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

CLASS: BE **SEMESTER : III**
BRANCH: BIO-TECH **SESSION : MO/18**

SUBJECT: BT3029-CHEMICAL ENGINEERING I

TIME: 03:00 HRS. **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
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) How many grams of NaCl are required to make 1000mL of a 2.0M solution? [2]

(b) A liquid mixture of O_2, CH_4 and CO has the composition 32% O_2, 16% CH_4 and 52% CO, then what is the mole fraction of CH_4? [4]

(c) A solution of common salt in water is prepared by adding 20 kg of salt to 100 kg of water, to make a liquid of density 1323 kg/m^3. Calculate the concentration of salt in this solution as a (a) weight fraction, (b) weight/volume fraction, (c) mole fraction, (d) molal concentration [6]

Q.2(a) Write about conversion and yield. [2]

(b) Solution-1 containing 10% nitric acid flowing at the rate 10 Kg/min combines with Solution-2 containing 40% nitric acid flowing at the rate 5 Kg/min, if their product contains 30% nitric acid, what is the flow rate of product? [4]

(c) In the concentration of orange juice, a fresh extracted and strained juice containing 7.08 wt % solids is fed to a vacuum evaporator. In the evaporator, water is removed and the solids content increased to 58 wt % solids. For 1000 kg/h entering, calculate the amounts of the outlet streams of concentrated juice and water. [6]

Q.3(a) Write about recycle and purge. [2]

(b) Methanol can be converted into ethylene (C_2H_4) or propylene (C_3H_6) by the reactions: [4]
$2\ CH_3OH \rightarrow C_2H_4 + 2H_2O$ desired product (economical)
$3\ CH_3OH \rightarrow C_3H_6 + 3H_2O$ by-product
What is the selectivity of C_2H_4 relative to the C_3H_6 at 80% conversion of the CH_3OH?

(c) The oxidation of ethylene to produce ethylene oxide proceeds according to the equation [6]
$2\ C_2H_4 + O_2 \rightarrow 2\ C_2H_4O$
The feed to a reactor contains 100 kmol C_2H_4 and 100 kmol O_2 .
i) Which reactant is limiting? ii) What is the percentage excess of the other reactant? iii) If the reaction proceeds to completion, how much of the excess reactant will be left; how much C_2H_4O will be formed; and what is the extent of reaction? iv) If the reaction proceeds to a point where the fractional conversion of the limiting reactant is 50%, how much of each reactant and product is present at the end, and what is the extent of reaction? v) If the reaction proceeds to a point where 60 kmol of O_2 is left, what is the fractional conversion of C_2H_4, the fractional conversion of O_2 & the extent of reaction?

Q.4(a) Define Compressibility factor (Z). [2]

(b) A 1000-liter tank is filled to a pressure of 10 atm at 298 K requires 11.5 kg of gas. How many moles of gas are required? What is the molecular weight of the gas? As the gas to be pure element, can you identify it? [4]

(c) Compare the pressure given by Ideal gas law and Vander Waals equation for 1 mole of CO_2 occupying a volume of $381 \times 10^5\ m^3$ at 40°C. Given a = $0.3646 m^6\ N/m^2 mole^2$ and b = $4.28 \times 10^{-5} m^3/mole$. [6]

Q.5(a) Define: Relative Humidity and Percentage Humidity. [2]

(b) A binary liquid mixture of benzene and toluene contains 20 mol% of benzene. At 350 K the vapour pressures of pure benzene and pure toluene are 92 kPa and 35 kPa, respectively. The mixture follows Raoult's law. Calculate the equilibrium vapour phase mole fraction (rounded off to the second decimal place) of benzene in contact with this liquid mixture at 350 K. [4]

(c) An equimolar liquid mixture of species 1 and 2 is in equilibrium with its vapour ar 400K. At this temperature the vapour pressures of the species are P_1 = 180 kPa and P_2 = 120 kPa. Assuming Raoults law is valid the value of y_1 is? [6]

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Q.6(a) Write about latent heat of vaporization, latent heat of fusion and latent heat of sublimation? [2]

(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 1000^0C. The specific heat (Cp) of the material (in J/mol-K) is expressed as Cp= 20 + 0.005T, where T is in ^{0}C. Assume no phase change. [4]

(c) Liquid water at 25 °C enters an open heating tank at a rate of 20 kg h^{-1}. Liquid water leaves the tank at 88°C at a rate of 18 kgh^{-1}. 2 kgh^{-1} water vapour is lost from the system through evaporation. At steady state what is the rate of heat input to the system? [6]

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 $kJkg^{-1}$

Q.7(a) Write about integral heat of solution or integral heat of mixing. [2]

(b) Fumaric acid is produced from malic acid using enzyme fumarase. Calculate the standard heat of reaction for the reaction. The standard heat of combustion for malic acid and fumaric acids are -1328.8 kJ $gmol^{-1}$ and -1334.0 kJ $gmol^{-1}$. [4]

(c) Citric acid is manufactured using submerged culture of *Aspergillus niger* in a batch reactor operated at 30 °C. Over a period of two days, 2500 kg glucose and 860 kg oxygen are consumed to produce 1500 kg citric acid, 500 kg biomass and other products. Ammonia is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15 Kw; Approximately 100 kg water is evaporated over the culture period. Estimate the cooling requirements. [6]

Heat of reaction at 30°C is -460 $kJgmol^{-1}$ oxygen consumed and Latent heat of vaporization of water at 30°C is 2430.7 $kJkg^{-1}$.

********30.11.18******E**