BIRLA INSTITUTE OF TECHNOLOGY
MESRA – 835215, RANCHI, INDIA

UG

Name: …… Roll No.: ……..

Branch: …… Signature of Invigilator: ……

Semester: IVth Date: 29/04/2022 (MORNING)

Subject with Code: **CL215 MASS TRANSFER OPERATION - I**

Marks Obtained	Section A (30)	Section B (20)	Total Marks (50)

INSTRUCTION TO CANDIDATE

1. The booklet (question paper cum answer sheet) consists of two sections. First section consists of MCQs of 30 marks. Candidates may mark the correct answer in the space provided / may also write answers in the answer sheet provided. The Second section of question paper consists of subjective questions of 20 marks. The candidates may write the answers for these questions in the answer sheets provided with the question booklet.
2. The booklet will be distributed to the candidates before 05 minutes of the examination. **Candidates should write their roll no. in each page of the booklet.**
3. Place the Student ID card, Registration Slip and No Dues Clearance (if applicable) on your desk. All the entries on the cover page must be filled at the specified space.
4. Carrying or using of mobile phone / any electronic gadgets (except regular scientific calculator)/chits are strictly prohibited inside the examination hall as it comes under the category of unfair means.
5. No candidate should be allowed to enter the examination hall later than 10 minutes after the commencement of examination. Candidates are not allowed to go out of the examination hall/room during the first 30 minutes and last 10 minutes of the examination.
6. Write on both side of the leaf and use pens with same ink.
7. The medium of examination is English. Answer book written in language other than English is liable to be rejected.
8. All attached sheets such as graph papers, drawing sheets etc. should be properly folded to the size of the answer book and tagged with the answer book by the candidate at least 05 minutes before the end of examination.
9. The door of examination hall will be closed 10 minutes before the end of examination. Do not leave the examination hall until the invigilators instruct you to do so.
10. Always maintain the highest level of integrity. Remember you are a BITian.
11. Candidates need to **submit the question paper cum answer sheets before leaving the examination hall**.

BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B.Tech **SEMESTER: IV**
BRANCH: Chemical/Chemical P&P **SESSION: SP/22**

SUBJECT: CL215 (Mass Transfer Operation-I)

TIME: 2 HOURS **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 2 parts (Part-I carries 30 marks and Part-II carries 20 marks)
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data handbook/Graph paper etc. to be supplied to the candidates in the examination hall.

SET-A

PART-I

Q.1 Overall efficiency of the distillation column is **[1]**

(a) the ratio of number of ideal plates to actual plates.

(b) the ratio of number of actual plates to ideal plates.

(c) same as the Murphree efficiency.

(d) always more than the point efficiency.

Q.2 To increase the absorption factor, (where, *G* = gas flow rate, *S* = solvent flow rate) **[1]**

(a) increase both 'G' and 'S'.

(b) decrease both 'G' and 'S'.

(c) increase 'S' and decrease 'G'.

(d) increase 'G' and decrease 'S'

Q.3 In case of an absorber, the operating **[1]**

(a) line always lies above the equilibrium curve.

(b) line always lies below the equilibrium curve.

(c) line can be either above or below the equilibrium curve.

(d) velocity is more than the loading velocity.

Q.4 Mass transfer co-efficient (K) and diffusivity (D) are related according to film theory as **[1]**

(a) $K \propto D^{-1}$

(b) $K \propto D$

(c) $K \propto D^{1.5}$

(d) $K \propto D^{2}$

Q.5 Weeping in a distillation column **[1]**

(a) increases tray efficiency.

(b) provides large interfacial surface for mass transfer.

(c) results due to very high gas velocity.

(d) results due to very low gas velocity.

Q.6 Wetted wall tower experiment determines the **[1]**

(a) molal diffusivity.

(b) volumetric coefficient.

(c) mass transfer coefficient.

(d) none of these.

