MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

V SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATION – DEC 2021 / JAN 2022

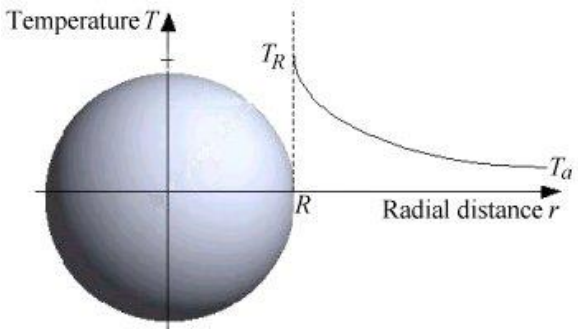
SUBJECT: TRANSPORT PHENOMENA (CHE 3154)

(Part B – Descriptive)

Date of Exam: 30/12/2022 **Time: 75 + 10 min** **Max. Marks:** 20

Instructions to Candidates:

- Answer ALL the questions & missing data may be suitable assumed
- Use of formula sheet is permitted

1A	Assume a Newtonian fluid is flowing through a circular pipe under laminar conditions. The distribution of velocity, u (m/sec) with radius 'r' in 'm' inside the pipe of 120 mm inner diameter is given by, $u = 6 - M r^2$,where M is a constant. Determine the flow rate in m^3/s.	**2**
1B	• A heated sphere of diameter D is placed in a large amount of stagnant fluid. Consider the heat conduction in the fluid surrounding the sphere in the absence of convection. The thermal conductivity k of the fluid may be considered constant. The temperature at the sphere surface is T_R and the temperature far away from the sphere is T_a.  • Set up the differential equation describing the temperature T in the surrounding fluid as a function of r, the distance from the centre of the sphere and determine the temperature profile. (Boundary conditions: @r=R, $T = T_R$ and @ $r = \infty$, $T = T_a$)	**3**
1C	A Newtonian fluid flows down an inclined (θ = angle of inclination with horizontal axis) plane surface in a steady, fully developed laminar film of thickness 'H'. Obtain the expressions for the fluid velocity profile and maximum velocity using Navier-Stokes equations.	**5**
2A	If Thiele-modulus parameter is given by the following expression, $$\varphi = \frac{V_p}{S_x} \frac{\lvert -r_A \rvert_{C_{AS}}}{\sqrt{2}} \left\{ \int_0^{C_{AS}} D_{Ae}(-r_A) dC_A \right\}^{-1/2}$$ Derive an expression for the same for a flat plate catalyst, I order reaction.	**2**
2B	You have a spherical porous particle (8mm) used for a first order reaction with a rate constant of 0.002 sec^{-1} and an effective diffusivity of 2×10^{-9} m^2/sec. The concentration of the reactant A at the surface is 3×10^{-3} kg/m^3. Calculate the steady-state substrate concentration inside the particle at 3, 2 and 1 mm distance from the center (No need to plot the data).	**3**
2C	Derive an expression for the substrate concentration with respect to the distance inside a flat slab catalyst. Assume that the substrate is transferred by molecular diffusion in the x direction only and the slab is thick enough to catalyze all the substrate while it diffuses into the slab.	**5**