U.S.N.										

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

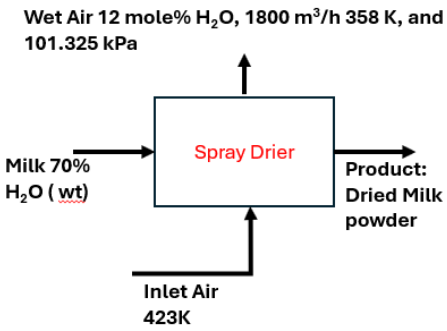
Autonomous Institute Affiliated to VTU

August 2024 Supplementary 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.

			UNIT - I	CO	PO	Marks
1	a)		Explain Amagat's law of additive volumes with its limitation.	CO1	PO1	04
	b)		98 grams of sulphuric acid (H_2SO_4) are dissolved in water to prepare one liter of solution. Calculate the normality and molarity of the solution	CO2	PO1	06
	c)		An empirical equation for calculating the inside heat transfer coefficient (hi) for the turbulent flow of liquids in a pipe is given by. $$h_i = \frac{0.023\, G^{0.8} k^{0.67} C_p{}^{0.33}}{D^{0.2} \mu^{0.47}}$$ Where, hi = heat transfer coefficient, (Btu/h ft^2 °F) G = mass velocity of the liquid, (lb/h ft^2) K = thermal conductivity of the liquid, (BTU/h ft °F) Cp = heat capacity of the liquid, (BTU/lb °F) μ = Viscosity of the liquid, (lb / ft °F) D = inside diameter of the pipe, (ft) i. Verify, if the equation is dimensionally consistent ii. What will be the value of the constant given as 0.023 if all are converted to SI Units?	CO1	PO1	10
			UNIT - II			
2	a)		Discuss the material balance for distillation column operation for a binary system (A+B). Give the overall material balance and material balance of the component A.	CO1	PO1	05
	b)		A solution containing 53.8 g of $MgSO_4$ per 100g is cooled from 353K to 323K. During the process 6% of the water evaporates. How many kg of $MgSO_4 7H_2O$ crystals are obtained per 100g of the original solution? At 323K the solution contains only 0.3 mass fraction of $MgSO_4$. Given:	CO3	PO2	07

			Molecular weight of $MgSO_4$= 120 and Molecular weight of $MgSO_4 7H_2O$ = 246.			
		c)	A mixture of phenol and water forms two separate liquid phases, one rich in phenol and other rich in water, composition of layers is 70 % and 9 % (by weight) phenol, respectively. If 500 kg of phenol and 700 kg of water are mixed and layers allowed to separate, Calculate the weights of each layer.	***CO4***	***PO2***	**08**
			OR			
	3	a)	Explain with block diagram, the bypass operations and recycle operation.	***CO2***	***PO1***	**04**
		b)	2000 kg of wet solids containing 70% solids by weight are fed to tray drier and dried using hot flue gas. The product finally obtained is found to contain 1% moisture by weight. Calculate (i) Amount of water (in kg) removed from wet solids (ii) Amount of product (in kg) of desired product obtained after drying.	***CO3***	***PO2***	**08**
		b)	A milk powder is produced in a spray drier which evaporates all the liquid water. The operation is shown below.  Assuming inlet air contains no water, Calculate. i. Production rate of the powdered milk. ii. Molal flow rate of the inlet air.	***CO4***	***PO2***	**08**
			UNIT - III			
	4	a)	Explain the terms percentage yield, percentage conversion, limiting reagent and stoichiometric ratio	***CO1***	***PO1***	**08**
		b)	A quantity of barite ore containing barium sulphate and infusible matter is fused with an excess of pure anhydrous soda ash. The reaction is as follows $$BaSO_4 + Na_2CO_3 \rightarrow BaCO_3 + Na_2SO_4$$ Upon analysis the fusion mass is found to contain, $BaSO_4$= 11.3%; Na_2CO_3= 20.35%; Na_2SO_4=27.7% and $BaCO_3$ is reminder and infusible mass. i) Estimate the percentage composition of the original barite ore ii) Estimate the percentage conversion of $BaSO_4$ to carbonate iii) Evaluate the percentage excess in which Na_2CO_3 was used above the amount theoretical required. Given: Molecular Weight: Ba=137.4; S=32; C=12; O=16; Na=23	***CO4***	***PO2***	**12**
			UNIT- IV			
	5	a)	Determine the flue gas analysis and air fuel ratio by weight when a medium fuel oil having the following composition. C= 85.7%; H =10.3%; S=3.4% ; O=0.5% and Ash 0.1% by weight This fuel oil is burnt with 30% excess air. Assume that complete combustion takes place.	***CO5***	***PO3***	**10**

b) 10kg of PbS and 3kg of Oxygen react to yield 6kg of Pb and 1 kg of PbO_2 according to the reaction. *CO5* *PO3* **10**

$$PbS + O_2 \rightarrow Pb + SO_2 \quad \text{and} \quad PbS + 2O_2 \rightarrow PbO_2 + SO_2$$

Calculate

i. Amount of PbS that does not react
ii. % excess of oxygen based on the amount of PbS that actually react.
iii. Amount of SO_2 produced
iv. Percentage Conversion of PbS to Pb.

Data: MW of PbS=239.2; Pb=207.2 ; SO_2=64; PbO_2=239.2 and O_2=32.

OR

6 a) Explain in detail the analysis which can determine carbon, hydrogen, nitrogen and sulfur in a wide type of organic and inorganic samples, both solid and liquid. *CO2* *PO1* **08**

b) A producer gas contains 28 % CO, 3.5% CO_2, 0.5 %O_2, and 68% N_2. 100kg of this gas is burnt with 20% excess air. If the combustion is only 90% complete. *CO5* *PO3* **12**

Determine the following,

i. The Composition of the flue gas.
ii. The weight of the gases produced.

UNIT - V

7 a) State Hess's Law of constant heat summation and explain with an example *CO4* *PO1* **04**

b) Calculate the amount of heat to be supplied for raising temperature from 350K to 1500K of 1 kmole of oxygen using the Cp° (standard heat capacity) data given below *CO6* *PO2* **06**

$$C^\circ_{pO_2} = 26.01 + 11.76\times10^{-3}T - 2.3426\times10^{-3}T^2 - 0.5623\times10^{-9}T^3, \text{ kJ/(kmol.K)}$$

c) Obtain and empirical equation for calculating the heat of reaction at any temperature T (in K) for the following reaction *CO6* *PO2* **10**

$$CH_4(g) + C_2H_4(g) \rightarrow C_3H_8(g) \qquad \Delta H^\circ_R = -82.66\ kJ/mol$$

Heat Capacity data: $C^\circ_p = \alpha + \beta T + \gamma T^2 + \delta T^3$, $\frac{kJ}{kmol\ K}$

Component	α	β×10³	γ×10⁶	δ×10⁹
CH_4(g)	19.2494	52.1135	11.973	-11.3173
C_2H_4(g)	4.1261	155.0213	-81.5455	16.9755
C_3H_8 (g)	-4.2227	306.264	-158.6316	32.1455

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