



Name ..... Student ID .....

1. (40 points) Please answer the following equations in Thai
  - 1.1. (12 points) Describe Fick's first law (i.e. equation, driving force, etc.), and specify the assumption used
  - 1.2. (6 points) Specify the equations used to predict diffusivity (or diffusion coefficient) for gas, liquid and solid (one example each)
  - 1.3. (10 points) Describe film theory (i.e. how to apply, equation, assumption, etc.)
  - 1.4. (12 points) Describe effect of correction term on molar flux

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2. (45 points)

Air at 32°C is humidified by flowing over a 10 cm (diameter) × 15 cm (height) container filled with water. The interfacial temperature is 28 °C. If the initial humidity of air is 40% and its velocity is 12 cm/s, and diffusivity of air-water system is  $2.2 \times 10^{-5} \text{ m}^2/\text{s}$

- 2.1. (20 points) Calculate the mass transfer coefficient,  $k_c$  in cm/s
- 2.2. (25 points) Determine the molar flux,  $N_A$  in mole/cm<sup>2</sup>.s

3. (37 points)

A 20% NaOH solution is to be concentrated in a single – effect evaporator with a vertical tube 6 m in diameter and 15 m long. The feed rate is 60,000 kg/h at 35°C and the evaporator capacity is required at 30,000 kg/h. Steam is available at a gauge pressure of 20 lb/in<sup>2</sup>. The boiling point of water at the absolute pressure in vapor space is 150°F.

- 3.1. (6 points) Calculate the product fraction,  $x$
- 3.2. (6 points) Determine boiling point elevation (BPE) in °F
- 3.3. (25 points) Calculate the evaporator economy

4. (30 points)

50 wt.% of NaOH-H<sub>2</sub>O has been mixed with 15 wt.% of NaOH-H<sub>2</sub>O as shown in Figure-1, it is assumed that the diffusion occurs only within 2 mm thick of a stagnant film at 298 K.

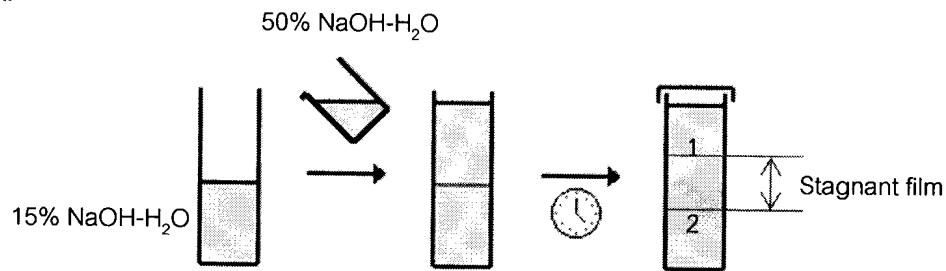


Figure – 1: Diffusion of NaOH – H<sub>2</sub>O system

Its density and molecular weight is 1.51 g/mL and 24.8 g/mole for the 50 wt.% solution, and 1.30 g/mL and 19.62 g/mole for the 15 wt.% solution respectively at temperature 298 K.

- 4.1. (5 points), You think the diffusion should be Equimolar counter-diffusion or One-way diffusion? (Please explain the assumption used in Thai).
- 4.2. (25 points), Calculate molar flux in (kmole/s.m<sup>2</sup>) if diffusivity of this system is  $0.74 \times 10^{-9} \text{ m}^2/\text{s}$ , and molecular weight of NaOH is 40 g/mol.