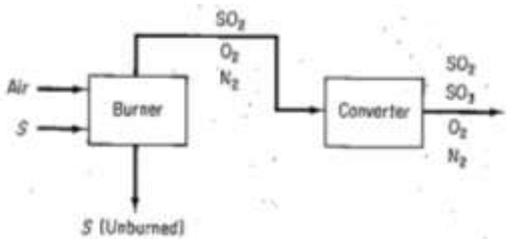
Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

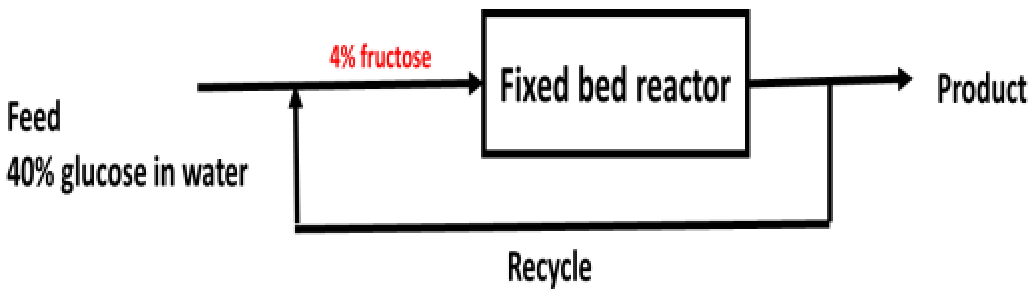
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2020

Program Name : B. Tech. (APE-Gas/ CERP) **Semester : III**
Course Name : Material and Energy Balance Computations **Time : 3 hours**
Course Code : CHCE 2013 **Max. Marks: 100**
Nos. of page(s) : 03
Instructions : Assume any missing data. Draw the diagrams, wherever necessary.

SECTION A
(6X10=60 marks)

S. No.		Marks	CO
1	A mixture of gas has the following composition by mass O_2- 16%, CO-4%, CO_2- 8% and rest N_2, **tabulate** the molar composition and average molecular weight?	**10**	**CO1**
2	Aluminum sulfate can be made by reacting crushed bauxite ore with sulfuric acid, according to the following equation $$Al_2O_3 + 3\,H_2SO_4 ----\rightarrow Al_2(SO_4)_3 + 3H_2O$$ The bauxite ore contains 55.4%by weight aluminum oxide, the reminder being impurities. The sulfuric acid solution contains 77.7% H_2SO_4, the rest being water. To produce crude aluminum sulfate containing 1798 lb of pure aluminum sulfate, 1080 lb of bauxite ore and 2510 lb of sulfuric acid solution are used. a) Identify the excess reactant b) What percent of excess reactant was consumed c) What was the degree of completion of the reactant?	**10**	**CO2**
3	The vapor pressure of Benzene is measured at two temperatures, with the following results $T_1 = 7.6\ ^{O}C$ $p_1^* = 40$ mm Hg $T_2 = 15.4\ ^{O}C$ $p_2^* = 60$ mm Hg **Determine** the latent heat of vaporization and the parameter B in Clausius-Clapeyron equation and then estimate p^* at **42.2** in ^{O}C using this equation. $$lnp^* = -\frac{\Delta Hv}{RT} + B$$ p^* = saturation vapor pressure ΔH_v = latent heat of vaporization B = constant T = absolute Temperature	**10**	**CO3**

	(Hint: Evaluate ΔH_v */ R using Clausius- Clapeyron equation first and then solve for B)*		
4	Moist air contains 0.0109 kg water vapor per cubic feet of the mixture at 300 K and 101.325 kPa. Calculate the following a) Partial pressure of water vapor b) The relative saturation c) Absolute humidity of the air d) The percentage saturation The vapor pressure of water is approximated by the following Antoine equation $$lnp^* = 16.26205 - \frac{3799.887}{T - 46.854}\ where\ T\ in\ K\ and\ p\ in\ kPa.$$	**10**	**CO4**
5	A simplified process for the production of SO_3 is to be used in the manufacture of sulfuric acid is as follows:  Sulfur is burned with 100% excess air (than required) in the burner where the conversion of sulfur to sulfur dioxide is only 90%. Assuming the excess oxygen present is utilized in the converter, and conversion of SO_2 to SO_3 is 95%, find kg of air required per 100 kg of sulfur burnt. Also find the exiting gas composition coming out of converter and burner.	**10**	**CO5**
6	The heat capacity of CO_2 gas is given as $C_p = 6.393 + 10.1x10^{-3}\ T – 3.405x10^{-6}\ T^2$ where C_p is in cal/g mol K and T in K. Estimate a) Mean heat capacity by arithmetic average b) Mean heat capacity by integral average. When the gas is heated from 500 to 1000 K.	**10**	**CO6**
SECTION B **(2 X 20=40 marks)**			
7	Immobilized glucose isomerase is used as a catalyst in producing fructose from glucose in a fixed bed reactor (water is the solvent) for the system shown in figure. What percent conversion of glucose results on one pass through the reactor when the exit stream/ recycle ratio in mole is 8.33? The reaction is $$C_6H_{12}O_6(Glucose) - -\!-\!\!\rightarrow C_6H_{12}O_6(fructose)$$	**20**	**CO5**



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The conversion of solid waste to innocuous gases can be accomplished in incinerators in an environmentally acceptable fashion, However the hot exhaust gases must be cooled or diluted with air. An economic feasibility study indicates that solid municipal waste can be burnt to a gas of the following composition (on a dry basis). 9.2% CO_2, 1.5% CO, 7.3% O_2 and the rest is N_2.

What is the enthalpy difference for this gas per lb mol between the bottom and top of the stack if the temperature at the bottom of the stack is 550 ^oF and the temperature at the top of the stack is 200 ^oF. Ignore the water vapor in the gas. Because these are ideal gases, you can neglect any energy effects resulting from the mixing of the gaseous components.

The heat capacity equation is $C_p = A + B\,T - C\,T^2 + D\,T^3$ where C_p is in Btu/lbmol ^0F and T in ^0F. The values of constants are as given in the table.

(HINT: Use integral method for finding average heat capacity)

Component	A	B	C	D
N_2	6.895	0.7624×10^{-3}	0.7009×10^{-7}	
O_2	7.104	0.7851×10^{-3}	0.5528×10^{-7}	
CO_2	8.448	5.757×10^{-3}	21.59×10^{-7}	3.059×10^{-10}
CO	6.865	0.8024×10^{-3}	0.7367×10^{-7}	

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CO6