國立臺灣大學 104 學年度碩士班招生考試試題

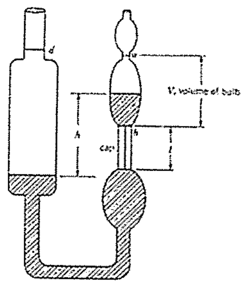


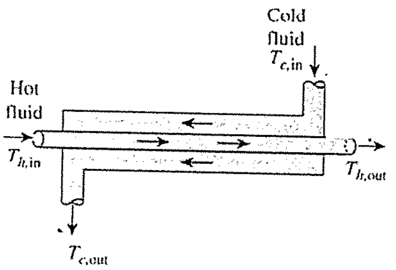
FIGURE 6.2 The Oswald viscometer.

1. a. To simplify the Navier–Stokes equations with appropriate boundary deriving the Hagen–Poiseuille equation for a vertical tube with inside diameter R and length L. (10%)
b. Kinetic viscosity of a fluid can be measured using an Oswald viscometer by the following equation. How was the equation derived? t: elapsed time (10%)

$$\nu = \frac{\pi R^4 g}{8Vl} \cdot t$$

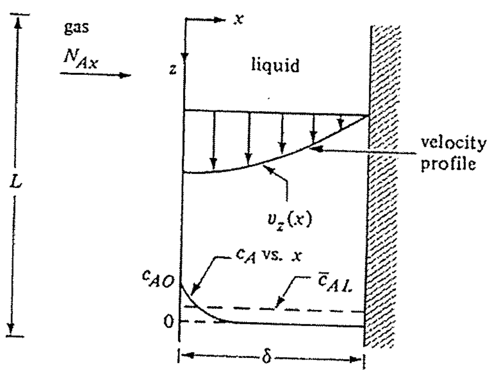
ν : Kinetic viscosity

$$\rho\left(\frac{\partial u_z}{\partial t} + u_r\frac{\partial u_z}{\partial r} + \frac{u_\theta}{r}\frac{\partial u_z}{\partial \theta} + u_z\frac{\partial u_z}{\partial z}\right) = -\frac{\partial P}{\partial z} + \rho g_z + \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u_z}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 u_z}{\partial \theta^2} + \frac{\partial^2 u_z}{\partial z^2}\right]$$



2. The log mean temperature difference method is frequently used in heat exchanger design.
a. Using nomenclatures in fig. 2 to define the log mean temperature. (10%)
b. Cold water (c_p=4kJ/Kg K) enters a counter-flow heat exchange at 5˚C at a rate of 8 kg/s, and exits at 35˚C, to chill processed olive oil(c_p=2kJ/Kg K) at 50˚C at a rate of 16 kg/s. If the overall heat transfer coefficient is 1000W/m^2, determine the heat transfer area of the heat exchanger. (10%)

3. Gas absorption in a wetted-wall columns is schematically shown in fig. 3, The



solute A in the gas is absorbed at the interface and then diffuses a distance into the liquid so that it has not penetrated the whole distance x= δ at the wall. The operation is at steady state and the inlet concentration c_A=0. A simplified governing equation of diffusion in a laminar falling film is depicted as follow.

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$$v_{zsurface}\frac{\partial c_A}{\partial z} = D_{AB}\frac{\partial^2 c_A}{\partial x^2}$$

a. To determine the local molar flux at the surface x=0 at point z. (10%)
b. To determine the average molar flux over the entire length z=0 to z=L. (10%)

For your reference, temperature profile of transient heat conduction in a semi-infinite solid can be shown as,

$$\frac{T(x,t)-T_i}{T_\infty - T_i} = erfc\left(\frac{x}{2\sqrt{\alpha t}}\right) \qquad erfc(x) = 1 - erf(x) \qquad \frac{d}{dx}erfc(x) = \frac{2e^{-x^2}}{\sqrt{\pi}}$$

4. A filtration test was carried out, with a particular product slurry, on a laboratory filter press under a constant pressure (ΔP) of 340 kPa and volumes of filtrate were collected as follows: (20%)

Filtrate weight: V (g)	20	40	60	80
Time: t (min)	8	25	54.5	93

The area (A) of the laboratory filter was 0.186 m^2. In a plant scale filter, it is desired to filter a slurry containing the same material, but at 50% greater concentration (w) than that used for the test, and under a pressure of 270 kPa. Estimate the quantity of filtrate that would pass through in 1 hour if the area of the filter is 9.3 m^2.

