Name:

Enrolment No:

UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2019

Programme Name: B. Tech. (APE-Gas/ CERP) **Semester** : III

Course Name : Material and Energy Balance Computations **Time** : 3 hrs

Course Code : CHCE 2013 **Max. Marks: 100**

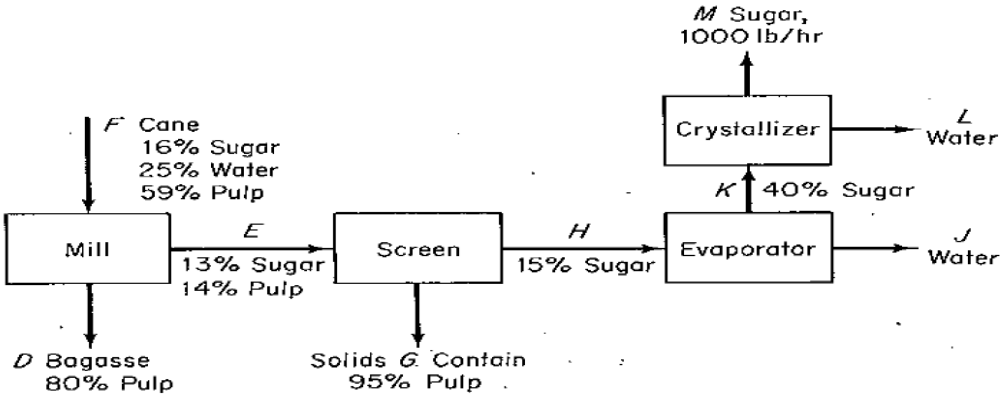
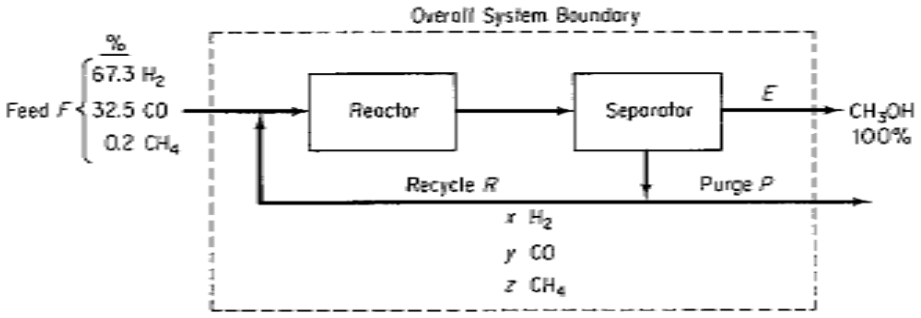
Nos. of page(s) : 04

Instructions : Assume any missing data. Draw the diagrams, wherever necessary.

SECTION-A (4× 5 = 20 marks)

		Marks	CO
1.	A hydrocarbon fuel is burnt with excess air. The Orsat analysis of flue gas shows **10.2% CO_2**, **1% CO**, **8.4% O_2** and **80.4% N_2**. **Review** the atomic ratio of **H** to **C** in the fuel.	5	CO1
2.	A liquefied mixture of butane, pentane and hexane has the compositions of **50, 30** and **20** respectively by volume. **Determine** mol%, weight %, and average molecular weight of the mixture.	5	CO1
3	A container holds **1.704 lb** of **HNO_3/ lb water** and has a specific gravity of **1.382** at **20^O C**. **Estimate** (1) weight % HNO_3 (2) **lb** of HNO_3 per cubic feet of solution at **20^O C** (3) molarity. Density of water at **20^O C** is **0.9982 g/cc**.	5	CO2
4.	A flask is evacuated and found to weigh **134.567 g.** It is filled to a pressure of **735 Torr**. at **31^O C** with a gas of unknown molar mass and then reweighed; **137.456 g**. The flask is then filled with water and weighed again; **1067.9 g**. **Predict** the molar mass of the unknown gas? (density of water at **31^O C** is **0.997 g/cm^3**)	5	CO3
	SECTION-B (4× 10 = 40 marks)		
5	A small cylindrical vessel contains **1** kg of humid air at **85^OF** under a total pressure of **101.4 kPa**. The humid air inside the vessel contains **0.150 kg** of water vapor. Vapor pressure of water at **85^O F** is **50 kPa**. **Solve** for 1) Partial pressure of vapor 2) Molal humidity 3) Absolute humidity 4) relative humidity of the air in the container 5) Percentage humidity	10	CO4
6	A tank holds **10000 kg** of saturated solution of **$NaHCO_3$** at **60^O C**. You want to crystallize **500 kg** of **$NaHCO_3$**. **Determine** the temperature of solution it must be cooled to.	10	CO5

Temp. ^{o}C	60	50	40	30	20	10
Solubility (g $NaHCO_3$/100 g of water)	16.4	14.45	12.7	11.1	9.6	8.15

