Reg. No.

B.TECH. DEGREE EXAMINATIONS, MAY 2023

Seventh Semester

CH16704 – TRANSPORT PHENOMENA

(Chemical Engineering)

(Regulation 2016)

Time: Three Hours **Maximum : 100 Marks**

Answer ALL questions

PART A - (10 X 2 = 20 Marks)

1. Illustrate the meaning of substantial time derivative with example.
2. Differentiate Eulerian and lagrangian frames of reference.
3. Elucidate the shell balance approach used to derive transport equations.
4. Show that the ratio of average velocity to the maximum velocity for the laminar flow of a Newtonian fluid in a circular tube is 1/2.
5. Sketch the temperature distribution of a cylindrical wire heated using an electrical heat source.
6. Write the commonly used boundary conditions for deriving mass transport (diffusion) equations combined with chemical reactions.
7. Write the Navier-stokes equation and its application.
8. Demonstrate the application of scale factors in scale-up.
9. Differentiate instantaneous pressure and time-smoothed pressure.
10. Elucidate the condition at which the thermal boundary layer thickness is greater than the momentum boundary layer.

PART B - (5 X16 = 80 Marks)

11. (a) Elucidate in detail the two parameter and three parameter Rheological models to describe fluid flow behaviour. **(16)**

(OR)

(b) Explain the theory of viscosity of liquids and gases at low density. State the assumptions involved clearly. **(16)**

12. (a) Consider the flow of a Newtonian fluid over an inclined plane. Derive the expression for the maximum velocity, average velocity, volumetric flow rate, Forces acting on the wall surface. Calculate the ratio of average velocity to the maximum velocity of the fluid. State the assumptions clearly. **(16)**

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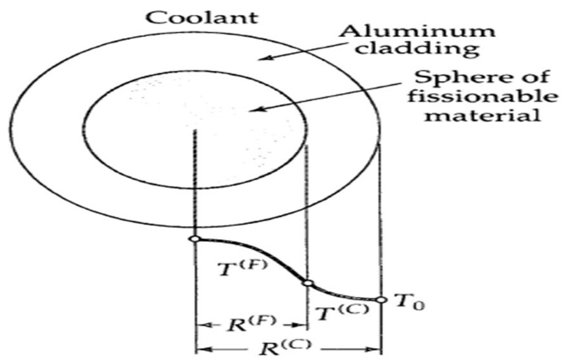
(OR)

12. (b) A viscous fluid is in laminar flow in a slit formed by two parallel wall distance 2B apart. Perform a differential momentum balance and obtained the expressions for the distributions of momentum flux and velocity. Derive the analogous equation of Hagen-Poiseuille law for slit flow. **(16)**

13. (a) Consider a nuclear fuel element shown in the figure. Using a suitable second order equation for the generation of heat energy by nuclear fission, derive the temperature profile equations for the sphere of fissionable material, and the expression for amount of heat. **(16)**



(OR)

13. (b) Consider the diffusion of Acetone from a beaker to the surrounding air. Using the Fick's law of diffusion, derive the equation for the concentration profile of Acetone diffusing to air by setting up a shell mass balance. **(16)**

14. (a) A fluid of constant density and viscosity is in a vertical cylindrical container of radius R. The container is made to rotate about its own axis with an angular velocity. Using equations of change, derive the expression for the shape of the free surface as a function of angular velocity, when steady state has been established. Comment on the shape of the free surface. State the assumptions made clearly. **(16)**

(OR)

14. (b) A Solid cylinder in which heat generation is occurring uniformly is insulated on its ends. The temperature of the surface of the cylinder is held constant at T_w. The radius of the cylinder is R_m. Using the equations of change, derive an equation for the temperature **(16)**

profile at steady state if the solid has a constant thermal conductivity. State the assumptions made clearly.

15. (a) Air passes through a naphthalene tube, that has an inside diameter of 2.5 cm, flowing at a bulk velocity of 15 m/s. The air is at 283 K and an average pressure of 1.013×10^{5} Pa. Assuming that the change in pressure along the tube is negligible and that the naphthalene surface is at 283 K, determine the length of tube that is necessary to produce a naphthalene concentration in the exiting gas stream of 4.75×10^{-4} mol/m^3. At 283 K, naphthalene has a vapor pressure of 3 Pa and a diffusivity in air of 5.4×10^{-6} m^2/s. Use Fanning Friction factor $f = 0.007\ Re^{0.11}$. **(16)**

(OR)

15. (b) An oil is manufactured by the vapour phase catalytic reaction. The reaction gas mixture leaving the catalytic reactor in the plant is condensed in a shell-and-tube heat exchanger. The condensation occurs on the shell side while the cooling water flows through the tubes. The tubes are 3 m long and 25 mm outside diameter, 21.2 mm inside diameter. Water flows at a rate of 0.057 m^3/min per tube. Water enters at 32 °C. The tube wall temperature may be assumed to be constant at 80 °C. Calculate the heat transfer coefficient by the Reynolds analogy and Prandtl analogy. **(16)**

Properties of water: Density = 995 kg/m^3, Viscosity = 7.65×10^{-4} kg/m.s, Thermal conductivity = 0.623 W/m°C, Specific heat = 4. 17 kJ/kg°C.

The Fanning Friction factor may be calculated using the relation $f = 0.0014 + (0.125/N_{Re}^{0.32})$.

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