U.S.N.										

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

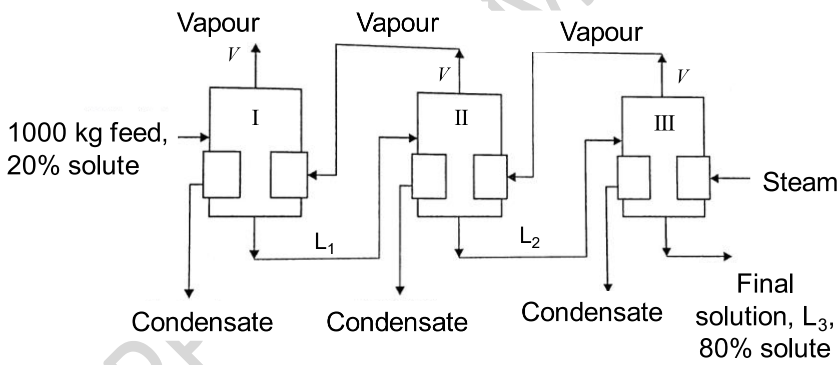
Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: III**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 23CH3PCPPC/22CH3PCPPC **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.

		UNIT - I	*CO*	*PO*	Marks
1	a)	A gas mixture has a composition of 25% carbon dioxide, 25% carbon monoxide, 10% oxygen, and 40% nitrogen, on a mole basis. Express the composition of the mixture on a weight basis.	*CO2*	*PO2*	**06**
	b)	Define normality, molarity, and molality with equations.	*CO1*	*PO1*	**06**
	c)	A stock solution concentration is 25 N. Calculate the volume of this solution to be added to prepare the following list of solutions. i. 500 mL of 0.2 N ii. 125 mL 1 N iii. 250 mL 5 N iv. 100 mL 20 N	*CO2*	*PO2*	**04**
	d)	What is the density of CO_2 gas at 350 K and 2 bar pressure?	*CO2*	*PO2*	**04**
		OR			
2	a)	Convert the following. i. 700 kg/m^3 to lb/ft^3 ii. 7 BTU to J iii. 70 °F to K iv. 7000 cP to Pa s v. 0.7 kg/L to ppm	*CO1*	*PO1*	**10**
	b)	Calculate the molality and molarity of a solution when 5 mL of 100% H_2SO_4 was added to a 100 mL-standard volumetric flask and then the volume is made up to 100 mL using distilled water. Given data: density of 100% H_2SO_4 is 1.20 g/cc.	*CO2*	*PO2*	**06**
	c)	The solubility of sodium chloride in water at 290 K is 35.8 kg/100 kg of water. Express the solubility as the mass fraction and mass percent of NaCl.	*CO2*	*PO2*	**04**
		UNIT - II			
3	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	*CO3*	*PO2*	**12**

			to contain 39 % H_2SO_4 and 42 % HNO_3 by addition of concentrated sulphuric acid 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.			
		b)	A binary mixture consists of 35 % benzene and 65 % toluene, which is continuously fed to the distillation column at a rate of 1000 kg/h. The distillate flow rate was 10% of the feed flow rate. The distillate (top product) contains 85 % benzene. Calculate quantity and compositions of the residue stream.	*CO3*	*PO2*	**08**
			OR			
	4	a)	2000 kg of wet solids containing 70% solids by weight are fed to a tray dryer, where it is dried by hot air. The product finally obtained is found to contain 1% moisture by weight. Calculate the following. i. Amount of water removed from the wet solids in kg. ii. Amount of product obtained after drying in kg. iii. Verify using the material balance for water in the feed.	*CO3*	*PO2*	**08**
		b)	A triple effect evaporator (as shown in the below Figure) is used to concentrate 1000 kg of aqueous solution from a concentration of 20% solute to 80% solute. Assuming an equal amount of vaporization in each effect, calculate the composition and weight of the solution entering the second and third effects. 	*CO3*	*PO2*	**12**
			UNIT - III			
	5	a)	Sulfur dioxide reacts with oxygen producing sulfur trioxide as given reaction $SO_2 + ½ O_2 \rightarrow SO_3$. To ensure a complete reaction, twice as much oxygen is supplied than that required theoretically. However, only 60% conversion is obtained. The pressure was 500 kPa and the temperature 800 K. 100 kg of SO_2 was charged to the converter. Determine the following: i. The volume of pure oxygen supplied at 1.5 bar and 300 K ii. The volume of sulfur trioxide produced iii. The volume of gases leaving the converter iv. The composition of gases leaving the converter in mol%	*CO4*	*PO2*	**12**
		b)	Explain the terms: excess reactant, conversion, yield, and selectivity.	*CO4*	*PO2*	**08**

