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

Autonomous Institute Affiliated to VTU

May 2023 Semester End Main Examinations

Programme: B.E. **Semester: III**
Branch: Biotechnology **Duration: 3 hrs.**
Course Code: 19BT3DCPPC **Max Marks: 100**
Course: Process Principles and Calculations **Date: 08.05.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Psychrometric chart is allowed.

UNIT - I

1 a) The solubility of sodium chloride in water at 290 K is 35.8 kg/100 kg water. Express the solubility as the following **08**
   i. Mass fraction and Mass % of NaCl
   ii. Mole fraction and mole % of NaCl
   iii. kmole of NaCl/1000 kg of water

b) A product gas from a reaction has the composition by weight as follows: **12**
Cl_2= 67%, Br_2 = 28%, O_2 = 5%. Using the ideal gas law, calculate (i) the composition of the gas by volume (ii) density of the gas mixture in g/L at 25°C (iii) specific gravity of gas mixture (iv) average molecular weight of gas mixture. Data: atomic wt of Cl=35.5, Br=80, O=16 & average molecular weight of air= 29.

UNIT - II

2 a) The dry bulb temperature and dew point of ambient air were found to be 303 K and 289 K respectively Calculate **10**
   i. The absolute molal humidity
   ii. The absolute humidity
   iii. The % relative humidity
   iv. The Humid heat

The vapour pressure of water at 289 K and 303K is 1.818 kPa and 4.243 kPa respectively. Barometric pressure is 100 kPa.

b) A mixture of ideal gases has the following composition by mass at 30° C and 1000mm Hg, CO_2= 17%, CO=4%, O_2= 16% and rest N_2. Calculate (i) partial pressure of oxygen (0_2) in mm Hg (ii) pure component volume of nitrogen (N_2) in m3 per 100 m^3 of gas mixture (iii) composition of components of gas mixture in mole % (iv) average molecular weight (v) density of gas mixture in g/L at existing condition. **10**

UNIT - III

3 a) A crystallizer that is charged with 7000 kg of an aqueous solution a1 104 °C 29.6% by which is anhydrous sodium sulfate. The solution is cooled. During cooling, 5 % of initial water is lost by evaporation. As a result , Na_2SO_4. l0 H_2O crystallizes out. If the mother liquor is found to contain 18.3 % anhydrous Na_2SO_4, calculate the % yield of the crystals and quantity of mother liquor left over in kg. Atomic weight of Na=23, S=32,O= 16, H= l **10**

b) A distillation column separates a feed mixture containing 30% benzene (C_6H_6), 50% toluene ($C_6H_5CH_3$), rest xylene ($C_6H_4C_2H_6$) on mole basis into an **10**

overhead fraction containing 95% benzene, 4% toluene and rest xylene and a bottom product of 2% benzene. The reflux ratio is 2.5. on the basis of 1000 kmol of feed per hour, calculate i) mass flow rate of top product ii) % recovery of benzene in top product and iii) % recovery of xylene in bottom product.

UNIT - IV

4 a) In the production of chlorine gas by the oxidation of HCI gas, air is used 30% in excess of that theoretically required. Based on 4 kmol HCI and the reaction is 80% complete, calculate the composition of the product stream on mole basis, **10**

$$4HCI + O_2 \rightarrow 2Cl_2 + 2H_2O$$

b) Define the following with suitable examples: (i) limiting reactant (ii) excess reactant (iii)% conversion (iv) % yield (v) selectivity **10**

OR

5 a) The CO is reacted with hydrogen to produce methanol. Calculate the following from this reaction **10**

i. The stochiometric ratio of H_2 to CO
ii. kmol of CH_3OH produced per kmol of CO reacted
iii. The weight ratio of CO to H_2 if both are fed to the reactor in the stoichiometric ratio.
iv. The quantity of CO required to produce 1000 kg of CH_3OH.

b) The gross heating value of gaseous butane is 2877.4 kJ/kg at 298 K. Calculate its net heating value in kJ/kg. the latent heat of water vapour at 298K is 2442.5 kJ/kg. the reaction is **04**

$$C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O$$

c) Explain proximate and ultimate analysis of coal. **06**

UNIT-V

6 a) Derive an expression for heat of reaction at an elevated temperature from standard heat of reaction and heat capacity data. Consider that Cp varies with temperature. **10**

b) Aerobic degradation of benzoic acid by mixed culture of microorganisms is given by **10**

$C_6H_5COOH + aO_2 + bNH_3 \rightarrow cC_5H_7NO2 + dH_2O + eCO_2$

Substrate(l22) 32 17 bacteria (l 13) 18 44

i) Determine a, b, c, d and e if RQ=0.9
ii) Determine the yield coefficient Y xis and Y x/O_2
iii) Determine degree of reduction for the substrate and bacteria

OR

7 a) Define the degrees of reduction. Find the degrees of reduction of methane, glucose and ethanol. **10**

b) If the cells of certain organisms can convert two third (wt/wt) of the substrate carbon (hexadecane and glucose) to biomass, Calculate stoichiometric coefficients for the following biological reactions: **10**

Hexadecane:

hexadecane: $C_{16}H_{34} + aO_2 + bNH_3 \rightarrow cC_{4.4}H_{7.3}N_{0.86}O_{1.2} + dH_2O + eCO_2$

glucose: $C_6H_{12}O_6 + aO_2 + bNH_3 \rightarrow cC_{4.4}H_{7.3}N_{0.86}O_{1.2} + dH_2O + eCO_2$

Calculate the yield coefficients Yx/s (g dry weight cell/g substrate), $Y/0_2$ (g dry weight cell/g O_2) for both reactions.

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