UNIVERSITY OF GHANA

FACULTY OF ENGINEERING SCIENCES

DEPARTMENT OF FOOD PROCESS ENGINEERING

B.Sc SECOND SEMESTER FINAL EXAMINATION, 2012/2013

FDEN 312: MASS TRANSFER (3 Credits)

Answer FOUR questions only. All questions carry equal marks. **Time: 2½ Hrs**

Question 1

(a) Derive a relationship between the overall mass transfer coefficient based on the gas phase, K_y, and the individual coefficients, k_y and k_x.

(b) Consider the one-dimensional mass transfer for a mixture of oxygen and carbon dioxide at 294 K and a total pressure of 1.519 x10^5 Pa. Designate oxygen as gas A and carbon dioxide as gas B. From the conditions: x_A = 0.40 and v_A = 0.08 m/s and v_B = - 0.02 m/s, calculate the following:

(i) N_A, N_B the molar fluxes of A and B with respect to stationary axes
(ii) n_A, n_B, the mass fluxes of A and B
(iii) j_B, the flux of B with respect to moving axes in kg/m^2.s
(iv) j_B, in mol/m^2.s

Use only the definitions of the concentrations, velocities and fluxes.

Question 2

If the heat transfer coefficient for the flow of air over a streamlined-shaped body is 17.04 W/m^2.^{o}C at a given mass velocity, determine the mass flux from an identically shaped body made out of naphthalene to an air stream flowing at the same mass velocity. Air at 100^{o}C, essentially free of any naphthalene is 20 mmHg, the diffusivity of naphthalene vapour in air is 0.034 m^2/h and the thermal diffusivity of air is 0.12 m^2/h.

Chilton-Colburn j-factor correlation

$$\frac{h}{\rho v_\infty C_p}(Pr)^{2/3} = \frac{k_c}{v_\infty}(Sc)^{2/3}$$

Pr = 0.692

Density = 0.93 kg/m^3
C_p=1.012×10^3 J/kg.K

Question 3

A charcoal briquette, approximately spherical shaped with a 3-cm radius, has an initial moisture content of 500 kg/m^3. It is placed into a forced-air dryer that produces a surface moisture concentration of 1 kg/m^3. If the diffusivity of water in the charcoal is 1.3×10^{-6} m^2/s and the surface resistance is negligible, estimate the time required to dry the center of the briquette to a moisture concentration of 50 kg/m^3.

Use the unsteady state calculations graph provided in your solution.

Question 4

In the desorption of component A from an aqueous solution into an air stream at a particular point in the mass transfer tower, the bulk concentration of the two streams were analyzed to be

P_{AG}=15 mm Hg

The overall gas coefficient, K_G, was equal to 0.08 kg mol A/(hr)(m^2) (atm). Sixty-five percent of the total mass transfer for resistance was encountered in the gas film, 55% in the liquid film. Henry's law constant was equal to 0.265 atm/(mol A/m^3 of solution). Determine

a) the gas-film coefficient, k_G
b) the liquid-film coefficient, k_L
c) the mass flux of A
d) the interfacial pressure, p_{Ai}
e) the interfacial concentration, c_{Ai}

(1atm=760 mm Hg)

Question 5

The exhaust emission from a boiler is to be tested with a gaseous mixture of 5.0 ppm volume (i.e parts per million on a volumetric basis) of a hydrocarbon-in-air mixture. The mixture is made by allowing the hydrocarbon to diffuse out of a small tube into a stream of air. The hydrocarbon liquid level is held constant in the tube by a suitable reservoir. For an air flow rate of 1.80×10^{-5} m^3/s, what diameter of tube is needed if the liquid level is 0.15m below the end of the tube exposed to the flowing air?

