U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester: III**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 19CH3DCPPC **Max Marks: 100**
Course: Process Principles and Calculations

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	Marks
1	a)	The heat transfer equation is given by $$h = \frac{16.6 C_p G^{0.8}}{D^{0.2}}$$ Convert the following and write the final expression. (i) Heat capacity (C_p), Btu/lb.°F to kcal/Kg.°C (ii) Diameter of pipe (D), inch to m (iii) Mass velocity (G), lb/ft^2.s to kg/m^2.s (iv) Heat transfer coefficient (h), Btu/hr.ft^2.°F to kcal/m^2.hr.°R	*1*	*1*	**10**
	b)	N_2O_4 decomposes to NO_2 at high temperatures. 20 g of N_2O_4 when heated to 373 K at 96 kPa, is found to occupy a volume of 0.0125 m^3. Assume ideal gas law, calculate the percentage dissolution of N_2O_4 to NO_2.	*1*	*1*	**10**
		OR			
2	a)	An orifice meter is used to measure the rate of flow of a fluid in pipes. The flowrate is related to the pressure drop by the following equation. $$u = c\sqrt{\frac{\Delta P}{\rho}}$$ Where u = fluid velocity, ΔP = pressure drop, ρ = density of the fluid and c = constant. What are the units of constant in the SI system.	*1*	*1*	**10**
	b)	A product gas from a reaction has the composition by weight. Cl_2 = 67%, Br_2 = 28%, O_2 = 5%, using the ideal gas law calculate the following.	*1*	*1*	**10**

			i) The composition of gas by volume ii) The density of the mixture in g/L at 25ºC iii) Specific gravity of the mixture iv) Average molecular weight of the mixture			
			UNIT - II			
	3	a)	With block diagram, write material balance equations for distillation and crystallization.	3	3	**10**
		b)	A gaseous mixture (F) consists of 16 mol% CS_2 and 84 mol% air is fed to the absorption column at a rate of 1000 lb-mol/hr. Most of the CS_2 input are absorbed by the liquid benzene (L) which is fed at the bottom of the column. 1% of benzene input are evaporated and out with the exit gas stream which consists of 96 mol% air, 2 mol% CS_2 and 2 mol% benzene. The product liquid stream (P) consists of benzene and CS_2. Calculate the mole flow rates of G, L and P and the compositions.	3	3	**10**
			OR			
	4	a)	The waste acid from a nitrating process contains 30% H_2SO_4, 35% HNO_3, and 35% H_2O by weight. The acid is to be concentrated to contain 39% H_2SO_4 and 42% HNO_3 by addition of concentrated H_2SO_4 containing 98% H_2SO_4 and concentrated nitric acid containing 72% HNO_3 (by weight). Calculate the quantities of three acids to be mixed to get 1000 kg of desired mixed acid.	3	3	**10**
		b)	With neat diagrams, write steady state material balance equations for evaporation and extraction.	2	2	**10**
			UNIT - III			
	5	a)	Explain the following terms. (i) Percentage conversion (ii) Percentage Yield (iii) Percentage excess (iv) Limiting and excess reactants (v) Selectivity	2	2	**10**
		b)	In production of SO_3, 50 kmol of SO_2 and 100 kmol of O_2 are fed to the reactor. The product stream is found to contain 40 kmol of SO_3. Determine the percentage conversion of SO_2.	4	3	**10**
			OR			
	6	a)	In kiln, calcium oxide is formed by decomposing pure limestone $CaCO_3$ and the reaction given below. If this conversion is having 70%. Calculate the following. (i) The composition of the solid product withdrawn from the kiln.	4	3	**08**

			(ii) What is the yield in kg of CO_2 produced per kg of limestone charged? $CaCO_3 \rightarrow CaO + CO_2$			
		b)	Sulphur trioxide gas is obtained by the combustion of pyrites (FeS_2) according to the following reaction. $4FeS_2 + 15O_2 \rightarrow 2Fe_2O_3 + 8SO_3$ The reaction is accompanied by the following side reaction. $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$ Assume that 80% (weight) of the pyrites charged reacts to give sulfur trioxide and 20% reacts giving sulfur dioxide. (i) How many kg of pyrites charged to give 100 kg SO_3? (ii) How many kg of oxygen will be consumed in the reaction?	*4*	*3*	**12**
			UNIT - IV			
	7	a)	Explain the following terms. (i) Theoretical oxygen (ii) Net oxygen content (iii) Gross calorific value of the fuel (iv) Net calorific value of fuel (v) Fixed carbon content	*5*	*3*	**10**
		b)	The gas obtained from the furnace fired with a hydrocarbon fuel analysis as CO_2 = 10.2%, O_2 = 7.9%, and N_2 = 81.9% by Orsat analysis. Calculate the percentage excess air.	*5*	*3*	**10**
			OR			
	8	a)	A coal containing C = 69.7%, H_2 = 3.5%, S = 1.3%, N_2 = 1.7%, O_2 = 7.7%, ash = 4.3%, and H_2O = 11.8% is burnt in the furnace. The combustion of dry gas has the following composition. CO_2 = 13.9%, O_2 = 4.5%, and N_2 = 81.6%. Calculate (i) The percentage of excess air. (ii) The theoretical volume of air per 100 kg of coal.	*5*	*3*	**10**
		b)	Explain the proximate and ultimate analysis of fuels.	*5*	*3*	**10**
			UNIT - V			
	9	a)	The heat capacity of CO_2 is given by the following relation. $C_p = 26.54 + 42.45 \times 10^{-3}T - 14.298 \times 10^{-6}T^2$ Where C_p is in kJ/(kmol.K) and T is in K Calculate the heat required to heat 1 kg of CO_2 from 300 K to 1000 K.	*6*	*3*	**10**
		b)	Calculate the heat of reaction (kJ) at 25ºC for the reaction . $Na_2CO_3 + Fe_2O_3 \rightarrow Na_2OFe_2O_3 + CO_2$	*6*	*3*	**10**

			Thermodynamic data:			

Component	ΔH_f (kcal/gmol)
Na_2CO_3	-269.8
Fe_2O_3	-195.2
$Na_2OFe_2O_3$	-337.3
CO_2	-24.05

			OR			
	10	a)	Explain adiabatic flame temperature and theoretical flame temperature. Write the step-by-step calculation procedure for adiabatic flame temperature.	6	3	**10**
		b)	Calculate the enthalpy change between reactants and products at standard condition if 50 mole of CO_2 is produced according to the following reaction.	6	3	**10**

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O$$

Data:

S. No.	Components	ΔH_f (kJ/mol)
1	$C_4H_{10}(g)$	-30.04
2	$O_2(g)$	0
3	$CO_2(g)$	-93.98
4	H_2O	-68.27

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