UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	MASS TRANSFER
COURSE CODE	:	BNQ 20303
PROGRAMME	:	2 BNN
EXAMINATION DATE	:	DECEMBER 2013/JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) State the Fick's law of diffusion analogy terms.

(2 marks)

(b) Discuss the concept of mass transfer.

(3 marks)

(c) Explain briefly about the diffusion coefficient D_{AB}.

(5 marks)

(d) Explain the differences of steady state and unsteady state mass transfer.

(5 marks)

(e) State **FIVE (5)** types of dimensionless number that usually used in convective mass transfer.

(5 marks)

Q2 A sphere of naphthalene having a radius of 2.0 mm is suspended in a large volume of still air at 318 K and 1.01325 X 10^5 Pa (1 atm). The surface temperature of the naphthalene can be assumed to be at 318 K and its vapor pressure at 318 K is 0.555 mm Hg. The D_{AB} of naphthalene in air at 318 K is 6.92 x 10^{-6} m^2/s. Solve the rate of evaporation of naphthalene from the surface.

(20 marks)

Q3 A very thick slab has a uniform concentration of solute A of $c_o = 1.0 \times 10^{-2}$ kg mol A/m^3. Suddenly, the front face of the slab is exposed to a flowing fluid having a concentration $c_1 = 0.1$ kg mol A/m^3 and a convective coefficient $k_c = 2 \times 10^{-7}$ m/s. The equilibrium distribution coefficient $K = c_{Li}/c_i = 2.0$. Assuming that the slab is a semi-infinite solid, calculate the concentration in the solid at the surface at the following distance from the surface after $t = 3 \times 10^4$ s. The diffusivity in the solid is $D_{AB} = 4 \times 10^{-9}$ m^2/s.

(a) x = 0 m

(10 marks)

(b) x = 0.01 m

(10 marks)

Q4 Pure water at 26.1 °C is flowing at a velocity of 0.0305 m/s in a tube having an inside diameter of 6.35 mm. The tube is 1.829 m long, with the last 1.22 m having the walls coated with benzoic acid. The solubility of benzoic acid in water is 0.02948 kg mol/m^3. Assuming that the velocity profile is fully developed,

(a) Illustrate and label the diagram of the tube.

(5 marks)

(b) Calculate the average concentration of benzoic acid at the outlet.
$\mu = 8.71 \times 10^{-4}$ Pa.s, $\rho = 996$ kg/m^3, $D_{AB} = 1.245 \times 10^{-9}$ m^2/s.

(15 marks)

Q5 In a single-stage leaching of soybean with hexane, 100 kg of soybean containing 20 wt% oil is leached with 100 kg of fresh hexane solvent. The value of N for the slurry underflow is essentially constant at 1.5 kg insoluble solid/kg solution retained.

(a) Construct the process flow diagram and label the process variables.

(5 marks)

(b) Calculate the amounts and compositions of the overflow V_1 and the underflow slurry L_1 leaving the stage.

(15 marks)

- END OF QUESTION -

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FORMULA

(i)

$$p_{BM} = \frac{p_{B1} + p_{B2}}{2}$$

$$N_{A1} = \frac{D_{AB} P (p_{A1} - p_{A2})}{RTr_1 p_{BM}}$$

(ii)