Q.7 Pick out the system with minimum boiling azeotrope at 1 atm. **[1]**

(a) benzene-toluene

(b) ethyl alcohol-water

(c) hydrochloric acid-water

(d) all (a), (b) and (c)

Q.8 The individual mass transfer coefficients (moles/m^2. s) for absorption of a solute from a gas mixture into a liquid solvent are, K_L = 4.5 and K_G = 1.5. The slope of the equilibrium line is 3. Which of the following resistance (s) is/are controlling? **[1]**

(a) liquid side

(b) gas side

(c) interfacial

(d) both liquid and gas side

Q.9 Rose oil is extracted from rose leaves using _____ distillation. **[1]**

(a) high pressure

(b) low pressure

(c) extractive

(d) steam

Q.10 Fenske equation determines the **[1]**

(a) maximum number of ideal plates.

(b) height of the distillation column.

(c) minimum number of theoretical plates.

(d) optimum reflux ratio.

Q.11 According to the Fenske equation, what will be the minimum number of plates required in a distillation column to separate an equimolar binary mixture of components A and B into an overhead fraction containing 99 mol% A and a bottom fraction containing 98 mol% B? Assume that relative volatility (α_{AB} = 2) does not change appreciably in the column. **[1]**

(a) 5

(b) 9

(c) 12

(d) 28

Q.12 Experimental determination of _____ is done by wetted wall column method. **[1]**

(a) diffusion coefficient

(b) mass transfer co-efficient

(c) NTU

(d) none of these

Q.13 Experiments were conducted to determine the flux of a species A in a stagnant medium across a gas-liquid interface. The overall mass transfer co-efficient based on the liquid side for dilute systems for the above was estimated to be 4×10^{-3} kg mole/m^2 s. The equilibrium data for the system is given as y = 2x. The flux across the interface (in kmol/m^2 s) for bulk concentrations of A in gas phase and liquid phase as y = 0.4 and x = 0.01 respectively is **[1]**

(a) 5.6×10^{-4}

(b) 8.5×10^{-4}

(c) 5.6×10^{-3}

(d) 8.5×10^{-3}

Q.14 H_2S present in naphtha reformed gas is removed by absorbing with **[1]**

(a) ethanolamine

(b) K_2CO_3

(c) HCl

(d) vacuum gas oil

Q.15 Assume that benzene is insoluble in water. The normal boiling points of benzene and water are 80.1°C and 100°C, respectively. At a pressure of 1 atm, the boiling point of a mixture of benzene and water is **[1]**

(a) 80.1°C

(b) less than 80.1°C

(c) 100°C

(d) greater than 80.1°C but less than 100°C

Q.16 In a binary distillation column, if the feed contains 40 mole% vapor, the q-line will have a slope of **[1]**

(a) 0.6

(b) -0.6

(c) 1.5

(d) -1.5

Q.17 The number of transfer units for absorption of three gases A, B and C in water are 10, 4 and 15 m, respectively. The inlet and exit concentrations (mole fraction) of the gas-phase and of the liquid-phase have the same values in all the cases. For which system is the average driving force for mass transfer minimum? **[1]**

(a) A

(b) B

(c) C

(d) Insufficient data

Q.18 For the nth tray (counted from the bottom of a distillation column), the Murphree tray efficiency is given by **[1]**

(a) $\frac{y_{n+1} - y_n}{y_n^* - y_{n-1}}$

(b) $\frac{y_n - y_{n-1}}{y_n^* - y_{n-1}}$

(c) $\frac{y_{n-1} - y_n}{y_{n+1} - y_n}$

(d) $\frac{y_n^* - y_{n-1}}{y_n^* - y_{n+1}}$

Q.19 Methane is being cracked on a catalyst, CH4 ---------→ C + 2H2, under circumstances such that CH4 diffuses to the cracking surface and H2 diffuses back. At steady state the ratio NA/(NA+NB) is **[1]**

(a) 1/3

(b) -1

(c) 2/3

(d) -2

Q.20 Relative volatility (α) for a binary system **[1]**

(a) Decreases with increase in pressure

(b) Increases with increase in pressure

(c) Increases with increase in temperature at constant pressure

(d) Has no significance in distillation operation

Q.21 At one place in the apparatus where the pressure is 1 bar and the temperature is 300 K, the analysis of the gas is 20% NH_3, 40% N_2, and 40% H_2 by volume. Estimate the effective diffusivity of NH_3 assuming other components are stagnant. $D_{NH3\text{-}N2}$ = 0.237 cm^2/s, and $D_{NH3\text{-}H2}$ = 0.728 cm^2/s. **[2]**

(a) 0.46 cm^2/s

(b) 0.43 cm^2/s

(c) 0.36 cm^2/s

(d) 0.48 cm^2/s

Q.22 The equilibrium distribution of a solute A between air and water a low concentration and at a particular temperature is y = 1.2x. At a certain point in a mass transfer device, the concentration of solute A in the bulk air is 0.04 mole fraction and that in the bulk aqueous phase is 0.025. Calculate the overall gas **[2]**

phase driving force for mass transfer. The individual mass transfer coefficients k_x and k_y are 4.6 and 7.2 kmol/m^2h(Δ mole fraction), respectively.

