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

Autonomous Institute Affiliated to VTU

December 2023 Supplementary Examinations

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

1 a) The pressure drop for a fluid flowing through a packed bed of solids is given by the relation: **10**

$$\Delta P = 3.61\left[\frac{\mu^{0.15} H \rho^{0.85} v^{1.85}}{Dp^{1.15}}\right]$$

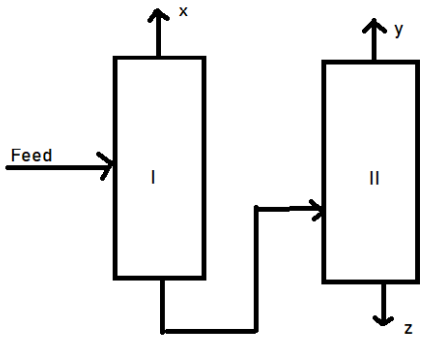
Where ΔP is pressure drop in Pa, μ is fluid viscosity in poise$\left(\frac{g}{cm\ s}\right)$, H is the bed depth in m, ρ is fluid density in kg/m^3, v is fluid velocity in m/s and Dp is packing diameter in m. Modify the relation such that the pressure drop is still in Pa, but other terms are in FPS units.

b) Pure water and ethanol are mixed to get a 60% (weight) alcohol solution. The densities (kg/m^3) of water, alcohol and the solution may be taken to be 998, 798 and 895, respectively at 293 K. Calculate the following: **10**

i. The volume percent of ethanol in the solution at 293 K
ii. The molarity
iii. The molality

UNIT - II

2 a) The feed to a fractionating system is 30,000 kg/h of 50% benzene, 30% toluene and 20% xylene. The fractionating system consists of two towers No. I and No. II. The feed enters tower I. The overhead product from I is x kg/h of 95% benzene, 3% toluene and 2% xylene. The bottom product from I is feed to II resulting in an overhead product of y kg/h of 3% benzene, 95% toluene and 2% xylene while the bottom from II tower is z kg/h of 1% benzene, 4% toluene and 95% xylene. Find x, y and z **10**



b) A mixture containing 30% acetone and 70% chloroform is extracted with a mixed solvent containing acetic acid and water. The two immiscible phases-the raffinate and extract phases-that result after the extraction had the following analysis: **10**

Extract: Acetone 7.5%, chloroform 6.06%, acetic acid 31.88% and water 54.56%

Raffinate: Acetone 20.0%, chloroform 67.0%, acetic acid 10.0% and water 3.0%

For a basis of 100 kg of the feed mixture, determine the following:

i) The composition of the mixed solvent on weight basis

ii) The quantities of raffinate and extract phases

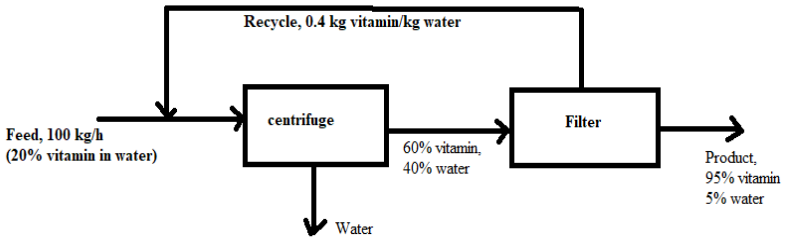
iii) The amount of mixed solvent used

OR

3 a) In the processing of fish after the oil is extracted, the fish cake is dried in rotary drum drier. Finely ground and packed. The resulting product contains 65% protein. If a given batch of fish cake contains 80% water, 100 kg of water is removed and it is found that the fish contains 40% water. Calculate the weight of fish cake originally put into drier. **08**

b) Final purification stage in the preparation of vitamins from natural sources requires centrifuging and continuous filtration, as depicted in the figure: **12**

Determine the flow rate of the recycle stream in kg/h.



UNIT - III

4 a) In a reactor, 130 kg of Zn powder and 560 kg of HNO_3 are fed. The reaction is 80% complete. The products formed are $Zn(NO_3)_2$, NO_2 and H_2O. Calculate the amount of $Zn(NO_3)_2$ and NO_2 formed as a product. **08**

Reaction: $Zn + 4HNO_3 \rightarrow Zn(NO_3)_2 + 2NO_2 + 2H_2O$

(Molar mass of Zn = 65.38)

b) In the process of manufacturing HCl from common salt and sulphuric acid, the two reactants are heated in a retort; HCl gas coming out of retort is absorbed **12**

in water to produce 31.5% HCl by weight. Some HCl is lost during absorption. To produce 1 ton of 31.5% HCl, the retort is charged with 550 kg NaCl and 480 kg of 98% H_2SO_4. The reaction goes to completion. Calculate
a. % loss of HCl during absorption.
b. quantity and composition of residue left in the retort assuming 50% of water distills over.

UNIT - IV

5 a) Explain the following with respect to fuel analysis. **08**
   i) Ultimate analysis
   ii) Proximate analysis

b) A furnace uses coke, which contains C – 80 %, H_2 – 0.5 % and ash – 19.5 %. Furnace operates with 50 % excess air. The solid residue left after burning contains 2 % unburnt carbon. Of the carbon burnt, 5 % goes to form CO. Calculate **12**
a) Composition of flue gases
b) Ash or residue produced over 100 kg of coke burnt
c) Weight of carbon lost per 100 kg of coke burnt

OR

6 a) A producer gas made from coke has the following composition CO-28%, CO_2- 3.5%, O_2-0.5 % and the rest N_2. The gas is burnt with such a quantity of air that the O_2 from air is 25% in excess of that required for combustion. The combustion is 95% complete. Calculate the composition of the flue gases by volume and by weight for 100 kg of gas burnt. What is the density of the flue gas? **12**

b) A combustion chamber is fed with butane and excess air. The combustion of butane is complete. The composition of combustion gases by volume is given below. CO_2-9.39%, H_2O –11.73%, O_2-4.5% and N_2-74.38%. Find the % excess air used and mole ratio of air to butane used. **08**

UNIT – V

7 a) Calculate the heat of reaction of the following reaction. **08**

$$CO_2 + H_2 \longrightarrow CO + H_2O$$

The formation reactions are

CO_2 : $C + O_2 \longrightarrow CO_2$ $\quad \Delta H_{f298} = -94.051$ kcal

CO : $C + 1/2\ O_2 \longrightarrow CO$ $\quad \Delta H_{f298} = -26.416$ kcal

H_2O : $H_2 + 1/2\ O_2 \longrightarrow H_2O$ $\quad \Delta H_{f298} = -57.798$ kcal

b) Calculate the heat of reaction at 873 K and 1.013 bar for the following reaction. **12**

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

ΔH_f data at 298 K:
$CO_2 = -393.65$ kJ/g mole
$H_2O = -241.90$ kJ/g mole
$CH_4 = -74.89$ kJ/g mole
Specific heat data J/g mole 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: $29.18 + 14.50\times10^{-3}T - 2.02\times10^{-6}\ T^2$

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