UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	MASS AND ENERGY BALANCES
COURSE CODE	:	BNQ 20903
PROGRAMME CODE	:	BNN
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1.ANSWER **ALL** QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) Based on the situation listed below, examine the situation and propose a possible solution for each of the problem.

(i) A group of year 2 student conducted an experiment to separate ethanol and water using lab scale distillation column. After 10 minutes, one of the group members take out the distillate sample and analyze the content. He found that the ethanol content is very low and does not meet the product requirement.

(3 marks)

(ii) Luqman wants to commercialize his fruit yogurt drink product and he needs to do some research before putting it in the market. After his yogurt drink undergo pasteurization process, he found that his product is too diluted.

(3 marks)

(iii) In lab scale solid-liquid extractor, 1kg of peanut oil was extracted using water as a solvent. However, there is no traces of peanut oil in the water after 2 hours.

(3 marks)

(iv) An engineer needs to design a chemical process plant. He needs to optimize and control the inlet and outlet parameters for each of the equipment. When he reaches a dryer for catalyst drying, wet air and catalyst are among the inlet feed. He needs to do something in order to save the cost and control the humidity of the air.

(3 marks)

(v) In an absorber, carbon dioxide needs to be separated from air using water as the solvent. The output samples were analyzed for every 5 minutes. The content of carbon dioxide in water keeps increasing until the time reach 2 hours. After 2 hours, the carbon dioxide content in water becomes constant even though the carbon dioxide in the feed was still high.

(3 marks)

(b) Mei Lee needs to conduct a mini project in order to pass her subject. She proposes an interesting idea where she wants to treat wastewater discharged from the university café and she wants to use the treated wastewater as a coolant for the centralize air conditioning system. Plan the activities that need to be conducted for her mini project and come out with the explanation on how to complete her project.

(10 marks)

Q2 Streptomycin is recovered by contacting the fermentation broth with ethanol in an extraction process. The extraction process is able to recover the Streptomycin because Streptomycin has a greater affinity for dissolving in ethanol than in the aqueous solution. The inlet of 1000 mol/min fermentation broth aqueous solution contain 30 mol% of streptomycin and only 40% of the streptomycin manage to be recovered. The inlet flow rate of ethanol is 60 L/min. The outlet of aqueous solution is analyzed and found to contain 10 mol% of streptomycin. Assume that no water exits with the solvent and no solvent exits with the aqueous solution. The density and molecular weight of ethanol are 789 kg/m^3 and 46.07 kg/kmol respectively.

(a) Sketch and label in detail the process, including the unknown and equipment involved for the above statement.

(6 marks)

(b) Calculate all unknown stream variables in (mol/min).

(17 marks)

(c) The mol fraction of streptomycin recovered is monitored and found to have the value calculated in part **Q2(b)** for the first 2 hours of operation, and after that it begins to decrease. Predict the most likely causes of the decrease.

(2 marks)

Q3 At low to moderate pressures, the equilibrium state of the water–gas shift reaction performs as below:

$$CO + H_2O \Leftrightarrow CO_2 + H_2$$

is approximately described by the relation:

$$\frac{y_{CO2}\,y_{H2}}{y_{CO}\,y_{H2O}} = K_e(T) = 0.0247\exp\left[\frac{4020}{T(K)}\right]$$

where T is the reactor temperature, K_e is the reaction equilibrium constant, and y is the mol fraction of species in the reactor contents at equilibrium. Assume a basis of 1 mol feed to a batch shift reactor, it contains 20 mol% CO, 10 mol% CO_2, 40 mol% water, and the balance an inert gas. The reactor is maintained at T= 1123 K.

(a) Draw and label in detail a flowchart for the process mentioned above.

(5 marks)

(b) Determine the extent of reaction and the equilibrium composition of the reactor output stream.

(10 marks)

(c) Determine the limiting reactant, excess reactant, fractional conversion of the limiting reactant and % of excess reactant.

(10 marks)

Q4 A stream of air flowing at a rate of 10 kg/h at STP (1 mol = 22.4 m^3 (STP)/kmol) is mixed with a stream of methane gas to produce one mixture stream in the outlet. The methane enters the mixer at a rate of 20 m^3/hr at 150°C and 1.5 bar. (MW_{air} = 29 kg/kmol)

(a) Draw and label completely the diagram of the process.

(5 marks)

(b) Calculate the volumetric flow rate (m^3/hr) of the gas mixture in the outlet stream.

(10 marks)

(c) Calculate the molar composition of the mixture in the outlet stream.

(10 marks)

- END OF QUESTIONS –

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FACTORS FOR UNIT CONVERSIONS

Quantity	**Equivalent Values**
Mass	1 kg = 1000 g = 0.001 metric ton = 2.20462 lb_m = 35.27392 oz
	1 lb_m = 16 oz = 5×10^{-4} ton = 453.593 g = 0.453593 kg
Length	1 m = 100 cm = 1000 mm = 10^6 μm = 10^{10} Å
	1 m = 39.37 in = 3.2808 ft = 1.0936 yd = 0.0006214 mile
	1 ft = 12 in = 1/3 yd = 0.3048 m = 30.48 cm
Volume	1 m^3 = 1000 liters = 10^6 cm^3 = 10^6 ml
	1 m^3 = 35.3145 ft^3 = 220.83 imperial gallons = 264.17 gal = 1056.68 qt
	1 ft^3 = 1728 in^3 = 7.4805 gal = 0.028317 m^3 = 28.317 liters = 28317 cm^3
Force	1 N = 1 kg·m/s^2 = 10^5 dynes = 10^5 g·cm/s^2 = 0.22481 lb_f
	1 lb_f = 32.174 lb_m·ft/s^2 = 4.4482 N
Pressure	1 atm = 1.01325×10^5 N/m^2 (Pa) = 101.325 kPa = 1.01325 bars
	1 atm = 1.01325×10^6 dynes/cm^2
	1 atm = 760 mmHg at 0°C (torr) = 10.333 m H_2O at 4°C = 14.696 lb_f/in^2 (psi)
	1 atm = 33.9 ft H_20 at 4°C = 29.921 inHg at 0°C
Energy	1 J = 1 N·m = 10^7 ergs = 10^7 dyne·cm = 2.778×10^{-7} kW·h
	1 J = 0.23901 cal = 0.7376 ft-lb_f = 9.486×10^{-4} Btu
Power	1 W = 1 J/s = 1.341×10^{-3} hp