BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
Second Semester 2022-2023
CHE F414 Transport Phenomena
Mid Semester Exam (Closed Book)

Date: 16.03.2023, 2-3:30 PM **Duration: 90 Min.** **Total Marks: 30**

- **State and justify any assumptions that you make. Nomenclature should be defined properly.**

Q.1 Briefly answer the following questions.

a. Compare Newton's law of Viscosity, Fourier's Law of Heat Conduction, and Fick's Law of diffusion.

b. Glycerine at 25 ºC flows through a horizontal tube 25 cm long and 2.5 mm inside diameter. For a pressure drop of 250 kPa, the volume flow rate is 6 liter/hr. The density of glycerine at 25 ºC is 1.25 g/cm^3. Determine the viscosity of glycerine.

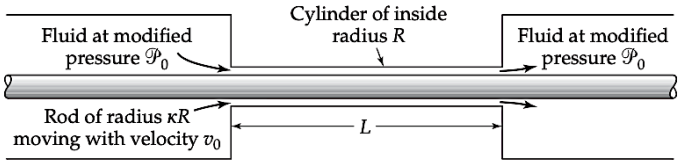
c. A plastic panel area of 1 m^2 and thickness of 6 mm was found to conduct heat at a rate of 30 J/s at a steady state with a temperature difference of 2ºC imposed between two main surfaces. Determine the thermal conductivity of the plastic.

d. Define and state the significance of the Reynolds number, Prandtl number, Schmidt number, and Lewis number.

[4*2 = 8 M]

Q.2 A cylindrical rod of radius kR moves axially with velocity v_0 along the axis of a cylindrical cavity of radius R. The pressure at both ends of the cavity can be assumed to be as same. The fluid moves through the annular region solely because of the rod motion. The figure shows the schematic of the flow. (a) Make the shell momentum balance, (b) write the relevant boundary conditions, (c) derive the governing equation for the velocity distribution, (d) determine the velocity distribution in the narrow annular region, and (e) mass rate of flow through the annular region.

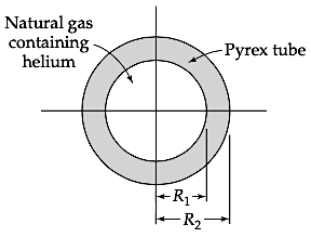
[8 M]



Q.3 Consider an electrical wire of a circular cross-section with a radius R and length L with an electrical heat source. The electrical heat S_e is energy production per unit volume in the wire. Assume the thermal conductivity and electrical conductivity are independent of temperature. The surface of the wire is maintained at temperature T_0. (a) Make a shell energy balance, (b) state the boundary conditions, (c) derive the governing equation for heat flux, and then governing equation for the temperature, (d) determine the temperature distribution in the wire, (e) average temperature rise, (f) maximum temperature rise.

[8 M]

Q.4 Pyrex glass is almost impermeable for all gases except Helium and may be used to separate Helium from a gas mixture. Consider a stream of natural gas containing helium (A) in a Pyrex (B) tube of the dimensions given in the figure. The concentration of helium at R_1 is C_{A1} and at R_2 is C_{A2}. Using the shell mass balance approach: (a) determine the concentration of helium in the Pyrex tube in the r direction, (b) determine the flux of helium (N_{Ar}) through the Pyrex. Assume the convective flux of A is zero ($N_{Br} = 0$ since x_A is very small). Fick's law of diffusion is applicable.



[6 M]

~ALL THE BEST~