

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

Autonomous Institute Affiliated to VTU

## May 2023 Semester End Main Examinations

**Programme: B.E.**

**Branch: Biotechnology**

**Course Code: 19BT3DCPPC**

**Course: Process Principles and Calculations**

**Semester: III**

**Duration: 3 hrs.**

**Max Marks: 100**

**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  
 $\text{Cl}_2 = 67\%$ ,  $\text{Br}_2 = 28\%$ ,  $\text{O}_2 = 5\%$ . 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,  $\text{CO}_2 = 17\%$ ,  $\text{CO} = 4\%$ ,  $\text{O}_2 = 16\%$  and rest  $\text{N}_2$ . Calculate (i) partial pressure of oxygen ( $\text{O}_2$ ) in mm Hg (ii) pure component volume of nitrogen ( $\text{N}_2$ ) in  $\text{m}^3$  per 100  $\text{m}^3$  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

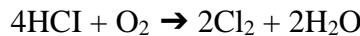
3 a) A crystallizer that is charged with 7000 kg of an aqueous solution a1 104 °C 29.6% by which is anhydrous sodium sulfate. The solution is cooled. During cooling, 5 % of initial water is lost by evaporation. As a result,  $\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$  crystallizes out. If the mother liquor is found to contain 18.3 % anhydrous  $\text{Na}_2\text{SO}_4$ , 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=1 10

b) A distillation column separates a feed mixture containing 30% benzene ( $\text{C}_6\text{H}_6$ ), 50% toluene ( $\text{C}_6\text{H}_5\text{CH}_3$ ), rest xylene ( $\text{C}_6\text{H}_4\text{C}_2\text{H}_6$ ) on mole basis into an

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 HCl gas, air is used 30% in excess of that theoretically required. Based on 4 kmol HCl and the reaction is 80% complete, calculate the composition of the product stream on mole basis, 10



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 stoichiometric ratio of H<sub>2</sub> to CO
- ii. kmol of CH<sub>3</sub>OH produced per kmol of CO reacted
- iii. The weight ratio of CO to H<sub>2</sub> if both are fed to the reactor in the stoichiometric ratio.
- iv. The quantity of CO required to produce 1000 kg of CH<sub>3</sub>OH.

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

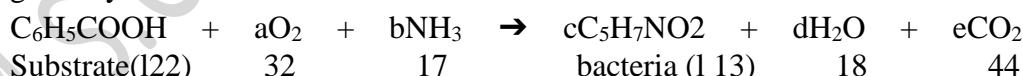


c) Explain proximate and ultimate analysis of coal. 06

#### 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



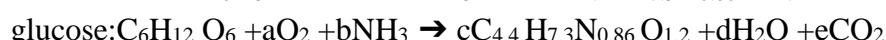
- i) Determine a, b, c, d and e if RQ=0.9
- ii) Determine the yield coefficient Y x/s and Y x/O<sub>2</sub>
- iii) Determine degree of reduction for the substrate and bacteria

#### 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:

Hexadecane:



Calculate the yield coefficients Y<sub>x/s</sub> (g dry weight cell/g substrate), Y<sub>02</sub> (g dry weight cell/g O<sub>2</sub>) for both reactions.

\*\*\*\*\*