BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BTECH **SEMESTER : III**
BRANCH: BIOTECHNOLOGY **SESSION : MO/2024**

SUBJECT: BE206 CHEMICAL PROCESS CALCULATIONS

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	A liquefied mixture has the following composition: n-C_4H_{10} =50% (MW=58), n-C_5H_{12} =30% (MW=72), and n-C_6H_{14} =20% (MW=86). For this mixture, calculate: (a) mole fraction of each component. (b) Average molecular weight of the mixture. (Hint: Basis 100 kg)	[5]	CO1	Understanding
Q.1(b)	At 25°C, an aqueous solution containing 35% H_2SO_4 has a specific gravity of 1.2563. A quantity of 35% H_2SO_4 solution that contains 195.5 kg of H_2SO_4 is needed. i. Calculate the required volume of the solution in liters. ii. Estimate the percentage error that would have resulted if pure component specific gravities (SG for H_2SO_4 = 1.8255) were used instead of the specific gravity of the aqueous solution.	[5]	CO1	Applying
Q.2(a)	1000 kg/h of a mixture of benzene (B) and toluene (T) containing 50% benzene by mass is separated by distillation into two fractions. The mass flow rate of benzene in the top stream is 450 kg B/h and that of toluene in the bottom stream is 475 kg T/h. The operation is at steady state. Write balances on benzene and toluene to calculate the unknown component flow rates in the output streams.	[5]	CO2	Remembering
Q.2(b)	Soyabean seeds oil is extracted with hexane in a batch extractors. The flaked seeds contain 18.2% oil, 69.5% solid and 12.3% moisture. At the end of the process, cake is separated from hexane oil mixture. The cake analysis yields 0.8% oil, 88.2% solids and 11.0% moisture. Find the percentage recovery of oil. All percentage are by weight.	[5]	CO2	Creating
Q.3(a)	The chlorination of methane occurs by the following reaction: $CH_4+Cl_2 \rightarrow CH_3Cl+HCl$ You are asked to determine the product composition if the conversion of the limiting reactant is 67%, and the feed composition in mole % is given as: 40% CH_4, 50% Cl_2, and 10% N_2	[5]	CO2	Evaluating
Q.3(b)	In the Deacon process for the manufacture of chlorine, HCl and O_2 react to form Cl_2 and H_2O. Sufficient air (21 mole% O_2 , 79% N_2) is fed to provide 35% excess oxygen and the fractional conversion of HCl is 85%. Determine the amount of air required per mole of HCl fed into the process. Calculate the mole fractions of the product stream components using (i) molecular species balances (ii) atomic species balances (iii) extent of reaction	[5]	CO2	Evaluating
Q.4(a)	(i) Fifty grams of benzaldehyde vapour is condensed at 179 °C. What is the enthalpy of the liquid relative to the vapour? The standard heat of vaporisation is 38.40 kJ $gmol^{-1}$ (ii) Rich cows' milk (4536 kg/h) at 4.4°C is being heated in a heat exchanger to 54.4°C by hot water. How much heat is needed? The average heat capacity of rich cows' milk is 3.85 kJ/kg K	[5]	CO3	Analyzing

PTO

Q.4(b)	Liquid water at 25 °C enters an open heating tank at a rate of 10 kg h^{-1}. Liquid water leaves the tank at 88°C at a rate of 9 kgh^{-1}. 1 kgh^{-1} water vapour is lost from the system through evaporation. At steady state what is the rate of heat input to the system? h (Liquid water at 88 °C) =368.5 $kJkg^{-1}$ h (Saturated steam at 88 °C) =2656.9 $kJkg^{-1}$ h (Liquid water at 25 °C) =104.8 $kJkg^{-1}$	[5]	CO3	Evaluating
Q.5(a)	Fumaric acid ($C_4H_4O_4$) is produced from malic acid ($C_4H_6O_5$) using the enzyme fumarase. Calculate the standard heat of reaction for the following enzyme transformation: $C_4H_6O_5 \rightarrow C_4H_4O_4 + H_2O$ The standard heats of combustion of malic acid -1328.8 kJ $gmol^{-1}$ and fumaric acid -1334.0 kJ $gmol^{-1}$	[5]	CO3	Understanding
Q.5(b)	Reaction of Methane For the following reaction of I kg mol of CH4 at 101.32 kPa and 298 K, CH_4 (g) + H_2O(l) → CO(g) + 3H_2 (g) calculate the standard heat of reaction at 298 K in kJ.	[5]	CO4	Evaluating

Components	Heat of formation (kJ/kg mol)
CH_4(g)	-74.848×10^3
H_2O(l)	-285.840×10^3
CO(g)	-110.523×10^3
H_2 (g)	0

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