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

CLASS: B.TECH **SEMESTER : III**
BRANCH: BIOTECHNOLOGY **SESSION : MO/2022**

SUBJECT: BE206 CHEMICAL PROCESS CALCULATIONS

TIME: 3:00 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.

Q.1(a) The analysis of the gas sample is given below (volume basis): Basis: 100 m^3 of gas sample. [5]
CH4 = 66%, CO2 = 30%, NH3 = 4%.
Calculate: (i) The average molecular weight of the gas
(ii) The density of the gas at 2 atm and 303 K.

Q.1(b) In the production of a drug having a molecular weight of 192, the exit stream from the reactor flows at a rate of 10.5 L/min. The drug concentration is 41.2% (in water), and the specific gravity of the solution is 1.024. Calculate the concentration of the drug (in kg/L) in the exit stream, and the flow rate of the drug in kg mol/min. [5]

Q.2(a) A mixture containing 45% benzene (B) and 55% toluene (T) by mass is fed to a distillation column. An overhead stream of 95 wt% B is produced, and 8% of the benzene fed to the column leaves in the bottom stream. The feed rate is 2000 kg/h. Determine the overhead flow rate and the mass flow rates of benzene and toluene in the bottom stream [5]

Q.2(b) Solution-1 containing 30% sulfuric acid flowing at the rate 10 Kg/min combines with Solution-2 containing 20% sulfuric acid flowing at the rate 5 Kg/min, if their product is out at the rate 20 Kg/min what is the percentage of sulfuric acid in the product? [5]

Q.3(a) Two reactions take place in a continuous reactor operating at steady state, [5]
$C_2H_6 \rightarrow C_2H_4 + H_2$
$C_2H_6 + H_2 \rightarrow 2CH_4$
The feed stream contains 85.0 mole % ethane (C_2H_6) and 15 mole % inert (i.e. unreactive) components. The fractional conversion of ethane is 0.501, and the fractional yield of ethylene (C_2H_4) is 0.471. What is the molar composition of the product gas?

Q.3(b) In the Deacon process for the manufacture of chlorine, HCl and O2 react to form Cl2 and H2O. Sufficient air (21 mole% O2 , 79% N2) 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]

Q.4(a) To sterilize a fermenter, two streams of water are fed. Feed 1 is 120 kg/min at 30° C and Feed 2 is 175 g/min at 65° C. The pressure inside the fermenter is 17 bar (absolute) and 295 kg of water vapour leaving as saturated steam. The exiting steam leaves the fermenter through a 10-cm ID pipe. Calculate the required heat input to the fermenter in kJ/min if the steam leaving is saturated at the fermenter pressure. Neglect kinetic energies of the liquid inlet streams. Given Data: Specific enthalphy for H20 (l) at 30 ° C = 125.7 kJ/kg Specific enthalphy for H20 (l) at 65 ° C = 271.9 kJ/kg Specific enthalphy for saturated vapour H20 (v) at 17 bar = 2793.4 kJ/kg at 204° C [5]

Q.4(b) Calculate the heat required (in kJ, up to 1 digit after the decimal point) to raise the temperature of 1mole of a solid material from 100 °C to 1000 °C. The specific heat (Cp) of the material (in J/mol-K) is expressed as Cp= 20 + 0.005T, where T is in K. Assume no phase change.__________ [5]

PTO

Q.5(a) Calculate the standard heat of reaction of the following reaction. [5]

$CH_3OH(l) + O_2(g) \rightarrow HCHO(g) + H_2O(l)$

Data:

Component ΔH °f (kcal/mol)

CH_3OH	-57.13
HCHO	-25.94
H_2O	-68.27

Q.5(b) Calculate the enthalpy change between the reactants and products at standard condition if 50 mole of CO_2 is produced according to the following reaction. [5]

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$

Component ΔH °f (kcal/mol)

$C_4H_{10}(g)$	-30.04
$CO_2(g)$	-93.98
$H_2O(l)$	-68.27
$O_2(g)$	0.0

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