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: Biotechnology **Duration: 3 hrs.**

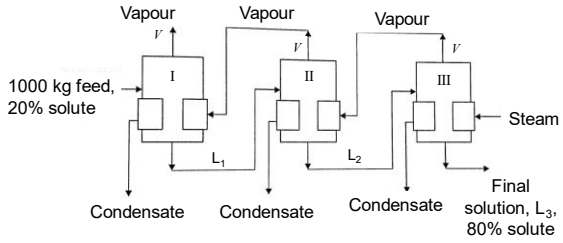
Course Code: 23BT3ESPPC / 22BT3PCPPC **Max Marks: 100**

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.
3. Use of psychrometric (humidity) chart and periodic table is allowed.

		UNIT - I	*CO*	*PO*	Marks
1	a)	A gas mixture has a composition of 50% methane, 20% nitrogen, 10% oxygen, 10% carbon dioxide, and 10% sulfur dioxide, on a weight basis. Express the composition of the mixture on a mole basis.	*CO1*	*PO 1*	**10**
	b)	A lab technician in the lab wants to prepare 500 mL of the following NaOH concentration solutions. i. 10 Normal ii. 10 Molar iii. 10 Molal iv. 10% by weight Assuming the solution density is equal to 1000 kg/m^3, calculate the quantity of NaOH to be added in grams to prepare the above solutions.	*CO1*	*PO1*	**10**
		OR			
2	a)	What is the relationship between pH and pKa? Explain.	*CO1*	*PO1*	**06**
	b)	Discuss with equations to determine the mole percentage from a given weight of two components A and B.	*CO1*	*PO1*	**04**
	c)	A sample of caustic soda flakes contains 74.6% Na_2O by weight. Determine the purity of flakes.	*CO1*	*PO1*	**04**
	d)	An aqueous solution of sodium chloride is prepared by dissolving 25 kg of sodium chloride in 100 kg of water. Determine i. weight % ii. mole % composition of solution	*CO1*	*PO1*	**06**

			UNIT - II			
	3	a)	By electrolyzing a mixed brine, a gaseous mixture is obtained at the cathode having the following composition by weight: Cl_2 = 67%, Br_2 = 28% and O_2 = 5%. Calculate the following. (i) Composition of gas by volume (ii) Average molecular weight and (iii) Density of gas mixture at 298 K and 101.325 kPa. Data: Atomic weights: Cl = 35.5, Br = 80 and O = 16	*CO1*	*PO1*	**10**
		b)	An air (B) – water vapor (A) sample has a dry bulb temperature 55°C and absolute humidity 0.030 $\frac{\text{kg of water vapour}}{\text{kg dry air}}$ at 1 standard atmospheric pressure. Tabulate its characteristics: a) Molal absolute humidity b) Partial pressure of water vapor c) Dewpoint d) Humid volume e) Enthalpy	*CO3*	*PO3*	**10**
			OR			
	4	a)	State and explain the Amagat's and Dalton's laws.	*CO1*	*PO1*	**05**
		b)	State and explain Henry's law and Raoult's law.	*CO1*	*PO1*	**05**
		c)	Natural gas is piped from the well at 300 K and 400 kPa. The gas is found to contain 93.0% methane, 4.5% ethane and the rest nitrogen. Calculate the following: i. The partial pressure of nitrogen ii. The pure-component volume of ethane in 10 m^3 of the gas iii. The density at standard conditions in kg/m^3	*CO1*	*PO1*	**10**
			UNIT - III			
	5	a)	A drier is fed with wet solid to reduce the moisture content from 80 % to 15 %. The product leaving the drier is admitted into an oven which further brings down the moisture to 2 %. If the drier can handle 1000 kg of wet solid per day, calculate (a) the weight of products leaving the drier and the oven per day (b) the percentage of the original water that is removed in the drier and the oven.	*CO2*	*PO2*	**10**
		b)	An aqueous solution of methanol containing 20% (weight) methanol is to be separated into a distillate product containing 97% (weight) methanol and a bottom product containing 2% (weight) methanol. For treating 100 kg of feed with a reflux ratio of 3.5 on a weight basis, calculate the following: (a) The amount of distillate and bottom products (b) The amount of vapor condensed in the condenser per kg of distillate (c) The amount of vapor condensed in the condenser per kg of feed.	*CO2*	*PO2*	**10**

			OR			
	6	a)	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.  	*CO2*	*PO2*	**10**
		b)	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 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.	*CO2*	*PO2*	**10**
			UNIT - IV			
	7	a)	A limestone analysis is reported as $CaCO_3$ = 92.89%, $MgCO_3$ = 5.41%, and Insoluble = 1.70%, all percentage by weight. (a) How many kilograms of CaO can be made from 6 tonnes of this limestone? (b) How many kilograms of CO_2 be recovered per kg of limestone? (c) How many kilograms of limestone are needed to make 2 tonnes of lime?	*CO2*	*PO2*	**12**
		b)	Explain the terms with examples: limiting reactant, conversion, yield, and selectivity.	*CO2*	*PO2*	**08**
			OR			
	8	a)	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. Reaction: $C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O$	*CO2*	*PO2*	**12**
		b)	What are fuel and flue gases? Discuss the following. i. Ultimate analysis ii. Proximate analysis	*CO2*	*PO2*	**08**

<table>
<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>Production of single cell proteins from hexadecane is given by the following equation. If the respiratory quotient (RQ) is 0.4, determine the stoichiometric coefficients.
$C_{16}H_{34} + aO_2 + bNH_3 \rightarrow cCH_{1.66}O_{0.27}N_{0.2}$ (biomass) + dCO_2 + eH_2O</td><td>CO4</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td></td><td>b)</td><td>Differentiate between the standard heat of formation and standard heat of combustion.</td><td>CO4</td><td>PO2</td><td>04</td></tr>
<tr><td></td><td></td><td>c)</td><td>Derive a relationship between temperature and heat of reaction for the following reaction.
aA + aB → lL + mM
Given, specific heat, $C_P = \alpha + \beta T + \gamma T^2$.</td><td>CO4</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>10</td><td>a)</td><td>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:
<table>
<tr><td>Component</td><td>ΔH_f° (kJ/mol)</td></tr>
<tr><td>CO_2</td><td>–393.65</td></tr>
<tr><td>CH_4</td><td>–241.90</td></tr>
<tr><td>H_2O</td><td>–74.89</td></tr>
</table>
Given the specific heat data:
<table>
<tr><td>Component</td><td>C_P (J/mol K)</td></tr>
<tr><td>CO_2</td><td>$26.54 + 42.25\times10^{-3}T - 14.29\times10^{-6}T^2$</td></tr>
<tr><td>H_2</td><td>$26.89 + 4.35\times10^{-3}T - 0.3265\times10^{-6}T^2$</td></tr>
<tr><td>CH_4</td><td>$13.41 + 77.06\times10^{-3}T - 18.76\times10^{-6}T^2$</td></tr>
<tr><td>H_2O</td><td>$29.18 + 14.50\times10^{-3}T - 2.02\times10^{-6}T^2$</td></tr>
</table></td><td>CO4</td><td>PO2</td><td>12</td></tr>
<tr><td></td><td></td><td>b)</td><td>Explain the terms: heat of formation, heat of reaction, heat of solution, and heat of mixing.</td><td>CO4</td><td>PO2</td><td>08</td></tr>
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