PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Exam	: Semester II	Academic Year	: 2009
Date	: December 24, 2009	Time	: 9:00-12:00
Subject	: Unit Operations I (230-323)		
Total pages	: 10 (inc. front page)	Room	: S203

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

อนุญาตให้นำเอกสารและเครื่องคำนวณทุกชนิดเข้าห้องสอบ

ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริต

และพักการศึกษา 1 ภาคการศึกษา

Question #	Total Score	Score
1	10	
2	35	
3	20	
4	30	
5	20	
6	25	
Total	**140**	

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ผู้ออกข้อสอบ

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

1. (10 points), These sentences are ✓ "*True*" or × "*False*"

..... **1.1.** Flux is a transfer rate per unit volume.

..... **1.2.** Driving force of mass transfer is concentration gradient.

..... **1.3.** In film theory, it is assumed that eddy diffusivity is zero within the effective film thickness.

..... **1.4.** A rate of transfer is reduced if boiling point elevation (BPE) of the solution increases.

..... **1.5.** BPE of the solution depends only on the concentration of solute.

..... **1.6.** Temperature drop in the evaporator is the difference between the superheated temperature of the steam and the temperature in vapor space.

..... **1.7.** For dilute solution, heat of dilution and BPE can be negligible.

..... **1.8.** To concentrating β - carotene, residence time in a evaporator should be minimized.

..... **1.9.** In two – phase theory, if $\frac{k_x}{mk_y} << 1$ it means that the mass – transport resistance of the gas phase has large effect.

..... **1.10.** Turbulent diffusion provides higher transfer rate due to addition of eddy diffusivity term.

2. (35 points) A 20% NaOH solutions is to be concentrated to 65% 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 40.56°C. The boiling point of water at the absolute pressure in vapor space is 110°C. Steam is available at a gauge pressure of 261.8 lb_f/in^2.

2.1. (20 points), calculate the steam requirement in kg/hr

2.2. (5 points), calculate the economy

2.3. (10 points), estimate the overall heat – transfer coefficient in W/m^2. °C

3. (20 points) Carbon tetrachloride (CCl_4) evaporates into a tube 1.02 in diameter containing oxygen. The distance between the CCl_4 liquid level and the top of the tube is 17.1 cm. The total pressure on the system is 755 mmHg, and the temperature is 0°C. The vapor pressure of CCl_4 at that temperature is 33 mmHg and its density is 1.629 g/cm^3.

3.1. (10 points), calculate the molar flux of CCl_{l4}, if it is found that 0.0208 cm^3 of CCl_{l4} evaporate in a 10 hours period.

3.2. (10 points), estimate the diffusivity of the gas pair O_2 - CCl_4 in cm^2/s

4. (30 points) A spherical drop of water 0.05 cm in diameter is falling at a velocity 215 cm/s through dry, still air at 105°F and 1 atm. The vapor pressure of water at 105°F is 0.0247 atm.

4.1. (15 points), estimate the mass transfer coefficient, k_c

4.2. (5 points), estimate the mass transfer coefficient relating partial pressure, k_G in $mol/cm^2.s.atm$

4.3. (10 points), calculate the evaporation rate

5. (20 points) A tube 0.2 cm in diameter is filled with liquid n–heptane at 21°C. The diffusivity of n–heptane in air at that temperature is 0.071 cm^2/s and the vapor pressure is 0.05 atm.

5.1. (10 points), estimate the mass transfer coefficient relating mole – fraction in gas phase, k_y if the liquid level is decreased 1 cm from the top

5.2. (10 points), calculate the rate of decrease of the liquid level in cm/h (molecular weight and density of n–heptanes is 100.2 g/mol, 0.66 g/cm^3)

6. (25 points) A dilute solution of organic colloids in water is to be concentrated from 8 to 45 % solids in a forced – circulation evaporator. The steam is available at 249°F, and a pressure in a vapor space is maintained at 102 mmHg. The feed rate to the evaporator is 20,000 kg/h, and the specific heat of the feed solution is 3.77 J/g.°C.

6.1. (5 points), determine the capacity of the evaporator

6.2. (20 points), calculate the feed temperature and the heating load, if the economy is required at 1.