

**GUJARAT TECHNOLOGICAL UNIVERSITY****BE - SEMESTER-VIII (NEW) EXAMINATION – SUMMER 2024****Subject Code:2180507****Date:18-05-2024****Subject Name:Transport Phenomena****Time:10:30 AM TO 01:00 PM****Total Marks:70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Simple and non-programmable scientific calculators are allowed.

|            |                                                                                                                                                                                      | <b>Marks</b> |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <b>Q.1</b> | <b>(a)</b> State and explain the conservation law in transport phenomena.                                                                                                            | <b>03</b>    |
|            | <b>(b)</b> To model a temperature, heat and momentum transport for a given system, what are the steps are involved to derive the profile of temperature, concentration and velocity? | <b>04</b>    |
|            | <b>(c)</b> Differentiate between the Cartesian, cylindrical and spherical coordinate system in context to equation of continuity.                                                    | <b>07</b>    |
| <b>Q.2</b> | <b>(a)</b> Discuss the driving force for heat, mass and momentum transport.                                                                                                          | <b>03</b>    |
|            | <b>(b)</b> Compare and contrast the molecular and convective mechanisms for momentum transport.                                                                                      | <b>04</b>    |
|            | <b>(c)</b> Develop the shear stress and velocity distribution profile for the laminar flow through an inclined plane. State assumptions made while deriving these expressions.       | <b>07</b>    |
|            | <b>OR</b>                                                                                                                                                                            |              |
|            | <b>(c)</b> What is steady state condition? Explain the newton's law of viscosity with a suitable diagram.                                                                            | <b>07</b>    |
| <b>Q.3</b> | <b>(a)</b> Define and state the range of thermal conductivity for gas, liquid and solid.                                                                                             | <b>03</b>    |
|            | <b>(b)</b> Differentiate between natural and forced convection with a suitable diagram.                                                                                              | <b>04</b>    |
|            | <b>(c)</b> Develop the heat flux and temperature distribution profile for heat conduction in an electric wire. State assumptions made while deriving these expressions.              | <b>07</b>    |
|            | <b>OR</b>                                                                                                                                                                            |              |
| <b>Q.3</b> | <b>(a)</b> Discuss the temperature and pressure dependence of thermal conductivity of gases and liquids with suitable expression.                                                    | <b>03</b>    |
|            | <b>(b)</b> Signify the following dimensionless no: (1) Biot number (2) Brinkman number.                                                                                              | <b>04</b>    |
|            | <b>(c)</b> Develop the heat flux and temperature distribution profile for heat conduction involving viscous heat source. State assumptions made while deriving these expressions.    | <b>07</b>    |
| <b>Q.4</b> | <b>(a)</b> Define the following:<br>(1) Fick's law of diffusion<br>(2) Diffusivity                                                                                                   | <b>03</b>    |
|            | <b>(b)</b> State the assumption made while developing the model for heat flux and temperature profile for system involving chemical heat source?                                     | <b>04</b>    |

- (c) Derive equation of molar flux for steady state diffusion of one gaseous component through stagnant non diffusing second component. **07**
- OR**
- Q.4** (a) Discuss the significance of momentum, thermal and mass diffusivities? **03**
- (b) Define the following: **04**
- (1) Molecular Mass and Molar Fluxes
- (2) Convective Mass and Molar Fluxes
- (c) Derive equation of molar flux for steady state equimolar counter diffusion. **07**
- Q.5** (a) List out systems in the chemical engineering plant involving simultaneous heat, mass and momentum transport. Explain any one with suitable example? **03**
- (b) Compare and contrast limiting conditions for heterogeneous catalysis and homogeneous catalytic system. **04**
- (c) Hydrogen gas is maintained at 3 bar and 1 bar on opposite sides of a plastic membrane, which is 0.3 mm thick. The temperature is 25°C, and the binary diffusion coefficient of hydrogen in the plastic is  $8.7 \times 10^{-8} \text{ m}^2/\text{s}$ . The solubility of hydrogen in the membrane is  $1.5 \times 10^{-3} \text{ kmol/m}^3 \cdot \text{bar}$ . What is the mass diffusive flux of hydrogen through the membrane? **07**
- Assumption
1. Steady-state, one-dimensional conditions exist.
  2. Membrane is a stationary, non-reacting medium of uniform total molar concentration.
- OR**
- Q.5** (a) State the expression for **03**
- (1) equation of continuity of pure component
- (2) equation of continuity for multicomponent system.
- Give the examples of each used in chemical engineering.
- (b) Explain temperature and pressure dependency of diffusivity. **04**
- (c) Helium gas is stored at 20°C in a spherical container of fused silica ( $\text{SiO}_2$ ), which has a diameter of 0.20 m and a wall thickness of 2 mm. If the container is charged to an initial pressure of 4 bars, what is the rate at which this pressure decreases with time? **07**
- Data:
- $D_{AB} = 0.4 \times 10^{-13} \text{ m}^2/\text{s}$
- $S = 0.45 \times 10^{-3} \text{ kmol/m}^3 \cdot \text{bar}$
- Assumption
1. Diffusion is one-dimensional and quasi-steady through a plane wall.
  3. Stationary medium has uniform density.
  4. Pressure of helium in outside air is negligible.
  5. Helium exhibits ideal gas behavior.

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