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Question Paper Code: R4905

B.E. / B.Tech. DEGREE EXAMINATION, APRIL / MAY 2025

Fourth Semester

Chemical Engineering

R21UCH405– MASS TRANSFER-I

(Regulations R2021)

Duration: Three hours

Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. If the vapour pressure of the two components in a binary mixture is same, then it is a _____ CO1-U
 - a) Isotope
 - b) Azeotrope
 - c) Differential boiling point
 - d) None of the mentioned
2. In a certain process, there is a variation in the driving force between the phases, such a process is CO1- U
 - a) Batch process
 - b) Semi-batch process
 - c) Continuous process
 - d) Isothermal process
3. Which of the following is present in turbulent flow mass transfer? CO1-U
 - a) Slow mass transfer
 - b) Less mass transfer
 - c) Eddy currents
 - d) Eddy diffusion
4. Diffusion is the result of: CO1-U
 - a) Random motion of particles
 - b) Concentration gradient
 - c) Kinetic energy of particles
 - d) All of the mentioned
5. In humidification the gas is _____ in the liquid for the mass transfer to take part. CO1-U
 - a) Soluble
 - b) Insoluble
 - c) Partially soluble
 - d) Inert

6. Humidification is a CO1-U
 a) Mass transfer operation b) Heat transfer operation
 c) Simultaneous heat and mass transfer d) Neither mass and heat transfer operation
7. For estimating the drier size it is necessary to know CO1-U
 a) Time of drying b) Heat of drying c) Speed of drying d) All of the mentioned
8. Direct dryers are CO1-U
 a) Batch driers b) Continuous driers
 c) Semi-batch driers d) None of the mentioned
9. How does concentration affect crystallization? CO1-U
 a) Increase in concentration leads to large crystals
 b) Decrease in concentration leads to large crystals
 c) Increase in concentration leads to small crystals
 d) Decrease in concentration leads to small crystals
10. What is meant by crystallization? CO1-U
 a) Concentration of atoms into a highly structured form
 b) Solidification of atoms into a highly structured form
 c) Solidification of solution
 d) Concentration of solution

PART – B (5 x 2= 10 Marks)

11. Define a mass transfer. CO1-U
12. What are the factors affecting the mass transfer Coefficient? CO2-App
13. How is the humidity ratio calculated using a psychrometric chart? CO2-App
14. What are the key steps involved in designing a dryer? CO2-App
15. What is the difference between batch and continuous crystallization? CO3-Ann

PART – C (5 x 16= 80 Marks)

16. (a) Discuss briefly about the classification of mass transfer operations. CO1- U (16)
 Or
 (b) Define mass transfer and explain its significance in chemical CO1- U (16)
 engineering and industrial processes

17. (a) Calculate the rate of sublimation from a Cylinder of Naphthalene 0.075m ID. by 6m long into a stream of pure Carbon dioxide flowing at a velocity of 6m/s at 1atm & 100^{°c} the vapour Pressure of Naphthalene at 373k and 1 atm. May be taken as 10mmHg and the diffusivity of naphthalene in Carbon dioxide as $8.3 \times 10^{-6} \text{ m}^2/\text{s}$. Density & Viscosity of Carbon dioxide are 0.946 kg/m^3 & $0.021 \times 10^{-3} \text{ p}$ respectively at operating condition.
 $C_f = 0.023(\text{Re})^{0.2}$, $(f/2 = 3.1648 \times 10^{-3})$ & $(\text{NA} = 6.073 \times 10^{-6} \text{ kmol/m}^2 \text{ s})$. Use analogy. CO2-App (16)
- Or
- (b) A pure gas is absorbed in a laminar liquid jet the volumetric flow rate of the liquid was 4cc/s & the diameter and length of jet were 0.1mm & 3mm respectively. The rate of absorption of A at atmospheric then Diffusivity is $1.23 \times 10^{-5} \text{ cm}^2/\text{s}$ pressure was 0.12cc/s at 273k. the solubility of gas final stage temperature at 303k is $(C_A^* = 0.001 \text{ gmol/cc.atm})$ then C_A is 0gmol/cc.atm Estimate the mass transfer coefficient. If the other diameter of jet is reduced to 0.09cm, under otherwise the same conditions how it would affect the rate of evaporation. Assume the validity of Higbie's penetration theory using mass transfer coefficient then a initial time at 22414 s & final time at 0.006s. CO2-App (16)
18. (a) Derive the general form of the humidity ratio and discuss its physical significance. CO3-Ann (16)
- Or
- (b) Derive the Equation for Degree of saturation. CO3-Ann (16)
19. (a) Wet solids contains 120kg/hr of dry stuff are dried continuously in a specially designed drier cross circulated with 2,000kg per hour of dry air under the following conditions: CO2-App (16)
- Ambient air temperature=20^{°c}
 Exhaust air temperature=75^{°c}
 Evaporation of water=150kg/hr
 Outlet solids moisture content=0.25kg/hr
 Inlet solids temperature=15^{°c}
 Outlet solids temperature=65^{°c}
 Power demand=5kw
 Heat loss=18kw
 Estimate heater load per unit mass of dry air and fraction of this heat used in evaporation of moisture.

Data:

Mean specific heat of dry air = $1 \text{ kJ kg}^{-1} \text{ K}^{-1}$

Or

- (b) 1500 kg dry weight of non-porous solid is dried under constant drying conditions. With an air velocity of 0.25 m/s, so that the surface area of drying is 4.5 m^2 . The critical moisture content of material may be taken as 0.155 kg water / kg dry solids? CO2-App (16)

(i) If the initial rate of drying is $0.2 \text{ g/m}^2 \cdot \text{s}$. How long will it take to dry the material from 0.10 to 0.020 kg water / kg dry solids?

(ii) If the air velocity were increased to 3.0 m/s, what would be the anticipated saving in time if surface evaporation is controlling. (Assume, $x^* = 0$).

20. (a) Mother liquor after crystallization has a solute content of 49.8 kg of CaCl_2 per 100 kg of water. Find out the weight of this solution needed to dissolve 100 kg of $\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$ at 25°C is 81.9 kg of CaCl_2 / 100 kg of water. CO2-App (16)

Or

- (b) Sodium nitrate solution at 45°C contains 30% by weight of sodium nitrate. CO2-App (16)

(i) Find out the percentage saturation of this solution.

(ii) Find out the weight of sodium nitrate crystal formed if 1500 kg of this solution is cooled to 15°C .

(iii) Find the percentage yield of this process.