Diffusion coefficient for hydrocarbon: 1.10×10^{-5} m^2/s
Vapor pressure: 10.132 kPa
Total pressure: 101.32 kPa
Temperature: 25°C

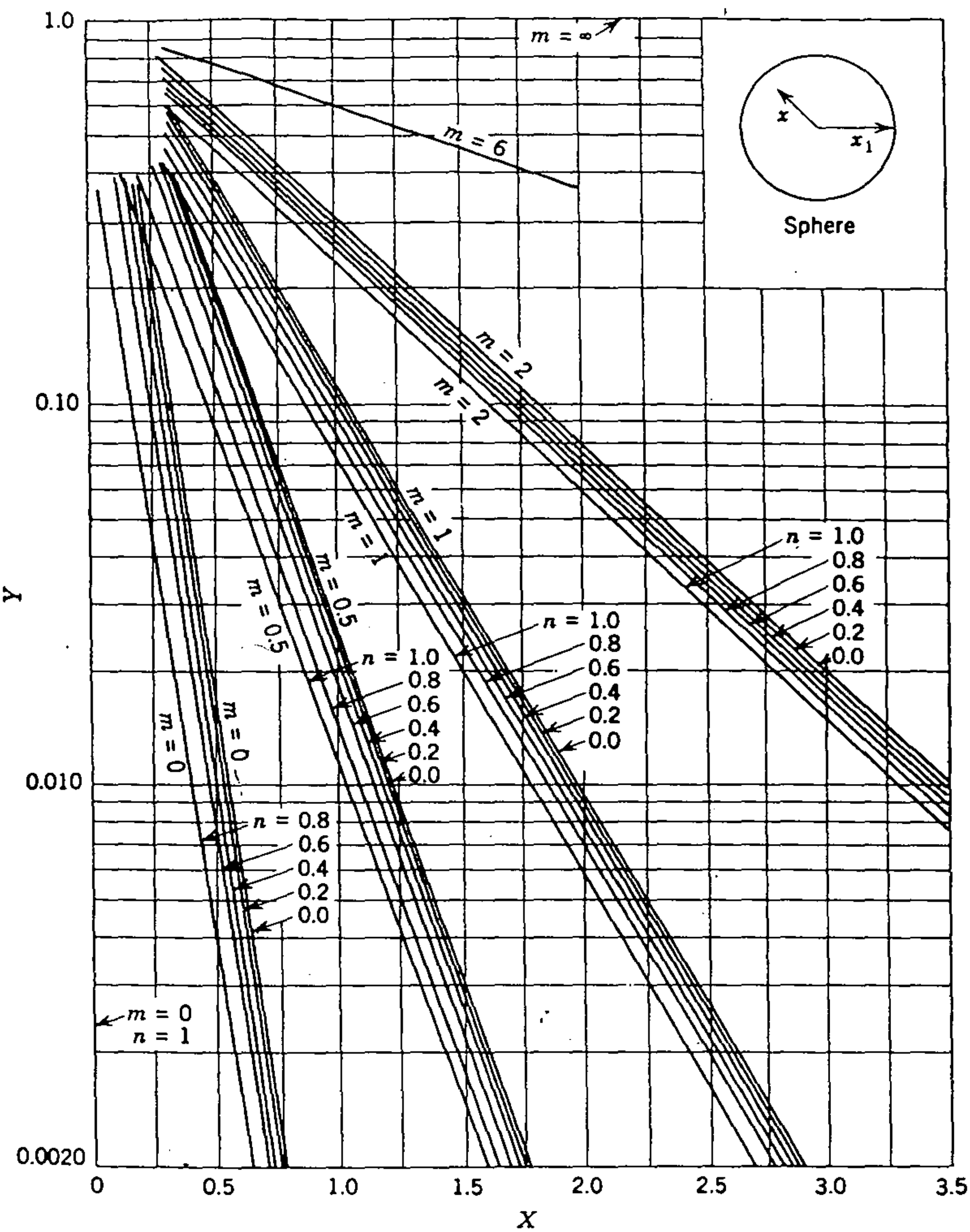

Figure F.3 Unsteady-state transport in a sphere.