U.S.N.										

B. M. S. College of Engineering, Bengaluru - 560019

Autonomous Institute Affiliated to VTU

August 2024 Supplementary Examinations

Programme: B.E. **Semester: V**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code:19CH5DCTRP **Max Marks: 100**
Course: Transport Phenomena

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1. a) State the Fourier's law of heat conduction and Fick's law of diffusion. **06**

b) A stainless steel (SS) panel of area A=1000 mm^2 and thickness Y= 0.0064 m, was found to conduct heat at a rate of 0.3W at steady state with temperatures T_0=25°C and T=60°C imposed on the two surfaces. **08**

i. Calculate the thermal conductivity of the SS material at 55°C.
ii. If the metal panel is replaced by brass material of same thickness as SS metal panel, conducts the same heat transfer rate of 3 W, with the thermal conductivity of the brass panel is 103.74 W/mK estimate the temperature difference in the brass panel.

c) What is the effect of temperature on thermal conductivity? **06**

UNIT - II

2. a) A Newtonian fluid is flowing through a circular pipe due to pressure difference. The flow is under steady state, laminar flow condition with constant density and viscosity in a circular tube of length (L) and radius (R). Find the average and maximum velocity. **12**

b) Oil is flowing in a laminar region in a 1.27×10^{-2} m diameter tube at the rate of 22.72 L/min. The oil viscosity is 250×10^{-3} Ns/m^2 and its density is 958 kg/m^3. Calculate **08**

i) The pressure drop per meter of the pipe length
ii) Wall Stress in N/m^2
iii) The velocity at the center of the tube

OR

3. a) A non-Newtonian fluid is flowing through a circular vertical tube due to pressure difference of length (L) and radius (R). Derive an expression for the shear stress and the maximum velocity & mass flow rate. **14**

b) A Newtonian liquid of viscosity μ is 0.1 N s/m^2 is flowing through a pipe. As a result of a process change a small quantity of polymer is added to the liquid and this causes the liquid to exhibit non-Newtonian characteristics; its rheology is described adequately by the "power law" **06**

model and the flow index *i.e.*, it obeys $\tau = \mu\left(-\frac{dv}{dx}\right)^n$, n is 0.33. The apparent viscosity (μ_a) of the modified fluid is equal to the viscosity (μ) of the original liquid at a shear rate, $\frac{du}{dy}$ is 1000 s^{-1}. Determine the rheological properties and represent as a rheological equation.

UNIT - III

4. a) Heat is generated within a solid sphere of radius R at a rate of S_n and this heat varies parabolically as $S_n = S_{n0}\left[1 + b\left(\frac{r}{R}\right)^2\right]$ where S_{n0} is the heat produced per unit volume at the center. The surface of the sphere is kept at a constant temperature. The thermal conductivity can be assumed to be constant. Derive an expression for steady state heat flux and temperature distribution. **14**

b) Heat is generated within a sphere at a rate of 10×10^5 kW/m^3. The diameter of the sphere is 0.16 m. The surface temperature of sphere is 100°C. The thermal conductivity of the metal of the sphere is 1400 W/m °C. Calculate the temperature (a) at the center of the sphere (b) at 0.02 m. **06**

OR

5. a) An iron rod is covered with three different materials of insulation A, B and C. Develop an expression for heat transfer by conduction through the composite material. **10**

b) A standard steel pipe of inside diameter 5.2 cm and wall thickness 0.31 cm is carrying steam and is insulated with 5 cm layer of 85% magnesia covered with 10 cm layer of cork material. Estimate heat loss per hour per meter of pipe if the inside surface of pipe is maintained at 140°C and outer surface of cork is 30°C. Given k_{steel} = 42.2 W/mK, $k_{85\%\ magnesia}$ = 0.09 W/mK and k_{cork} = 0.03 W/mK. Calculate the interface temperatures. **10**

UNIT - IV

6. a) Determine the expression for flux for a gas A diffusing through a stagnant gas B. **10**

b) Oxygen (X) is diffusing through methane gas (Y) under steady state conditions with methane gas non-diffusing. The total pressure is 1×10^7 Pa, and the temperature 10°C. The partial pressure of oxygen at two planes 2 mm apart is 13,000 and 6500 Pa, respectively. The diffusivity of the mixture is 1.86×10^{-5} m^2/s. Calculate the rate of diffusion of oxygen in kmol/s through each square meter of two planes **10**

UNIT - V

7. a) Briefly explain the Reynolds analogy and Colburn Chilton analogy. **06**

b) Derive an equation of continuity in Cartesian co-ordinates. **10**

c) Write the Navier-Stokes equation and Euler equation. For what type of fluid/flow are these equations applicable? **04**

*****