(Time: 3 Hours) **(Marks: 80)**

Instructions: **(1) Question No. 1 is compulsory.**
(2) Attempt any three questions from remaining five questions.
(3) Assume suitable data if necessary.
(4) Figure to the right indicates marks

Q. 1 **Answer any four questions** **20**

a) Explain Analogy between heat and mass transfer.

b) Explain and write Fourier's law of heat conduction in three-dimensional form.

c) What is diffusion? What factors may cause diffusion to occur?

d) Explain rules for writing shell mass balance.

e) Explain thermal conductivity and thermal diffusivity?

f) Explain and write the Navier-Stokes Equation and define the terms involved.

Q. 2

a) Derive an expression for momentum flux and velocity distribution for flow of falling film over an inclined plate. **10**

b) Compute the thermal conductivity of gas mixture, 30% methane & 70% ethane, at 1 atm & 373.2K. **10**

Species	Ω_μ	σ, Å	C_p, cal/gmol · K
Methane	1.1	4.4	7.134
Ethane	1.2	4.5	7.213

Q. 3

a) Derive Navier-Stokes Equation and define the terms involved. **10**

b) A value of $D_{AB} = 0.151$ cm^2/sec has been found for the system CO_2-air at 293K and 1atm. Calculate D_{AB} at 1500K by the following methods. a) Slattery Equations, b) Chapman Enskog Equation **10**
Data: For non-polar gas pairs,
b = 1.823, $(\Omega_{DAB})_{1500} = 0.734$, $(\Omega_{DAB})_{293} = 1.047$

Q. 4

a) Derive an expression for the ratio of average velocity to maximum velocity for a Newtonian fluid flowing through a circular tube. **10**

b) For an electrically heated cylindrical wire, show that the temperature distribution is **10**

$$T - T_0 = \frac{S_e R^2}{4K}\left[1 - \left(\frac{r}{R}\right)^2\right] \quad \text{and} \quad T_{max} - T_0 = \frac{S_e R^2}{4K}$$

Q. 5

a) Heat is being generated uniformly by a chemical reaction in long cylinder of radius 91.44 mm. The generation rate constant at 46.6 W/m^3. The wall of the cylinder are cooled so that wall temperature is held constant at 311 K. The thermal conductivity is 0.865 W/m K. Calculate the centerline temperature. **10**

b) Derive an expression for diffusion through stagnant gas film. **10**

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Q. 6

a) A small capillary tube with an inside diameter of 2.2×10^{-3} m and length of 0.317 m is beingcontinuously used to measure the rate of flow of liquid having density 990 kg/m^3 and viscosity of fluid, $\mu = 1.13\times10^{-3}$ Pa.s. The velocity of liquid is 0.275 m/sec. Calculate the pressure drop. **10**

b) The thermal conductivity of an insulating material was measured. The temperature of a flat slab of 25 mm of the material was measured to be 318.4 K and 303.2 K. The heat flux wasmeasured to be 35.1 W/m^2. Calculate the thermal conductivity of the material. **05**

c) If an *O2-N2* gas mixture at 1 atm. and 25^{o}C, the concentration of *O2* at two planes 2 mm apartare 10 % and 20 % (v/v) respectively. Calculate the flux of diffusion of *O2* for the case where A) *N2* is non-diffusing. B) For equimolar counter diffusion of gases. Given: *DO2-N2* at 0^{o}C $=1.86\times10^{-5}$ m^2/s. **05**

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