# 逢甲大學101學年度碩士班招生考試試題 編號：012 科目代碼：

| 科目 | 輸送現象及單元操作 | 適用系所 | 化學工程學系 | 時間 | 100 分鐘 |
|---|---|---|---|---|---|

**※請務必在答案卷作答區內作答。**

1. (60%) Water at 10°C enters a 0.0254 m (inside diameter) pipe at a rate of 0.00126 $m^3/s$. The pipe is 3.05 m long and the pipe wall is smooth. The temperature of the pipe wall is held constant at 99°C, and the water outlet temperature is 41°C. The viscosity, density, and heat capacity of the water are 0.001 Pa.s, 1000 $kg/m^3$, 4182 J/kg.K, respectively.
   (10%) (a). What is the shear stress at the pipe wall?
   (10%) (b). What is the force required (in the flow direction) to hold the pipe so that it can maintain its position?
   (20%) (c). What is the heat transfer coefficient on the pipe wall surface?
   (20%) (d). If the water flowrate is reduced to 0.00001 $m^3/s$, what is pressure drop required between the inlet and outlet of the pipe? What is the shear stress at the pipe wall?

2. (15%) In Taiwan, you feel that the weather is very cold under the strong wind especially in winter. This is called the "wind chill" effect. If you bought the ice cream in winter but find out there is no room in your refrigerator, you have to put the ice cream box outside for a while. Should you place the ice cream box in a place under strong wind or place it in a place without wind? Explain the reason of your choice otherwise no point will be given.

3. (40%) A spherical steel tank of 1 liter capacity and 2 mm wall thickness is used to store hydrogen at 500°C. The initial pressure is 10 bar (1 bar = $10^5$ Pa), and there is a vacuum outside the tank. Calculate the time in hours required for the pressure to drop to 5 bar. The diffusion coefficient of hydrogen in steel is $D_{AB} = 1.5 * 10^{-6} * e^{-4500/T}$ $m^2/s$. The solubility in mass fraction (w) of hydrogen in steel is $w = 2.0 * 10^{-4} * e^{-4000/T} * p^{1/2}$ where T is in kelvins and p is the partial pressure of hydrogen in bars. The total density of the steel with solubilized hydrogen is $\rho = 7800$ $kg/m^3$. The ideal gas constant is R = 8314 (Pa * $m^3$)/(kg mol * K). The molecular weight of hydrogen is M = 2 kg/ kg mol. Also calculate the radius of the tank in meters and the two mass fractions (w's) in the steel on the gas side and on the vacuum side.
   Hint: Use the SI units and assume the tank wall is so thin that the surface areas on its both sides are the same.

4. (35%) Given a solid disc of species A which is 8 cm in diameter and spinning (or rotating) at 25 rpm (or revolutions/min) and 30°C, calculate the angular speed ω in rad/s (or radians/s), the Reynolds number Re, the Schmidt number Sc, the Sherwood number Sh, the convective mass transfer coefficient $k_c$ in cm/s, the mass flux $N_{Az}$ in g/($cm^2$ s), the rate of dissolution $W_A$ in g/s in a large volume of water.

   Note that the diffusivity ($D_{AB}$) of species A in water is $1.0 * 10^{-5}$ $cm^2/s$, and solubility is 0.01 g/ $cm^3$. For water, $\rho = 1$ g/$cm^3$, $\mu = 1$ centipoise = 0.01 g/(cm s). Regarding this problem, please use the CGS units for best results.

   The following convective mass transfer correlation is applicable:

   $Sh = 0.62\, Re^{1/2}\, Sc^{1/3}$ or

   i.e., $\frac{k_c D}{D_{AB}} = 0.62\left(\frac{D^2 \omega \rho}{\mu}\right)^{\frac{1}{2}}\left(\frac{\mu}{\rho D_{AB}}\right)^{\frac{1}{3}}$ where ω is the angular speed in rad/s and 1 revolution = $2\pi$ radians.