t/(V/A)=(w/ΔP)K(V/A)+K'/ΔP

5. A counter flow dryer unit uses heated air to dry apple slices. The slices enter at a rate of 200 kg/h and a moisture content of m_1 = 0.9(WB). The "dried" slices have a moisture content of M_2 = 0.10(WB). The drying air enters at 50°C and exits at 25°C and 90% relative humidity.

a. Find the water removed, (kg/h). (10%)
b. Find the entering air flow rate, CMM(m^3/min) (10%)

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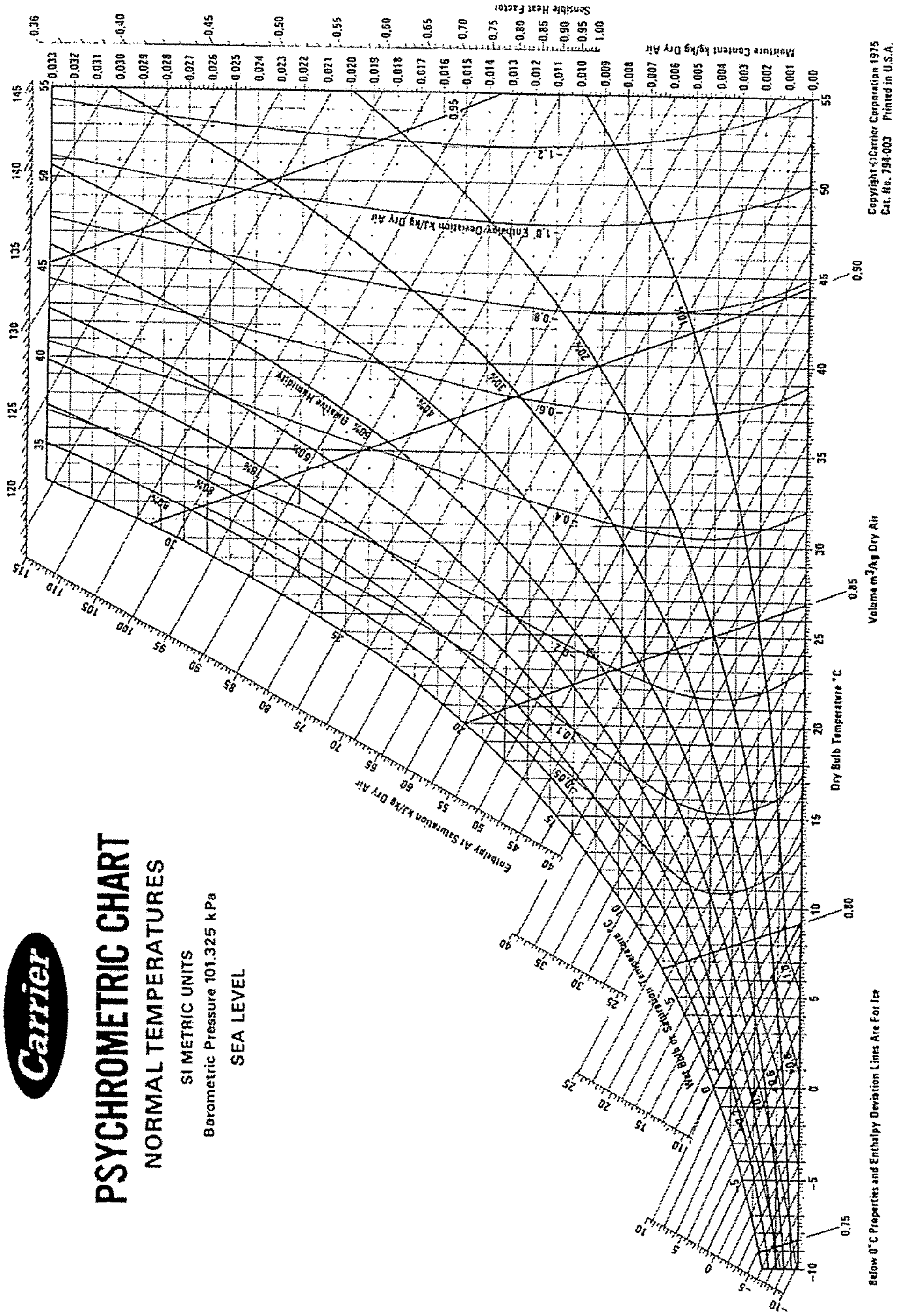

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