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

CLASS: BTECH **SEMESTER : III**
BRANCH: BIOTECHNOLOGY **SESSION : MO/19**

SUBJECT: BE206 CHEMICAL PROCESS CALCULATIONS

TIME: 3.00Hrs. **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) By electrolysing a mixed brine, a gaseous mixture is obtained at the cathode having the following composition by weight: Cl_2 = 67%, Br_2 = 28%, O_2 = 5% Calculate: (i) Composition of the gas by volume (ii) Average molecular weight (iii) Density of gas mixture at 298 K and 1 atm. [5]

Q.1(b) Glucose reacts with oxygen to produce carbon dioxide and water: [5]
$C_6H_{12}O_6$ (S) + $6O_2$(g) → $6CO_2$(g) + $6H_20$(l)
Just before a process calculation exam, suppose a friend reminds you that glucose is the major fuel used by the human brain. You therefore decide to eat a candy bar to make sure that your brain does not run out of energy during the exam (even though there is no direct evidence that consumption of candy bars improves performance on process calculation exams). If a typical 2 oz candy bar contains the equivalent of 45.3 g of glucose and the glucose is completely converted to carbon dioxide during the exam, how many grams of carbon dioxide will you produce and exhale into the exam room?

Q.2(a) A distillation column separates 20% C_6H_6, 50 % Toluene, 30 % Xylene into 95 % C_6H_6, 4% Toluene and 1% Xylene and waste product containing 2 % C_6H_6. Calculate the quantities of distillate and residue if 1000 kgmol/h of feed is fed. [5]

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]

Q.3(a) 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%. [5]
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

Q.3(b) The reaction between ethylene and hydrogen bromide to form ethyl bromide is carried out in a continuous reactor. [5]
C_2H_4 + HBr → C_2H_5Br
The product stream is analyzed and found to contain 51.7 mole% C_2H_5Br and 17.3% HBr. The feed to the reactor contains only ethylene and hydrogen bromide.
Calculate the fractional conversion of the limiting reactant and the percentage by which the other reactant is in excess. If the molar flow rate of the feed stream is 165 mol/s, what is the extent of reaction?

Q.4(a) Since blood is refrigerated for storage, it is warmed before contact with a patient to prevent hypothermia. Calculate the rate of heat required to continuously warm 10 L/min of blood from 30 ° C to 37 ° C using an electric heater. A stirrer adds work to the system at a rate of 0.50 kW. Assume the heat capacity of blood is constant at 4.185 J/g. ° C and the density of blood is 1 g/mL. Working volume of the tank is 1 L. [5]

Q.4(b) 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 6-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. [5]
Given Data: Specific enthalphy for H_20 (l) at 30 ° C = 125.7 kJ/kg
Specific enthalphy for H_20 (l) at 65 ° C = 271.9 kJ/kg
Specific enthalphy for saturated vapour H_20 (v) at 17 bar = 2793.4 kJ/kg at 204° C

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Q.5(a) (i) Write about relative Humidity? [5]

(ii) Toluene is to be heated from 290 K to 350 K at the rate of 250 g/s. Calculate the heat to be supplied to toluene using the heat capacity data given below. $C = a+bT+cT^2+dT^3$, kJ/ (kmol K)

Component	a	b	c	d
Toluene	1.80836	812.223×10^{-3}	1512.67×10^{-6}	1630.01×10^{-9}

Q.5(b) Calculate the heat of formation of liquid 1-3 butadiene at 298.15 K using the following data. [5]

Standard heat of formation of CO_2 = -393.51 kJ/mol

Standard heat of formation of H_2O = -285.83 kJ/mol

Heat of combustion of C_4H_6 (l) at 298 K = -2520.11 kJ/mol

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