erf}(0) = 0$ and $\text{erf}(\infty) = 1$. (20%)

國立雲林科技大學 113 學年度 碩士班招生考試試題

系所：化材系

科目：單元操作與輸送現象

4. In a plane wall, thermal energy is conducted only in x direction at steady state. The other walls in y, z directions are assumed to be insulated. The temperature of wall is T_1 ($x = x_1$) and T_2 ($x = x_2$). The thermal conductivity of the plane wall is $k = k_0(1 + \alpha\theta)$, wherein α, k_0 are constants and $\theta = T - T_0$ with the defined reference temperature of T_0. Please derive temperature profile in the x direction $\theta(x)$ as a function of x, x_1, x_2, α, θ_1 and θ_2 within the plane wall. (20%)

5. A sphere with the radius of R is suspended in the fluid. Thermal energy is conducted radially at steady state from the sphere into the fluid (thermal conductivity k) and convectional heat transfer is neglected. The surface temperature of sphere is Ts and bulk fluid temperature is To. Please derive temperature profile of the fluid in the radial direction T(r) as a function of r, R, To, Ts. (15%)

6. A hollow cylinder, with the inner radius of r_1 and outer radius of r_2, possesses thermal conductivity of $k = k_0(1 + \beta\theta)$, wherein β, k_0 are constants and $\theta = T - T_0$ with the defined reference temperature of T_0. The inner temperature of the cylindrical wall is T_1 at r_1. The outer surface of the cylindrical wall is T_2 at r_2. Find the heat transfer rate per unit length of the cylinder at steady state. (15%)