Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER- VII EXAMINATION-SUMMER 2023

Subject Code: 3170511 Date: 19/06/2023

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.**

			Marks
Q.1	**(a)**	Write the general governing equation for transport processes.	**03**
	(b)	Explain momentum diffusivity and thermal diffusivity.	**04**
	(c)	Velocity vector for a flow field is given by $v = iv_x + jv_y + kv_z$ Find which of the following cases represents incompressible flow. a. $v_x = 2(x^2 - y^2 + z^2),\ v_y = -4xy - 4xz,\ v_z = 2xy$ b. $v_x = x^2,\ v_y = yx - xz,\ v_z = y - 3xz$	**07**
Q.2	**(a)**	Define mass average and molar average velocities	**03**
	(b)	Compare and contrast the molecular and convective momentum transport.	**04**
	(c)	Derive the equation of energy for pure Newtonian incompressible fluids with constant thermal conductivity and explain the terms involved in it.	**07**
		OR	
Q.2	**(c)**	Consider an electric wire of circular cross section with radius *R* and electrical conductivity k_e ohm^{-1} cm^{-1}. Through this wire there is an electric current with current density I amp/cm^2. The transmission of an electric current is an irreversible process, and some electrical energy is converted into heat (thermal energy). The rate of heat production per unit volume is given by the expression $S_e = I^2/k_e$. The outer surface the wire is exposed to air at ambient temperature T_{air}. Find the radial temperature profile $T\text{-}T_{air}$.	**07**
Q.3	**(a)**	Define binary diffusivity	**03**
	(b)	State and explain Fick's law of binary diffusion.	**04**
	(c)	Derive equation of molar flux for steady state diffusion of one gaseous component through stagnant non diffusing second component.	**07**
		OR	
Q.3	**(a)**	Define mass and molar average concentration.	**03**
	(b)	Explain temperature and pressure dependency of binary diffusivity.	**04**
	(c)	With neat diagram derive an equation of molar flux for the diffusion with heterogeneous chemical reaction as $2A \longrightarrow B$	**07**
Q.4	**(a)**	Discuss equilibrium counter diffusion.	**03**
	(b)	An oil has a kinematic viscosity of $2\text{x}10^{-4}$ m^2/s and a density of $0.8\text{x}10^3$ kg/m^3. If we want to have a falling film of the oil of thickness 2.5 mm on a vertical wall, calculate the mass rate of flow of the oil per unit width of the film?	**04**

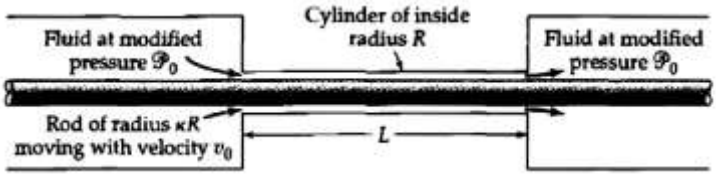
(c) An incompressible Newtonian fluid is flowing through a long cylindrical pipe of radius ***R*** and length ***L*** under a constant pressure gradient. Obtain the velocity and shear stress profile for the flow. **07**

OR

Q.4 **(a)** Explain Knudsen diffusivity. **03**

(b) Calculate the radius of a capillary from the following flow data: **04**
Length of capillary tube: 50.02 cm
Kinematic viscosity of liquid: 4.03×10^{-5} m^2/s
Density of liquid: 0.9552×10^3 kg/m^3
Pressure drop in the horizontal tube: 4.829×10^5 Pa
Mass rate of flow through tube: 2.997×10^{-3} kg/s

(c) A cylindrical rod of radius $\boldsymbol{KR}$ moves axially with velocity $\boldsymbol{v_z = v_o}$ along the axis of a cylindrical cavity of radius ***R*** as seen in the figure. The pressure at both ends of the cavity is the same, so that the fluid moves through the annular region solely because of the rod motion. Find the velocity distribution in the narrow annular region. **07**



Q.5 **(a)** What are isotropic fluids? **03**

(b) A copper wire, 5 mm in diameter and 15 ft long, has a voltage drop of 0.6 volts. Find the maximum temperature in the wire if the ambient air temperature is 25°C and the heat transfer coefficient h is 32.36 W/m^2K. The thermal conductivity of copper is 384.1 W/m.K. Given Data: Lorenz constant: $k/(k_eT_0) = 233 \times 10^{-8}$ $volt^2/K^2$. **04**

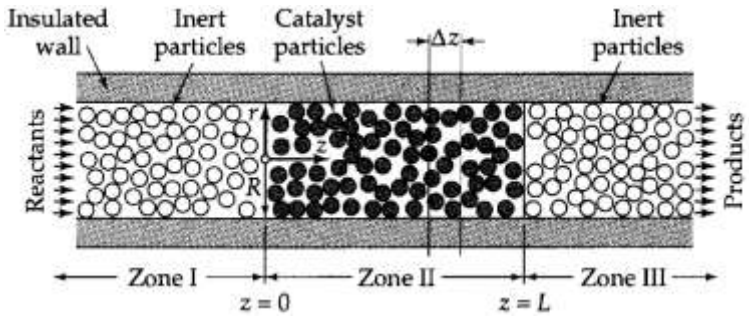
(c) Derive the temperature distribution for heat conduction due to the viscous heat dissipation for flow of an incompressible Newtonian fluid between two concentric cylinders. **07**

OR

Q.5 **(a)** Explain the Newton's law of viscosity. **03**

(b) A plastic panel of area A = 1 ft^2 and thickness Y = 0.252 in. was found to conduct heat at a rate of 3 W at steady state with temperatures T_o = 24 ºC and T_1 = 26 ºC imposed on the two main surfaces. What is the thermal conductivity of the plastic at 25 ºC? **04**

(c) For the fixed-bed axial flow reactor shown in figure, derive the steady state axial temperature distribution. The fluid is flowing axially in plug flow with superficial velocity v_0. **07**



The reactants enter at z = -∞ and leave at z = +∞. The reaction zone is from z = 0 to z = L.

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