Reg. No. | | | | | | | | | | | | |

B.E. / B.TECH. DEGREE EXAMINATION, MAY 2023

Third Semester

BT18302 – PROCESS CALCULATIONS

(Biotechnology)

(Regulation 2018A)

(Use of Pyschrometric chart and data book is allowed)

TIME: 3 HOURS **MAX. MARKS: 100**

CO 1 Recall different system of units and relate its conversions
CO 2 Explain the concept of material balance and relate its out comes
CO 3 Make use of various gas laws in real time applications
CO 4 Apply the concept of material balance in various unit operations
CO 5 Explain the concept of energy balance and relate its outcomes.

PART- A (10 x 2 = 20 Marks)
(Answer all Questions)

		CO	RBT LEVEL
1.	Define Molality.	1	1
2.	Calculate the volume of 50 kgs of O_2 at a pressure of 730 mm Hg and 40 ˚C.	1	2
3.	A gas mixture contains 9.5% CO_2, 0.2% CO, 9.6% O_2 and 80.7% N_2 (by volume). Calculate its molecular weight.	2	2
4.	What is purging and when does it become necessary?	2	1
5.	Define Raoult's law. When is it applicable?	3	2
6.	What is Phase rule?	3	1
7.	Write the material balance for crystallization.	4	2
8.	Mention the important uses of Humidity chart	4	1
9.	Define standard heat of reaction.	5	1
10.	Distinguish sensible heat and latent heat.	5	2

PART- B (5 x 14 = 70 Marks)

		Marks	CO	RBT LEVEL
11. (a)	Natural gas is piped from the well at 300 K and 400 kPa. The gas is found to contain by volume 93% methane, 4.5% ethane and the rest nitrogen. Calculate the following:	(14)	1	4

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1) The partial pressure of nitrogen
2) The pure component volume of ethane in 10 m^3 of the gas.
3) The density of the gas mixture at standard conditions in kg/m^3.
4) The average molecular weight of the gas mixture.
5) The composition of the gas mixture in weight percent

(OR)

			Marks	CO	RBT LEVEL
(b)	**(i)**	Find the average molecular weight of air at NTP conditions.	**(4)**	1	4
	(ii)	What is the weight of iron and water required for the production of 100 Kg of hydrogen? $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4 H_2$ Data: Mol. Wt of Iron: 55.845 g/mol.	**(10)**	1	4

		Marks	CO	RBT LEVEL
12. (a)	An evaporator is fed with 15000 kg/h of a solution containing 10% NaCl, 15% NaOH and rest water. In the operation, water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving the evaporator contains 45% NaOH, 2% NaCl and rest water. Calculate a) Kg/h evaporated, b) Kg/h salt precipitated, c) Kg/h thick liquor obtained.	**(14)**	2	4
	(OR)			
(b)	The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 90% HNO_3, to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kgs of desired mixed acid.	**(14)**	2	4
13. (a)	A gas mixture contains 0.274 kmol of HCl, 0.337 kmol of N_2 and 0.089 kmol of O_2. Calculate a) Avg. Molecular weight, b) Volume occupied by the mixture, c) partial pressure of each component at 405.3 kPa and 303K and d) density of the gas mixture.	**(14)**	3	4
	(OR)			
(b)	Carbureted water gas has the following composition by volume hydrogen 35.2%, methane 14.8%, ethylene 12.8%, carbon dioxide	**(14)**	3	4

1.5%, carbon monoxide 33.9%, Nitrogen 1.8%. The gas is available at 773 K and 4 bar. Find the molar volume of the mixture assuming i) Ideal gas law and ii) Vanderwaal's equation of state.

14. (a) **(i)** Explain Psychrometry. **(2)** **4** **3**

(ii) The dry bulb temperature and dew point of ambient air were found to be 302 K (29 ˚C) and 291 K (18 ˚C) respectively. The barometer reads 100 kPa (750 Torr). Partial pressure of water in air Pw= 2.0624 kPa. **(12)** **4** **3**

Calculate:

1) Absolute molar humidity

2) Absolute humidity and

3)) The %RH, if the vapor pressure at saturation is 4.004 kPa.

(OR)

(b) A crystallizer is charged with 6400 kgs of an aqueous solution containing 29.6% anhydrous Na_2SO_4. The solution is cooled and 10% of the initial H_2O is lost by evaporation. The crystals obtained are Na_2SO_4, $10H_2O$. If the mother liquor is found to be contain 18.3% Na_2SO4, calculate the weight of mother liquor and crystals. **(14)** **4** **3**

15. (a) **(i)** Write briefly about the latent heat of fusion and latent heat of vaporization. **(4)** **5** **3**

(ii) Ethyl alcohol reacts with acetic acid to give ethyl acetate. Heat of combustion of ethyl alcohol, acetic acid and ethyl acetate are -3,26,700 cal, -2,08, 340 cal, -5,38,760 cal respectively. Calculate the standard heat of reaction. **(10)** **5** **3**

(OR)

(b) **(i)** Calculate the heat of formation of glycerol ($C_3H_8O_3$) at 298.15 K from its elements using the following data: **(7)** **5** **3**

Data: ΔH°_f CO_2 (g) = -393.51 kJ/mol

ΔH°_f H_2O (l) = -285.3 kJ/mol

$\Delta H^\circ c$ C_3H_8 (l) = -1659.10 kJ/mol

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(ii) A stream of nitrogen flowing at 100 mol/min is heated from 20 ˚C to 100 ˚C. Calculate the heat capacity Cp for nitrogen at a constant pressure of 1 atm. **(7)** **5** **3**

Data:

Cp (kJ/mol˚C) = $0.029 + 0.219\times10^{-5}T + 0.57\times10^{-8}T^2 - 2.87 \times 10^{-12}T^3$

PART- C (1 x 10 = 10 Marks)

(Q.No.16 is compulsory)

		Marks	CO	RBT LEVEL
16.	Wet solid containing 50% water and 50% solids are to be dried to get solids with 5% H_2O by weight. Fresh air contains 0.010 kg H_2O per kg dry air and air leaving the dryer contains 0.05 kg of H_2O per kg of dry air. If 100 kg of dry air enters the dryer per kg of dry solids, calculate the fraction of air recirculated and recycle ratio.	**(10)**	**4**	**5**