

JK LAKSHMIPAT UNIVERSITY, JAIPUR
INSTITUTE OF ENGINEERING AND TECHNOLOGY
 End Term Examination (Regular/Backlog), November 2016
 B. Tech/ M. Tech (*as applicable*) in Chemical Engineering, Semester Third

Roll No.....

COURSE CODE: CHE301

Time: 3 hours

Max. Marks: 100

COURSE TITLE: Chemical Process Calculations

Instructions to students:

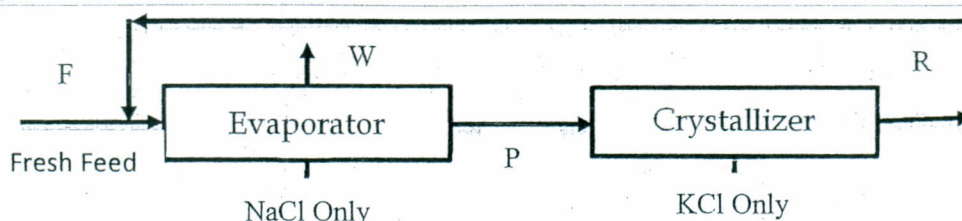
1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A	Objective type multiple choice questions (10 questions @ 1 mark)	10
i.	The specific weight of a substance has the units (a) N/m^3 (b) kg/m^3 (c) N/m^2 (d) kg/m^2	
ii.	Kinematic viscosity has the following dimensions (a) $\text{M}^{-1} \text{L}^{-1} \text{T}^{-1}$ (b) $\text{L}^2 \text{T}^{-1}$ (c) $\text{L}^{-2} \text{T}$ (d) MLT^{-2}	
iii.	Select the quantity in the following that is a dimensionless parameter (a) Specific gravity (b) Specific weight (c) Angular velocity (d) Specific volume	
iv.	A balanced chemical equation is in accordance with (a) Law of gaseous volumes (b) Law of Avogadro (c) Law of constant proportions (d) Law of conservation of mass	
v.	The symbolic representation of the molecules of a compound is called (a) Structural formula (b) Molecular formula (c) Empirical formula (d) Graphic formula	
vi.	A chemical reaction occurs when the energy of the reacting molecules is (a) Less than the activation energy of the reaction (b) Equal to the activation energy of the reaction (c) More than the activation energy of the reaction (d) Equal to or more than the activation energy of the reaction	
vii.	A reaction which proceeds with absorption of heat is termed as (a) Exothermic reaction (b) Endothermic reaction (c) Thermo-chemical reaction (d) Photochemical reaction	
viii.	A photochemical reaction is (a) Catalyzed by light (b) Used to convert heat energy into light (c) Initiated by light (d) Accompanied with emission of light	
ix.	The excess energy of the reactants required to dissociates into products is known as (a) Activation energy (b) Binding energy (c) Threshold energy (d) Thermal energy	
x.	Combustion reaction is (a) An endothermic reaction (b) An exothermic reaction (c) An autocatalytic reaction (d) A photochemical reaction	

Q.2	Short answer type questions (4 questions @ 2.5 marks)	(10)										
A.	Explain the standard heat of reaction with suitable example and correlation.											
B.	Define the calorific value of fuels and how to calculate the unknown properties of the fuel.											
C.	A gas mixture has the following composition by volume: sulphur dioxide 8.5%, oxygen 10 % and nitrogen 81.5%. Find (i) Density of gas mixture at a temperature of 473 K and 202.65 kPa and (ii) Composition by weight.											
D.	Calculate the standard heat of reaction ΔH_R^{298} for the reaction $2FeS_2 + 11/2 O_2 \rightarrow Fe_2O_3 + 4SO_2$ The standard heat of formation of the compound are											
<table><tr><td>Components</td><td>FeS_2</td><td>O_2</td><td>Fe_2O_3</td><td>SO_2</td></tr><tr><td>ΔH_R^{298} (kJ/mol)</td><td>-178.03</td><td>0</td><td>-822.75</td><td>-297.11</td></tr></table>			Components	FeS_2	O_2	Fe_2O_3	SO_2	ΔH_R^{298} (kJ/mol)	-178.03	0	-822.75	-297.11
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ΔH_R^{298} (kJ/mol)	-178.03	0	-822.75	-297.11								

Q.3A	Derive the correlation for Molal heat capacity at constant pressure and heat capacity at constant volume.	05
Q.3B	500 kgmol/h of 40% of solution of Ethylene dichloride in Toluene is fed to middle of the distillation column. The distillate column 95% mole% Ethylene dichloride and the bottoms consists of 90 mole% Toluene. What is the rate of flow of each stream?	05
Q.4A	Define the principle of stoichiometry, and also explain the stoichiometric coefficient, ratio and proportion with suitable example.	05
Q.4B	In manufacture of hydrochloric acid, gas containing 20% HCl and 80% air by volume enters an absorption tower at a temperature of 323 K and pressure of 99.325kPa. 98 % of HCl is absorbed in water and remaining gas leaves the tower at a temperature of 293K and pressure of 97.992 kPa. Calculate (i) the weight of HCl absorbed/ removed per m ³ of gas entering the system and (ii) the volume of gas leaving per m ³ of gas entering the system	05
Q.5A	Explain the limiting reactant and excess reactant with suitable example and correlation.	05
Q.5B	A gas containing 96 % ethylene and 4% butanes by volume is passed through a bed of an activated carbon where 98% of the original butanes are adsorbed and none of the ethylene. In five hours of continuous operation if quantities of butanes removed are 0.5 kmol, find (i) mole percent ethylene in gas leaving carbon bed and (ii) molar flow rate of the feed gas to the carbon bed.	05
Q.6A	Ethylene oxide is manufactured by the oxidation of ethylene. 120 kgmol of ethylene and 120 kgmol of oxygen are fed to the reactor. The conversion of ethylene is 75% and the percentage yield of C_2H_4O is 95. Calculate the composition of the product stream leaving the reactor. The reaction taking place in the reactor are: $C_2H_4 + 1/2 O_2 \rightarrow C_2H_4O$, $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$	05