(a) 0.01

(b) 0.03

(c) 2.5

(d) 3.7

Q.23 A packed tower is designed to recover 90% CO_2 from a gas mixture containing 10% CO_2 and 90% air (by volume) using pure water. The equilibrium relation is Y = 10X, where X and Y are mole ratio of solute to solvent in liquid and gas, respectively. Calculate minimum liquid to gas ratio. **[2]**

(a) 5

(b) 9

(c) 10

(d) 12

Q.24 A binary mixture of benzene and toluene containing 25 mol% benzene is to be flash distilled at atmospheric pressure to get 50% of the feed as distillate. Estimate the composition of distillate and bottom product. Relative volatility of the mixture is 2.5. **[2]**

(a) composition of distillate = 0.25, composition of bottom product = 0.25

(b) composition of distillate = 0.20, composition of bottom product = 0.30

(c) composition of distillate = 0.33, composition of bottom product = 0.17

(d) composition of distillate = 0.17, composition of bottom product = 0.33

Q.25 NH_3 is separated from a very dilute NH_3-air mixture using absorption with water in a counter-current absorption tower. For the system the equilibrium relation is y=2x. The operating line is represented by y = 5x+6. The absorption factor will be. **[2]**

(a) 2

(b) 5

(c) 6

(d) None

PART-II

Q.26 A test tube, 1.5 cm in diameter and 12cm tall, is partly filled with a solution of alkaline pyrogallate. The depth of the empty space above the solution is 5 cm. The temperature is 25°C and the total pressure is 1 atmosphere. Air may be assumed to contain 21% O_2 and 79% N_2. The diffusivity of O_2 in N_2 at the given condition is 0.21cm^2/s. Calculate the rate of absorption of oxygen from air in solution at steady state if air flows gently over the open end of the test tube. **[5]**

Q.27 For an absorption column, the HTU_{oG} is found to be 0.25 m. The absorption factor is 2.39. Calculate the HETP of the absorption column. **[2]**

Q.28 100 kmol/h of a SO_2-air mixture containing 5% by volume SO_2 is to be scrubbed with 10,000 kmol/h of pure water in a packed tower. The exit concentration of SO_2 is reduced to 0.15%. The tower operated at 1 atmosphere. The equilibrium relationship is given by Y = 30 X, where X and Y are the mole ratio of SO_2 in water and in air, respectively. Calculate the NTU of the absorption column. **[3]**

Q.29 A continuous fractionating column operating at atmospheric pressure is to separate a feed containing 30% CS_2 and 70% CCl_4 into an overhead product of 95 % CS_2 and a bottom product of 95 mole % CCl_4. The feed enters as a liquid at its boiling point. Assuming an overall plate efficiency of 70% and a reflux ratio of 3:1. Estimate the number of plates needed. All the compositions are in mole %. **[5]**

Equilibrium data:

x	0.0296	0.0615	0.258	0.39	0.532	0.663	0.758	0.86
y	0.0823	0.1555	0.494	0.634	0.747	0.830	0.880	0.932

Q.30 For a multicomponent system following compositions in distillate and bottom product are given: **[5]**

Component	$x_{N+1} = x_D$	$x_1 = x_B$
iC_4	0.0256	~0
nC_4 (LK)	0.9445	0.0147
iC_5 (HK)	0.0278	0.0563
nC_5	0.0021	0.0343
nC_6	~0	0.0563
nC_7	~0	0.0958
nC_8	~0	0.6667
nC_9	~0	0.0759
	1.0000	1.0000

Calculate the minimum number of theoretical stages for the given system. Relative volatility of light key (LK) wrt heavy key (HK) is 1.73.