(vi) NTU is a measure of
(a) efficiency of mass transfer (b) time taken for mass transfer
(c) difficulty of mass transfer (d) none of these.

(vii) In case of distillation, as the reflux ratio is increased, the intersection of both the operating lines
(a) moves towards the diagonal (b) moves away from the diagonal
(c) does not move at all (d) none of these.

(viii) In which of the following models the ratio of Murphree plate efficiency to point efficiency is 1?
(a) plug (b) perfectly mixed
(c) both (a) and (b) (d) neither (a) nor (b).

(ix) When the feed to a distillation column is a saturated vapour, the slope of the feed line is
(a) negative (b) zero (c) positive (d) infinite.

(x) Adsorption is generally favoured at
(a) Low temperature and low pressure
(b) High temperature and high pressure
(c) Low temperature and high pressure
(d) High temperature and low pressure.

Group - B

2. (a) Write Newton's law of viscosity, Fourier's law of heat conduction and Fick's first law of diffusion in such a way which shows the inherent similarity between momentum, heat and mass transfer. What is the ratio of momentum diffusivity and thermal diffusivity called?

(b) A film of Ammonia-water solution 4 mm thick at 278 K is in contact at one surface with an organic liquid. The concentration of ammonia in the organic phase is constant and is such that the equilibrium concentration of ammonia in water at the surface of the organic liquid is 2 weight% (density of solution: 991.7 kg/m^3) and that at the other end of the film is 10 weight % (density of solution : 961.7 kg/m^3). Water and the organic liquid are insoluble in each other. The diffusion coefficient of ammonia in water is 1.24×10^{-9} m^2/s. Calculate the molar flux of ammonia.

(4+1) + 7 = 12

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Group - E

8. (a) What do you understand by azeotropic distillation? Give example.

(b) Write down the desirable characteristics of an industrial adsorbent.

(c) The following table gives the data on adsorption of pure propane on a special type of activated carbon at 311 K temperature.

p =pressure of propane, kPa	**q**=amount of propane adsorbed at equilibrium (millimol/g)
2.27	1.04
15.6	2.82
31.7	3.48
59.6	3.97
89.7	4.21
100	4.34
293	4.94

If Langmuir isotherm model is followed in the gas adsorption, obtain the equation of the isotherm.

3 + 2 + 7 = 12

9. (a) What do you understand by "differential heat of adsorption" and "integral heat of adsorption"?

(b) Write down the difference between physical adsorption and chemisorption.

(c) In the context of break through curve of a fixed bed adsorption column, explain Mass Transfer Zone. Why it is so called?

(d) What are the basic difference between the methods of design of the columns for binary and multicomponent distillation?

3+3+3+3 = 12

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SEPARATION PROCESS - I
(CHEN 2202)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following: **10 × 1=10**

(i) The unit of eddy diffusivity is
(a) m/s (b) m^2/s
(c) mol/m^2s (d) none of these.

(ii) Schmidt number is the ratio of
(a) momentum and thermal diffusivity
(b) thermal and mass diffusivity
(c) momentum and mass diffusivity
(d) none of these.

(iii) In equimolar counter-diffusion, partial pressure of diffusing species varies with distance of diffusion
(a) exponentially (b) linearly
(c) logarithmically (d) none of these.

(iv) Example of a gas-phase controlled mass transfer operation is
(a) distillation (b) stripping
(c) absorption (d) none of these.

(v) Absorption will occur, provided that absorption factor (A) is
(a) < 1 (b) = 1 (c) << 1 (d) > 1.

3. (a) In case of diffusion of a component through a stagnant multicomponent mixture, how do you modify the binary diffusivity to determine the diffusion flux?

(b) Molecular weight of Ammonia gas is 17, while that of Carbon dioxide is 44. Which will have higher diffusivity with respect to air? Explain.

(c) If for a gas-liquid system, Henry's law constant is very large, what can you infer about the system regarding the ease of absorption of the gas from the liquid using a solvent?

4+4+4 = 12

Group - C

4. (a) The stripping section operating line of a distillation column receiving saturated open steam for the separation of an aqueous solution is y= 1.1x - 0.022.
What is the bottom product composition?

(b) A stream of aqueous methanol flowing at a rate of 200 K mol/h and having 46 mol% methanol is continuously fed to a distillation column. The top product of the column should contain at least 94 mol% methanol and a bottom liquid must not contain more than 5% methanol. The feed is at bubble point and operating pressure is 1 atm. A reflux ratio of 1.6 is suggested.
Equilibrium data at 1 atm.

x	0	0.04	0.08	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
y	0	0.23	0.37	0.42	0.58	0.67	0.73	0.78	0.83	0.87	0.92	0.96	1.0

Calculate the quantities of overhead and bottom products in kmol/h.
Determine the number of actual trays if the overall efficiency is 40%.

2 + (2+8) = 12

5. (a) Compare McCabe-Thiele and Ponchon-Savarit methods for calculation of the number of trays in a distillation column.

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(b) A given mixture of n-pentane and n-octane is heated and flashed when one mole of liquid having a mol fraction x=0.18 of n-pentane and two moles of vapour are generated. At the temperature of the flash drum, the relative volatility of n-pentane with respect to n- octane is 4.63. The solution is ideal. Calculate the composition of the original mixture.

(c) Explain the following phenomena in a sieve tray tower:
(i) flooding (ii) weeping

4 + 5 + 3 = 12

Group - D

6. (a) Differentiate between a stage-wise and a differential gas-liquid contactor.

(b) State the significance of absorption factor. Name three important industrial processes where absorption is essential.

(c) "The operating line for absorption lies above the equilibrium curve but the operating line for stripping lies below the equilibrium curve" – Explain.

(d) Which type of tower (plate/packed) will you choose for absorption considering the following factors: (i) Gas pressure drop (ii) Cleaning (iii) Corrosive solvent.

3 + 3 + 3 + 3 = 12

7. (a) Mention at least four characteristics of a good solvent for absorption.

(b) A gas stream contains 4 mol% ammonia. Its ammonia content is to be reduced to 0.5 mol% in a countercurrent packed absorption column at 293 K and 1 atm pressure. The inlet pure water flow is 68 k mol/h and inlet gas flow is 57.8 k mol/h. The tower diameter is 0.747 m. The film mass transfer coefficients are kya = 0.0739 k mol/m3.s.mol fraction, kxa = 0.169 k mol/m3.s.mol fraction. Calculate tower height using i) gas phase resistance only ii) Using overall resistance. Equilibrium relationship is y = 0.746 x.

4+8=12

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4+8=12

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