

GUJARAT TECHNOLOGICAL UNIVERSITY**BE – SEMESTER- VIII EXAMINATION-SUMMER 2023****Subject Code: 2180507****Date: 15/06/2023****Subject Name: Transport Phenomena****Time: 02:30 PM TO 05:00 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.

- Q.1** (a) Why the momentum, heat and mass transport should be studied together? **03**
(b) With neat sketch derive the expression for Newton's law of viscosity. **04**
(c) Make a differential momentum balance and obtain the expression for the distributions of momentum flux and velocity for the flow of a fluid through a circular tube. **07**

- Q.2** (a) State the Hagen-Poiseuille law with all the necessary assumptions. **03**
(b) One method for determining the radius of a capillary tube is by measuring the rate of flow of a Newtonian liquid through the tube. Find the radius of a capillary from the given data: Length of capillary tube 50.02 cm, Kinematic viscosity of liquid $4.03 \times 10^{-5} \text{ m}^2/\text{s}$, Density of liquid $0.9552 \times 10^3 \text{ kg/m}^3$, Pressure drop in the horizontal tube $4.829 \times 10^5 \text{ Pa}$, Mass rate of flow through tube $2.997 \times 10^{-3} \text{ kg/s}$. **04**
(c) Derive the equation for velocity and shear stress distributions in a couette viscometer for the tangential laminar flow of an incompressible fluid flowing between two coaxial cylinders, the outer one of which is rotating with an angular velocity Ω . **07**

OR

- (c) Make a differential momentum balance and obtain the expression for the distributions of momentum flux and velocity for the flow of two immiscible fluids flowing in a horizontal thin slit. **07**
- Q.3** (a) Write the equation of Fourier's law of heat conduction with the physical significance of each term. **03**
(b) State the equation and physical significance of Prandtl and Nusselt number. **04**
(c) Derive the equation for the temperature distribution, maximum temperature rise and average temperature for an electrical heat source. **07**

OR

- Q.3** (a) What is free and forced convection heat transport? State the two examples of each. **03**
(b) A plastic panel of area 929 cm^2 and thickness 0.640 cm was found to conduct heat at a rate of 0.717 cal/s steady state with temperatures $T_0 = 24^\circ\text{C}$ and $T_1 = 26^\circ\text{C}$ imposed on the two main surfaces. What is the thermal conductivity of the plastic in cal/cm.s. K at 25°C ? **04**
(c) Derive the expression for the heat conduction with chemical heat source. **07**

- Q.4 (a)** State the different boundary conditions used to solve heat transport problems. **03**
(b) Differentiate between thermal conductivity and thermal diffusivity with necessary equations. **04**
(c) Obtain the temperature distribution profiles for the heat transfer in forced convection laminar flow near a heated flat plate immersed in a viscous fluid. **07**

OR

- Q.4 (a)** Compare Fick's law of diffusion with Newton's law of viscosity. **03**
(b) Show that only one diffusivity value is needed to describe the diffusional behavior of an isotropic binary mixture. **04**
(c) Derive an expression for the diffusion through a stagnant gas film. **07**
Q.5 (a) Briefly discuss the molecular diffusion in gases with appropriate equations. **03**
(b) State the fundamental difference between N , J & n , j . **04**
(c) With neat diagram derive an equation of molar flux for the diffusion with heterogeneous chemical reaction as $2A \rightarrow A_2$. **07**

OR

- Q.5 (a)** Compare and contrast the mass average velocity and the molar average velocity. **03**
(b) State the dimensionless groups to express relation between mass diffusivity, thermal diffusivity and momentum diffusivity along with their significance. **04**
(c) Calculate the steady-state mass flux of helium at 500°C. The partial pressure of helium is 1 atm at $y = 0$ and zero at the upper surface of the plate. The thickness Y of the Pyrex plate is 0.01 mm, and its density is 2.6 g/cm³. The solubility and diffusivity of helium in Pyrex are reported as 0.0084 volumes of gaseous helium per volume of glass, and $\mathcal{D}_{AB} = 0.2 \times 10^{-7}$ cm²/s, respectively. **07**
