Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII EXAMINATION – SUMMER 2025

Subject Code:3170511 Date:27-05-2025

Subject Name:Transport Phenomena

Time:02:30 PM TO 05:00 PM Total Marks:70

Instructions:

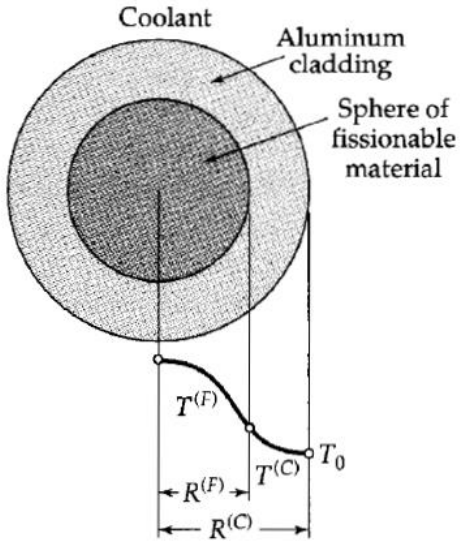
1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			Marks
Q.1	**(a)**	Write an expression for combined heat, mass and momentum transport.	**03**
	(b)	Compute the mean molecular velocity ū (in cm/s) and the mean free path λ (in cm) for oxygen at 1 atm. and 273.2 K. A reasonable value for diameter is 3 Å. What is the ratio of the mean free path to the molecular diameter under these conditions? What would be the order of magnitude of the corresponding ratio in the liquid state?	**04**
	(c)	For a steady-state axial flow of an incompressible liquid in a circular pipe, The Momentum flux profile is given by $\tau_{rz} = \left(\frac{\mathcal{P}_0 - \mathcal{P}_L}{2L}\right) r$ Find the Velocity profile as a function of r. Also, find 1. The maximum velocity 1. The average velocity 2. The mass flow rate 3. The force exerted by the fluid on the solid surfaces.	**07**
Q.2	**(a)**	What are Boundary conditions? Write commonly used boundary conditions for energy transport.	**03**
	(b)	Write the equation for Fourier's law of heat conduction. Explain the case where thermal conductivity and effective thermal conductivity are used.	**04**
	(c)	Develop the shear stress and velocity distribution profile for the laminar flow through the annulus. State assumptions made while deriving these expressions.	**07**
		OR	
	(c)	Develop an expression for the equation of continuity involving cylindrical coordinates.	**07**
Q.3	**(a)**	Write an expression for the following: 1. Convective energy flux vector 2. Molecular work flux vector 3. Molecular heat flux vector	**03**
	(b)	Define thermal diffusivity. The wall of an industrial furnace is constructed from 0.15 m thick fireclay brick having a thermal conductivity of 1.7 W/m.K. Measurements made during steady-state operation show 1400 and 1150 K at the inner and outer surfaces, respectively. What is the rate of heat loss through a wall of 0.5 m × 1.2 m on a side?	**04**

Assumptions
(1) One-dimensional conduction
(2) Steady-state conditions
(3) Constant properties.

(c) Develop the heat flux and temperature distribution profile for heat conduction involving nucleus heat source S_n. **07**

$$S_n = S_{n0}\left[1 + b\left(\frac{r}{R^{(F)}}\right)^2\right]$$



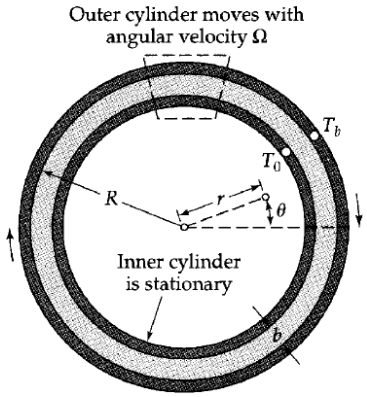
State assumptions made while deriving these expressions.

