Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Supplementary Examination, December 2023

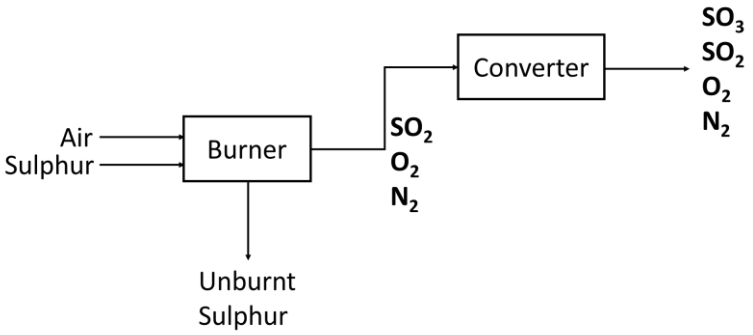
Programme Name: B. Tech. APE Gas **Semester : III**
Course Name : Material and Energy Balance Computations **Time : 3 hrs**
Course Code : CHCE 2025 **Max. Marks : 100**
Nos. of page(s) : 02
Instructions : Assume any missing data. Draw the diagrams, wherever necessary.

SECTION A
(5X4=20 marks)

S. No.		Marks	CO
1	A flue gas analyzes H_2=22 Cl_2 = 14 % CO = 51% and O_2 = 13% by volume. Find (i) Composition of the gas mixture by weight % (ii) Density of the gas mixture in lb/ft^3 at 180^{O}F & 760 mm Hg.	**4**	**CO1**
2	Carbon monoxide combines with chlorine in the presence of a suitable catalyst to give phosgene as CO + Cl_2 -----→ $COCl_2$. After reaction the product contains 12 moles of phosgene, 3 moles of chlorine when 8 moles of carbon monoxide is considered. **Identify** limiting reactant and calculate % excess reactant used.	**4**	**CO2**
3	The Orsat analysis of the flue gases from a boiler house chimney gives CO_2:11.4%, O_2:4.2% and N_2:84.4% (mole%). If complete combustion has taken place, (a) **Calculate** the % excess air, and (b) find the C:H ratio in the fuel.	**4**	**CO2**
4	In the process of production of PCl_5, 4.25 g of Cl_2 with 2.20 g of P_4 produces 4.28 g of PCl_5. According to the following reaction. **Detail** the following. P_4 + 10Cl_2 ---> 4PCl_5 (1)Limiting reactant (2) % excess reactant	**4**	**CO3**
5	The heat capacity of silicon carbide is given by Cp=37.221+1.22x10^{-2} T-1.189x10^5 T^{-2} where Cp is in KJ/kmol K and T is in K. **Estimate** the enthalpy change in silicon carbide in the range 0 to 1000 K.	**4**	**CO4**

SECTION B
(4 X 10=40 marks)

6	Power required in an agitator is a function of rotational speed (n), impeller diameter (d), fluid properties like density(ρ), viscosity (μ), and acceleration due to gravity (g). **Recognize** a relation between the dimensionless groups using dimensional analysis.	**10**	**CO1**
7	A producer gas made from coke has the following composition by volume. Item | CO | O_2 | CO_2 | N_2 Composition | 28 | 0.5 | 3.5 | 68 This gas is burned with 20% excess air. If the combustion is 98% complete, calculate the weight and composition of the stack gases formed per 100 lb of gas burned. **Express** the composition of stack gases in weight percent and mole percent.	**10**	**CO2**
8	The solubility of barium nitrate [$Ba(NO_3)_2$] in water at 373 and 273K are 34 g [$Ba(NO_3)_2$]/100 g water and 5 g [$Ba(NO_3)_2$]/100 g water, respectively. If the saturated solution at 373 K is cooled to 273 K, if 200 g of crystals precipitate out, **what** is the weight of the initial solution at 373K. Molar mass of barium = 137 g/mol.	**10**	**CO3**

9	Enthalpy of steam at 75 kPa and 573 K is 3075 KJ/kg referred to liquid water at 273K. If the mean heat capacity of liquid water and water vapor are 4.2 and 1.97 Kj/kg K respectively, **calculate** the heat of vaporization of water at 75 kPa. The saturation temperature of water at 75 kPa is 365K.	**10**	**CO4**
	SECTION C **(2 X 20=40 marks)**		
10	A simplified process for SO_2 to SO_3 is as shown in the figure below.  Sulfur is burned with 100% excess air in the burner though the conversion of SO_2 is only 90%. In the converter, the conversion from SO_2 to SO_3 is only 95%. ***Calculate*** the lbs of air needed to burn 100 lbs of Sulfur and the composition of exiting stream from the converter. **OR** In anaerobic digestion of grain, the yeast *saccharonnyces cerevisiae* digests glucose from plants to form products ethanol and propionic acid according to Reaction 1: $C_6H_{12}O_6$ --------→$2C_2H_5OH + CO_2$ Reaction 2: $C_6H_{12}O_6$ --------→$2C_2H_3CO_2H + 2H_2O$ In a batch process, 4000 Kg of a 12% glucose/water solution is charged, and after fermentation 120 Kg of carbon dioxide is produced leaving 90 kg of glucose unreacted. **Compute** the weight percent of ethyl alcohol and propionic acid remaining in the broth.	**20**	**CO3**
11	The heat capacity of benzene at two different temperatures is T (K) | 293 | 323 Cp (J/gmol K) | 131.05 | 138.04 Fit the data into an equation of the form Cp=a+bT. **Calcualte** the heat required to convert 100 kg of liquid benzene from 293.15 K to saturated vapor at the boiling point of 353.25 K. The latent heat of vaporization may be calculated using the Kistyakowsky equation $\frac{\Delta H}{T_b} = 36.63 + 8.31\, lnT_b$ where Tb is the boiling point of benzene and ΔH is the heat of vaporization.	**20**	**CO4**