BOWEN UNIVERSITY, IWO, OSUN STATE
COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE
INDUSTRIAL CHEMISTRY PROGRAMME
2022/2023 B.SC DEGREE FIRST SEMESTER EXAMINATION

Course Code: ICH 407 **Course Title:** Chemical Process Technology
Date: /02/2023 **Credits**: 3 **Time Allowed:** 2½hours

INSTRUCTIONS **(a) Answer any FOUR (4) questions**
(b) Answer each question on a fresh page

Question 1

a. Highlight the operations that depend on heat exchanger for proper functioning. **6 marks**
b. Explain in not more than three sentences, the difference between heat capacity and specific heat capacity. **6 marks**
c. Write short note on any **two** of the following mixing characteristics approach:
   i. Gas – Liquid
   ii. Solid – Solid
   iii. Gas – Liquid – Solid **8 marks**

Question 2

a. What is scale-up? **2 marks**
b. Differentiate between total reflux ratio and optimum reflux ratio. **4 marks**
c. Discuss the major issues and conditions in the design and scale-up of fixed bed catalytic reactor processes. **6 marks**
d. The vapor pressures of n-heptane and toluene at 373K (100°C) are 102 and 63.7kN/m^2 respectively. What are the fractions of toluene in the vapor and in the liquid phase of 363K if the total pressure is 101.3kN/m^2? **8 marks**

Question 3

a. What is distillation? **2 marks**
b. Write short note on the following terminologies in distillation process:
   i. Entrainment
   ii. Short circuiting
   iii. Weeping
   iv. Dumping of liquid **8 marks**
c. The overall column efficiency is related to Murphree plate efficiency by

$$E_o = \frac{\ln\left[1 + E_{mv}\left(\frac{mV}{L} - 1\right)\right]}{\ln\left(\frac{\quad}{L}\right)}$$

Given that the liquid and vapor leaving plate 'n' in a multistage distillation operation has flow rate of 0.1305kmol/s and 0.1035kmol/s with mvc component of 0.35 and 0.562 mole fractions respectively. The vapor entering the plate has mvc of 0.406 mole fraction. If the slope of the equilibrium curve of the mixture is 1.35, determine the overall column efficiency for the operation.

Hint: E_o = Overall efficiency, E_{mv} = Murphree efficiency, L = liquid flow rate, V = vapor flow rate, m = slope **10 marks**

Question 4

a. Given that 35 mole percent aqueous methanol at 35°C and 1 atmospheric pressure exit as ideal solution.
   i. Determine its equilibrium partial pressure if the vapor pressure of methanol at 35°C is 200mmHg.
   ii. Hence or otherwise, determine its vapor composition at the operating condition **4 marks**

b. Using schematic T-xy diagram only, distinguish clearly between
   i. Maximum and minimum boiling azeotropes
   ii. Bubble point and dew point curves
   iii. Saturated liquid phase and saturated vapor phases **6 marks**

c. Determine the vapor phase composition of a mixture in equilibrium with a liquid mixture of 0.4 mole fraction of toluene at 338K. Will the liquid vaporize at a pressure of 101.3 kN/m²?

Given Antoine equation constants

Benzene	**Toluene**
K_1= 6.90565	K_1 = 6.95334
K_2 = 1211.033	K_2 = 1343.943
K_3 = 220.79	K_3 = 219.377

10 marks

Question 5

a. Briefly state the functions of API **5 marks**

b. Let us consider two water columns at different temperatures, one being at 40°C and the other at 20°C. As both the water columns are separated by a glass wall of area 1m by 2m and a thickness of 0.003m. Calculate the amount of heat transfer. (Thermal conductivity of glass is 1.4W/mK) **5 marks**

c. A liquid mixture of benzene-toluene distillated in a fractionating tower with a pressure of 101.32 kPa, the feed is 100 kmol/hr. Liquid contains 35% benzene

enters at 327.6K. A distillate contains 95% moles benzene and the bottom contains 10% moles benzene. Reflux ratio is 5:1. The average heat capacity of the feed is 159 kJ/kmolK and average latent heat is 32099 kJ/kmol. The equilibrium data for this system is given in terms of temperature and vapor pressure as below. Calculate the distillate and bottom in kmol/hr and the number of theoretical plates. What is the actual number of trays if overall efficiency (η_o) is 75%? **10 marks**

T (K)	P_B^0 (kPa)	P_T^0 (kPa)	X_B	Y_B
353.3	101.32	-	1.0	1.0
358.2	116.90	46	0.780	0.900
363.2	135.50	54	0.581	0.777
368.2	155.76	63.3	0.441	0.632
373.2	179.26	74.3	0.258	0.456
378.2	224.26	86.0	0.111	0.246
383.8	224.06	101.32	0.000	0.000