7	In the process of making sugar, sugar cane is fed to the mills where juice is squeezed out and the resulting bagasse contains **80%** pulp. The juice containing pieces of pulp is fed to a screen where it removes all the pulp and produces clear juice containing **15%** sugar and **85%** water. Evaporator makes the syrup and crystallizer produces **1000 lb/hr** of crystals. **Measure**  1) The water removed in the evaporator J, lb/hr 2) Find the rate of feed of cane to the unit F, lb/hr 3) Of the sugar fed in the cane, what % is lost with the bagasse. 4) What is the kg of the sugar produced per kg of the cane fed? 5) Is this an efficient operation? Explain why or not. **OR** Considerable interest exist in the conversion of coal into more convenient liquid products for subsequent combustion. Two of the main products that can be generated under suitable conditions from in-situ of coal combustion of steam are H_2 and CO. After clean up these two gases combine to form methanol according to the following equation $CO + 2H_2 \text{ ----------} \rightarrow CH_3OH$ A purge stream is used to maintain the methanol concentration in the exit to the separator at no more than 3.2 mol%. The once through conversion of CO in the reactor is 18%.  **Evaluate** moles of recycle, methanol and purge per mole of feed and also compute the purge composition.	**10**	**CO5**
8	An inventor thinks that he has developed a new catalyst that can make the gas phase reaction	**10**	**CO6**

$$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$$

Proceeding with **100%** conversion, **depict** the heat must be provided or removed, if the gases enter and leave at a temperature of **500^{O} C**.

$C_p = a + b\,T + c\,T^2$ where T in K

Component	Standard Heat of formation (J/gmol) at 298K	A	b	C
CO_2	-393513	26.75	42.26×10^{-3}	-14.25×10^{-6}
H_2	0	26.88	4.35×10^{-3}	-0.33×10^{-6}
H_2O	-241826	29.16	14.49×10^{-3}	-2.02×10^{-6}
CH_4	-74828	13.41	77.03×10^{-3}	-18.74×10^{-6}

SECTION-C (2 × 20 = 40 marks)
(Answer both questions)

9

(a) Dry coke composed of **4%** inert solids (ash), **90%** carbon and **6%** hydrogen is burned in a furnace with dry air. The solid residue after combustion contains **10%** carbon and **90%** inert ash (and no hydrogen). The inert ash content does not enter into the reaction. The Orsat analysis of the flue gas gives **13.9% CO_2, 0.8% CO, 4.3% O_2** and **81% N_2**. **Workout** the percent excess air used based on the complete combustion of coke. **10**

(b) A fuel oil continuing **70%** carbon by weight and the rest combustible hydrogen and moisture is burned with excess air. The flue gas analyzed **9% CO_2, 2% CO, 3% O_2** and **86% Nitrogen**. **Measure** the following **10**

(1) Percentage of excess air

(2) The ratio of carbon to combustible hydrogen in the fuel on a weigh basis

(3) The ratio of carbon to total hydrogen in the fuel on a weight basis

(4) The percentages of combustible hydrogen and moisture in the fuel

(5) The mass of moisture % in the flue gas per kg of oil burned.

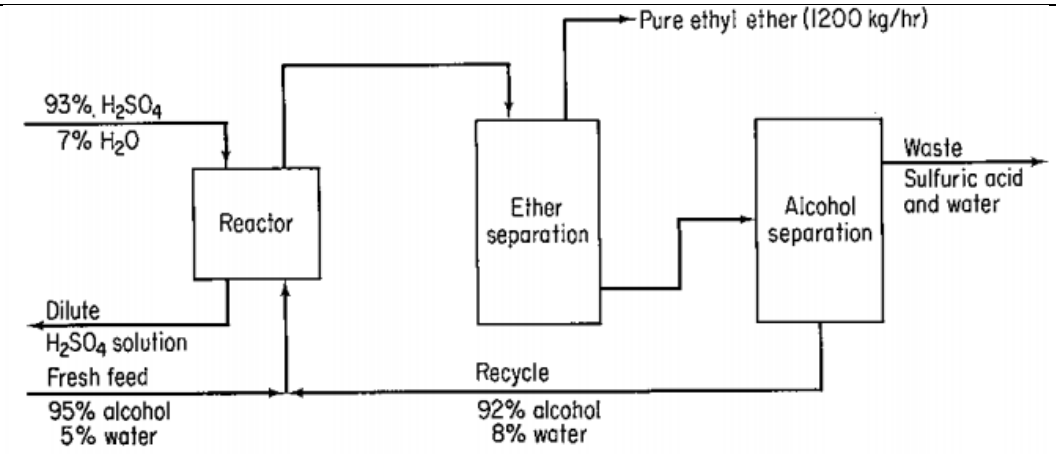
OR

Ethyl ether is made by the dehydration of ethyl alcohol in the presence of sulfuric acid at **140^{O} C.**

$$2C_2H_5OH \rightarrow C_2H_5OC_2H_5 + H_2O$$

A simplified process diagram is as follows.

CO5

	 If **87%** conversion of the alcohol fed to the reactor occurs per pass in the reactor**,** **summarize** kg per hour of fresh feed and kg per hour of recycle.		
10	Ammonium sulfate is dried from **4** to **0.2%** moisture in a counter current rotary drier. Hot air at **363K** containing **0.01 kg** of water per kg of dry air admitted at one end of the drier flows counter currently in contact with the solids and leaves at the other end at **305K**. The solid enters at **298K** and leaves at **333K**. The heat lost from the drier is estimated to be at the rate of **40,000 kJ/h**. The heat capacity of the dry air is **1.005 kJ/kg K**. The heat capacity of the water vapor is **1.884 kJ/kg K**. The heat capacity of the dry aluminum sulfate is **1.507 kJ/kg K**. The heat capacity of the water is **4.2 kJ/kg K**. The lateent heat of vaporization of water at **273K** is **2502.3 kJ/kg**. Estimate the air requirement for the drier for producing ammonum sulfate product at the rate of **1000 kg/h**.	**20**	**CO6**