Q.6B	A mixed acid containing 65% sulphuric acid, 20% HNO_3 and 15% water is to be made by blending the following liquids: (i) A spend acid containing 10% HNO_3, 60% H_2SO_4 and 30% H_2O. (ii) A concentrated HNO_3 containing 90% HNO_3 and 10% H_2O. (iii) 20% Oleum (80% H_2SO_4 and 20% SO_3). How many kg of the acid must be used to obtain 1000 kg of the mixed acid?	05
	OR	
Q.6B	Absorption system utilized for absorption of solute gas A. The flow rate of solute gas is 1000 m^3/h at temperature of 303K and pressure 101.325 kPa with 15 volume% of solute A, the molecular weight of solute gas is 64. The lean gas containing 1 volume% of solute A, the recovery of solute is 1 weight% of A and the solvent containing 0.01 weight% of solute A. calculate the mass flow rate of the solvent to the absorption tower.	05
Q.7A	The fresh feed to the process is 10,000 lb/hr of a 40% aqueous sodium hydroxide solution. The fresh feed is combined with the recycled filtrate from the crystallizer, and fed to the evaporator where water is removed to produce a 50% NaOH solution, which in turn is fed to the crystallizer. The crystallizer produces a filter cake that is 95% NaOH crystals and 5% solution that itself consists of 45% NaOH. The filtrate contains 45% NaOH. Calculate: (i) The flow rate of water removed by the evaporator, and the recycle rate for this process. (ii) Assume that the same production rate of NaOH flakes occurs, but the filtrate is not recycled. What would be the total feed rate of 40% NaOH have to be then? Assume that the product solution from the evaporator still contains 50% NaOH.	05
Q.7B	Sulphur trioxide is manufactured by the reaction of SO_2 and O_2. 130 kgmol of SO_2 and 130 kgmol of O_2 are fed to the reactor. If the percentage conversion of SO_2 is 60, calculate the composition of the product stream on mole basis.	05
	OR	
Q.7B	An aqueous solution of pyridine containing 27% pyridine and well in batch extractor and the mixture is the allowed to stand for phase separation. The extract phase contains 11% pyridine, 88% chlorobenzene and 1% water by weight. The raffinate phase contains 6% pyridine and 94% water by weight. Calculate: (i) The quantities of two phases (ii) The weight ration of solvent to feed based on 100 kg of feed.	05
Q.8A	A solution containing 10% sodium chloride, 3% potassium chloride and water is fed to the process shown in figure at the rate of 18,400 kg/h. The compositions of the stream are as follows: evaporator product NaCl: 16.8%, KCl: 21.6% and water. Recycle product NaCl: 18.9% and water, calculate the flow rate in kg/h and compute the composition of feed to the evaporator.	10



- Q.9A Flue gas leaving the boiler stack at 700 K has the following composition on mole basis. Carbon dioxide 14%, Water 11%, Oxygen 3% and Nitrogen 72%. Calculate the heat lost in 50 kgmol of gas mixture above 350 K using heat capacity data given below: $C_p^o = a + bT + cT^2, kJ / kgmol \cdot K$

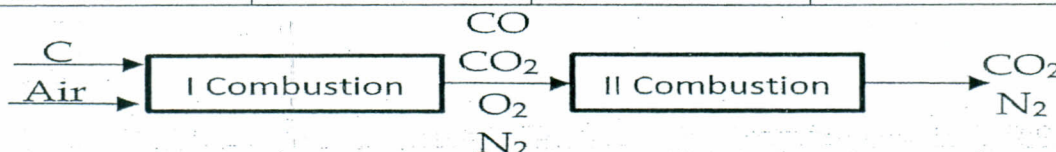
Component	a	$b \times 10^3$	$c \times 10^6$
CO ₂	21.35	64.27	-41.01
H ₂ O	32.49	0.08	13.21
O ₂	26.01	11.76	-2.35
N ₂	29.60	-5.15	13.19

- Q.9B The average molecular weight of a flue gas sample is calculated by two different engineers. One engineers uses the correct molecular weight of 28 for nitrogen and determines the average molecular weight to be 30.08, the other engineers uses an incorrect value of 14, and calculate the average molecular weight to be 18.74. Calculate: (i) Find the volume percentage of nitrogen in the flue gases. (ii) If the remaining components of the flue gases are carbon dioxide and oxygen; find the volume percentage of each of them.

OR

- Q.9B Calculate the calorific value of a blast furnace gas analyzing 22% Carbon Monoxide, 13.5% Carbon Dioxide and 63.57% Nitrogen.
(a) $C + O_2 = CO_2$; ΔH_{rxn} : -84kcal, (b) $C + 0.5 O_2 = CO$; ΔH_{rxn} : -36kcal
Also calculate the theoretical flame temperature for the combustion of this gas assuming theoretical amount of air is used, the combustion reaction is complete and reactants enter at 30 °C. $C_p^o = a + bT + cT^2, kJ / kgmol \cdot K$, where a, b and c are all dimensional constant and value are given below:

Component	a	$b \times 10^3$	$c \times 10^5$
CO ₂	10.55	2.16	-2.04
N ₂	6.66	1.02	-----



*****Good Luck*****