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

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: III**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 19CH3DCPPC **Max Marks: 100**
Course: Process Principles & 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 equation for the heat transfer to or from a stream of gas flowing in turbulent motion is as follows: **10**

$$h = \frac{\alpha C_P G^{0.8}}{D^{0.2}} = \frac{16.6 C_P G^{0.8}}{D^{0.2}}$$

where, h is heat transfer coefficient in kcal/h m^2 °C, C_P is heat capacity in kcal/kg °C, D is internal diameter of pipe in m, G is mass velocity in kg/m^2 s and α is constant.

It is desired to transform the equation into a new form,

$$h' = \frac{\alpha' C_P' G'^{0.8}}{D'^{0.2}}$$

where, h' is heat transfer coefficient in Btu/h ft^2 °F, C_P' is heat capacity in Btu/lb °F, D' is internal diameter of pipe in ft, and G' is mass velocity in lb/ft^2 s.

Determine the value of α'.

b) 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. **10**

(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

UNIT - II

2. a) The waste acid from a nitrating process containing 24% HNO_3, 56% H_2SO_4 and 20% H_2O by weight. This acid is to be concentrated to contain 26% HNO_3, 62% H_2SO_4 by the addition of 97% H_2SO_4 and 90% HNO_3. Calculate the weight of waste acid and concentrated acids that must be combined to obtain 10,000 kg of desired mixture. **10**

b) A crystallizer is charged with 7500 kg of an aqueous solution at 104°C, 28.5% by weight which is anhydrous sodium sulphate. The solution is cooled. During cooling operation 5% of water originally present was lost. As a result, the crystals of $Na_2SO_4 \cdot 10H_2O$ crystallize out. The mother liquor is found to contain 18.2% by weight of anhydrous salt. Calculate the yield of crystals and quantity of mother liquor. **10**

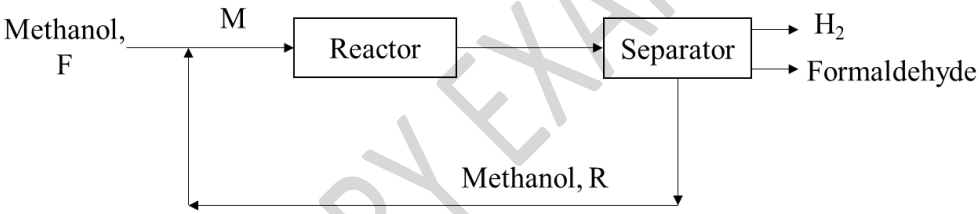
OR

3. a) Formaldehyde is produced by dehydrogenation of methanol, as shown in the figure below. **08**

$$CH_3OH \rightarrow HCHO + H_2$$

The per pass conversion is 67%. The product leaving the reactor is fed to a separation unit where formaldehyde is separated from methanol and hydrogen. The separated methanol is recycled to the reactor. If the production rate of formaldehyde is 1000 kg/h, calculate the following.

i. Combined feed ratio
ii. Flow rate of methanol required to the process as fresh feed



b) A continuous fractionating column separates 2000 kg/h of a solution of benzene and toluene containing 0.5 mass fraction benzene into an overhead product containing 0.97 mass fraction benzene and bottom product containing 0.03 mass fraction of benzene. Calculate the quantity of top and bottom product in kg/h. **06**

c) Explain the bypass and purging with the help of a diagram and material balance equations. **06**

UNIT - III

4. a) Discuss the following. **08**

i. Limiting reactant
ii. Excess reactant
iii. Yield
iv. Selectivity

b) In the manufacture of methanol by the reaction of carbon monoxide and hydrogen, some formaldehyde is also formed as a by-product. **12**

$$CO + 2H_2 \rightarrow CH_3OH$$
$$CO + H_2 \rightarrow HCHO$$

A mixture consisting of CO and H_2 is allowed to react and the product analysed as 2.92% CO, 19.71% methanol, 6.57% formaldehyde and 70.80% hydrogen. Calculate the following: (i) The percent conversion of limiting reactant (ii) Percent yield of methanol.

UNIT - IV

5. a) Discuss the following. **10**
   i. Proximate analysis
   ii. Ultimate analysis
   iii. Orsat analysis

   b) A fuel gas consists of 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. **10**

OR

6. a) The analysis of the flue gases from a boiler house chimney by volume is as given below. **08**
   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

   b) The ultimate analysis of a residual fuel oil (RFO) sample is as given below. C: 88.4%, H:9.4%, and S: 2.2% (weight%). It is used as a fuel in a power generating boiler with 25% excess air. Calculate **12**
   (i) The theoretical dry air requirement
   (ii) The actual dry air supplied, and
   (iii) The Orsat analysis of flue gases

UNIT - V

7. a) Discuss the following. **10**
   i. Heat of formation
   ii. Heat of reaction
   iii. Heat of combustion and
   iv. Heat of mixing
   v. Theoretical flame temperature

   b) Pure ethylene is heated from 303 K to 523 K at atmospheric pressure. Calculate the heat added per kmol ethylene using the heat capacity data given below. **10**

$$C_P^\circ = 4.1261 + 155.0213\times10^{-3}T - 81.5455\times10^{-6}T^2 + 16.9755\times10^{-9}T^3$$

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