OR

Q.3 **(a)** How thermal conductivity of a material is affected by its size, shape and composition? **03**

(b) Compare the temperature dependence of the thermal conductivities of gases, liquids, and solids. **04**

(c) i. An oil acting as a lubricant for a pair of cylindrical surfaces is shown in Fig. **07**



The differential form of energy balance expression is given as

$$-k\frac{dT}{dx} - \mu v_z \frac{dv_z}{dx} = C_1$$

Where C_1 is constant term.
Assume linear velocity profile

$v_z = v_b(x/b)$

in the above differential expression and develop a profile for a temperature of the fluid as a function of x using appropriate boundary conditions.

ii. The angular velocity of the outer cylinder is 7908 rpm. The outer cylinder has a radius of 5.06 cm, and the clearance between the cylinders is 0.027 cm. What is the maximum temperature in the oil if both wall temperatures are known to be 70°C? The physical properties of the oil are assumed constant at the following values:
Data :
Viscosity: 92.3 cp
Density: 1.22 g/cm^3
Thermal conductivity: 0.0055 Cal /s.cm. C

Q.4 **(a)** Write in brief about Mass average and molar average velocity. **03**

(b) Discuss Fick's law of diffusion with a suitable diagram. **04**

(c) A graduated cylinder cross-sectional diameter of 0.01128 m containing chloropicrin ($CC1_3NO_2$) is placed in a hood. The hood has a blower system that continually circulates dry air at a constant temperature (25°C) and pressure (atmospheric). Originally, the liquid surface was 0.0388 m from the top of the cylinder. After one day the liquid level is 0.0412 m below the top. If the vapour pressure and density of chloropicrin are 3178.3 N/m^2 and 1650 kg/m^3 respectively, estimate the substance diffusivity in air. The molecular weight of chloropicrin is 164.39 Kg/Kmol. **07**

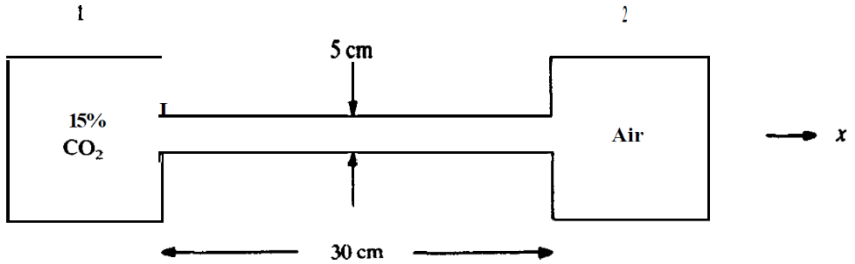
OR

Q.4 **(a)** Define the following **03**

1. Molecular mass flux
2. Convective mass flux

(b) What is the role of boundary conditions in shell mass balance? State the common boundary conditions for shell mass balance. **04**

(c) A tank containing 15 mole % of CO_2 in air is connected to a second tank containing only air. The connection line is 5 cm in diameter and 30 cm long, as shown in Fig. **07**



Both tanks are at 1 atmospheric pressure and 298.15 K. The volume of each tank is large compared to the volume of gas in the 30 cm connection line so concentration changes in each tank are negligible for a very long time after the beginning of the experiment. The diffusion coefficient of CO_2 in air at 1 atm. and 25°C is 0.164×10^4 m^2 s^{-1}. Calculate the initial rate of mass transfer of the CO_2?
Assume that both gases are ideal and the diffusional transfer is equimolar counter diffusion.

Q.5 **(a)** Define the following **03**

1. Self-diffusion
2. Biot Number
3. Lewis number

	(b)	How does the equation of change differ in single-component and multicomponent systems?	**04**
	(c)	Derive an expression for heat flux and temperature profile involving heat conduction in electric heat.	**07**

OR

Q.5	**(a)**	Define the following 1. Brinkman Number 2. Thiele modulus 3. Schmidt Number	**03**
	(b)	Discuss the effect of temperature and pressure on Diffusivity for 1. Binary gas mixtures 2. Liquid	**04**
	(c)	Distinguish between homogeneous and heterogeneous reactions. Discuss phenomena of diffusion-controlled reaction with a suitable example.	**07**

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