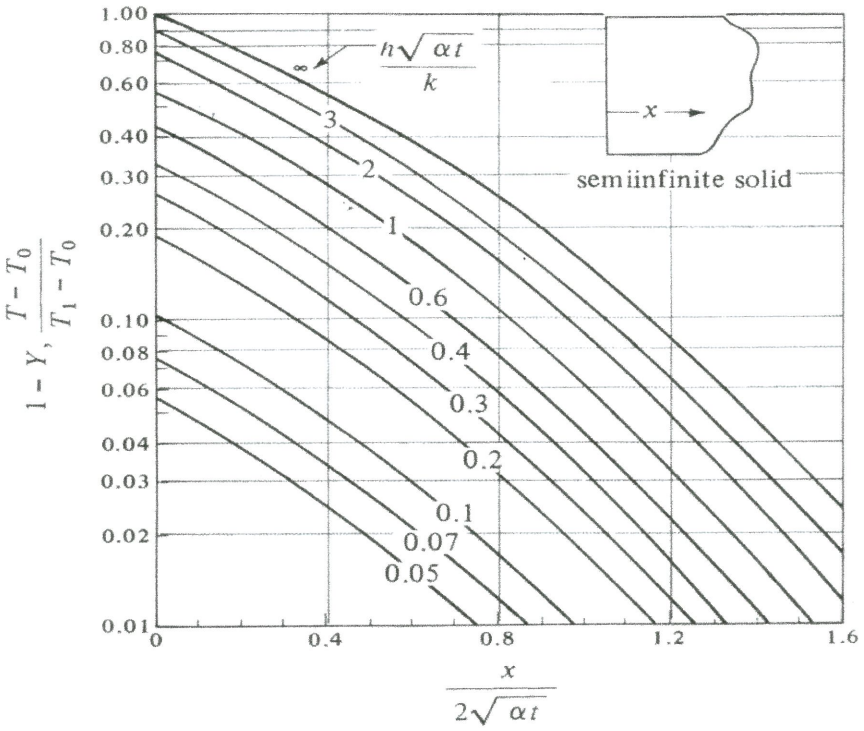

FIGURE 5.3-3. *Unsteady-state heat conducted in a semiinfinite solid with surface convection. Calculated from Eq. (5.3-7)(SI).*

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(iii)

TABLE 7.1-1. *Relation Between Mass- and Heat-Transfer Parameters for Unsteady-State Diffusion**

	Mass Transfer	
Heat Transfer	$K = c_I/c = 1.0$	$K = c_I/c \neq 1.0$
$Y, \dfrac{T_1 - T}{T_1 - T_0}$	$\dfrac{c_1 - c}{c_1 - c_0}$	$\dfrac{c_1/K - c}{c_1/K - c_0}$
$1 - Y, \dfrac{T - T_0}{T_1 - T_0}$	$\dfrac{c - c_0}{c_1 - c_0}$	$\dfrac{c - c_0}{c_1/K - c_0}$
$X, \dfrac{\alpha t}{x_1^2}$	$\dfrac{D_{AB} t}{x_1^2}$	$\dfrac{D_{AB} t}{x_1^2}$
$\dfrac{x}{2\sqrt{\alpha t}}$	$\dfrac{x}{2\sqrt{D_{AB} t}}$	$\dfrac{x}{2\sqrt{D_{AB} t}}$
$m, \dfrac{k}{h x_1}$	$\dfrac{D_{AB}}{k_c x_1}$	$\dfrac{D_{AB}}{K k_c x_1}$
$\dfrac{h}{k}\sqrt{\alpha t}$	$\dfrac{k_c}{D_{AB}}\sqrt{D_{AB} t}$	$\dfrac{K k_c}{D_{AB}}\sqrt{D_{AB} t}$
$n, \dfrac{x}{x_1}$	$\dfrac{x}{x_1}$	$\dfrac{x}{x_1}$

* x is the distance from the center of the slab, cylinder, or sphere; for a semiinfinite slab, x is the distance from the surface. c_0 is the original uniform concentration in the solid, c_1 the concentration in the fluid outside the slab, and c the concentration in the solid at position x and time t.

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(iv) $$N_{\mathrm{Re}} = \frac{D\upsilon\rho}{\mu}$$

$$N_{Sc} = \frac{\mu}{\rho D_{AB}}$$

$$\left(\frac{W}{D_{AB}\rho L}\right) = N_{\mathrm{Re}} N_{Sc} \frac{D}{L}\frac{\pi}{4}$$

$$\frac{c_A - c_{Ao}}{c_{Ai} - c_{Ao}} = 5.5\left(\frac{W}{D_{AB}\rho L}\right)^{-2/3}$$