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

**Autonomous Institute Affiliated to VTU**

## September / October 2023 Semester End Main Examinations

**Programme: B.E.** **Semester: IV**
**Branch: Chemical Engineering** **Duration: 3 hrs.**
**Course Code: 19CH4DCMT1 / 22CH4PCMT1** **Max Marks: 100**
**Course: Mass Transfer-I**

**Instructions**: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of steam table and humidity chart is allowed.

**Important Note:** Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

| | | UNIT - I | *CO* | *PO* | Marks |
|---|---|---|---|---|---|
| 1 | a) | Explain Fick's law of diffusion with an expression. Discuss the classification of mass transfer operations. | *CO1* | *PO1* | **04** |
| | b) | Calculate the rate of diffusion of NaCl at 20°C through a stagnant film of water 2 mm thick, when the concentrations are 20% and 10% respectively on either side of the film. Densities of 20% and 10% NaCl are 1.15 and 1.05 g/cc, respectively. The diffusivity of NaCl is $0.18 \times 10^{-6}$ $m^2/s$. | *CO 3* | *PO3* | **06** |
| | c) | Derive an equation for steady-state equimolar counter diffusion for liquids. | *CO 2* | *PO2* | **10** |
| | | **OR** | | | |
| 2 | a) | What is the application of the Wilkee-Lee equation? Write the equation and explain the terms. | *CO 1* | *PO1* | **05** |
| | b) | Solute A is absorbed from a gas mixture of A and B with liquid flowing as a thin film downward along the wall of a tower. At a certain point in the tower, the bulk gas concentration is 0.38 mole fraction and the bulk liquid concentration is 0.1 mole fraction. Solute A is moving and B is stagnant in the gas phase and gets absorbed in a non-diffusing liquid. Use the equilibrium data and find the interface compositions in both the liquid and gas phases. Considering the solution to be dilute, estimate flux conditions. Data is given as follows. | *CO 3* | *PO2* | **10** |

| $x_A$ | 0 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 |
|---|---|---|---|---|---|---|---|---|
| $y_A$ | 0 | 0.022 | 0.052 | 0.087 | 0.131 | 0.181 | 0.265 | 0.385 |

$k_y = 1.465 \times 10^{-3}$ kmol/m$^2$ s mole fraction and $k_x = 1.967 \times 10^{-3}$ kmol/m$^2$ s mole fraction

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|---|---|---|---|---|---|
| | c) | Discuss the diffusion through polymers. | *CO 1* | *PO1* | **05** |

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| | | | **UNIT - II** | | | |
| | 3 | a) | With schematic diagrams, elucidate the types of cooling towers used in industries. | *CO 1* | *PO1* | **10** |
| | | b) | In a mixture of benzene vapor (A) and nitrogen gas (B) at a total pressure of 800 mmHg and a temperature of 60°C, the partial pressure of benzene is 100 mmHg. Express the benzene concentration in mole fraction and volume fraction, and find absolute and molal absolute humidity. | *CO 4* | *PO2* | **10** |
| | | | **OR** | | | |
| | 4 | a) | Derive an equation for the adiabatic saturation temperature curve from basics. | *CO 2* | *PO2* | **07** |
| | | b) | With a neat diagram, elucidate the functions of various components in the spray chamber. | *CO 1* | *PO1* | **08** |
| | | c) | Draw the conditioning process of air in spray chambers and explain briefly. | *CO 1* | *PO1* | **05** |
| | | | **UNIT - III** | | | |
| | 5 | a) | Derive an equation to determine the time for a constant rate period. | *CO 2* | *PO2* | **05** |
| | | b) | Explain the classification of drying operations. | *CO 5* | *PO5* | **05** |
| | | c) | When a porous dry solid was dried under constant drying conditions, in a batch drier, it took 5 hours to reduce the moisture content from 30% to 10%. The critical moisture content was found to be 16%, and the equilibrium moisture content was 2%. All the moisture contents are on a dry basis. Assuming that the rate of drying during the falling rate period is proportional to the free moisture content, how long would it take to dry a sample of the above solids from 36% to 6% under the same drying conditions? | *CO 3* | *PO2* | **10** |
| | | | **UNIT - IV** | | | |
| | 6 | a) | With a suitable example, explain the application of the Freundlich equation. | *CO 1* | *PO1* | **08** |
| | | b) | Using material balance equations, obtain an expression to find the minimum total adsorbent for the two-stage counter-current operation. | *CO 2* | *PO2* | **08** |
| | | c) | What are the characteristics of industrial adsorbents? Name any four adsorbents used in industries. | *CO 1* | *PO1* | **04** |
| | | | **UNIT - V** | | | |
| | 7 | a) | What are the different methods of super-saturation? Explain. | *CO1* | *PO1* | **10** |
| | | b) | Classify the crystallizer equipment based on the methods of obtaining super-saturation. With a neat figure, explain the working and applications of the Swenson walker crystallizer. | *CO5* | *PO5* | **10** |

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