<table>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>6</td><td>a)</td><td>The electrolytic manufacture of Cl_2 gas from a NaCl solution, the following reaction is carried out.
$$2NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$$
How many kg of Cl_2 can be produced from 100 m^3 of a brine solution containing 7% by weight of NaCl? The specific gravity of the solution relative to the water at 4°C is 1.07.</td><td>CO4</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td></td><td>b)</td><td>A limestone analysis is reported as $CaCO_3$ = 92.89%, $MgCO_3$ = 5.41%, and Insoluble = 1.70%, all percentage by weight.
i. How many kilograms of CaO can be made from 6 tonnes of this limestone?
ii. How many kilograms of CO_2 be recovered per kg of limestone?
iii. How many kilograms of limestone are needed to make 2 tonnes of lime?</td><td>CO4</td><td>PO2</td><td>12</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - IV</td><td></td><td></td><td></td></tr>
<tr><td></td><td>7</td><td>a)</td><td>A fuel gas consists of a mixture of CH_4 and N_2. This mixture is burnt with air. The flue gas analysis is CO_2 = 7.3%, O_2 = 6.9% and N_2 = 85.8%. Calculate the percentage of excess air and composition of fuel gas mixture.</td><td>CO5</td><td>PO3</td><td>12</td></tr>
<tr><td></td><td></td><td>b)</td><td>What are fuel and flue gases? Discuss the following.
i. Ultimate analysis
ii. Proximate analysis</td><td>CO5</td><td>PO3</td><td>08</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>8</td><td>a)</td><td>A combustion reactor is fed with 50 kmol/h of butane and 2500 kmol/h of air. Calculate the percentage of excess oxygen and the composition of gases leaving the combustion reactor. Assume complete combustion.</td><td>CO5</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>The analysis of the flue gases from a boiler house chimney by volume is given below. CO_2: 11.4%; O_2: 4.2%; and N_2: 84.4%
Assuming the complete combustion takes place,
i. Calculate the % excess air and
ii. Find the C:H weight ratio in the fuel</td><td>CO5</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - V</td><td></td><td></td><td></td></tr>
<tr><td></td><td>9</td><td>a)</td><td>Define and explain the following terms.
i. Heat of reaction
ii. Heat of formation
iii. Heat of combustion
iv. Heat of mixing</td><td>CO6</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Natural gas has the following composition on a mole basis. CH_4 = 83%, C_2H_6 = 15%, and N_2 = 2%. Calculate the heat to be added to heat 20 kmol of natural gas from 300 K to 520 K using the heat capacity data given below. $C_P^\circ = a + bT + CT^2$, kJ/kmol · K
<table><tr><td>Component</td><td>a</td><td>$b \times 10^{-3}$</td></tr><tr><td>CH_4 (g)</td><td>19.26</td><td>52.12</td></tr><tr><td>C_2H_6 (g)</td><td>5.41</td><td>178.09</td></tr><tr><td>N_2 (g)</td><td>29.60</td><td>–5.15</td></tr></table></td><td>CO6</td><td>PO2</td><td>10</td></tr>
</table>

			OR			
	10	a)	Calculate the heat of the reaction at 873 K and 101325 Pa for the following reaction. $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$ Given the heat of formation data:	*CO6*	*PO2*	**12**

Component	ΔH_f° (kJ/mol)
CO_2	–393.65
CH_4	–241.90
H_2O	–74.89

Given the specific heat data:

Component	C_P (J/mol K)
CO_2	$26.54 + 42.25\times10^{-3}T - 14.29\times10^{-6}\ T^2$
H_2	$26.89 + 4.35\times10^{-3}T - 0.3265\times10^{-6}\ T^2$
CH_4	$13.41 + 77.06\times10^{-3}T - 18.76\times10^{-6}\ T^2$
H_2O	$29.18 + 14.50\times10^{-3}T - 2.02\times10^{-6}\ T^2$

		b)	Explain the Hess's law of constant heat summation with an example.	*CO6*	*PO2*	**08**

******