(3 Hours) **[Total Marks : 80**

N.B.

1) Question 1 is compulsory.
2) Attempt 3 questions out of remaining 5 questions.
3) Assume data whenever necessary.
4) Figures to the right indicate full marks.

Q1: Write short notes on: (20)

i) Describe similarity between Fick's law, Fourier's law and Newton's law.

ii) Explain temperature and pressure dependence of thermal conductivity.

iii) What are commonly used boundary conditions used for finding constants of integration in shell energy balances?

iv) Explain rules for writing shell mass balances.

Q.2. (a): Starting from basic principles, develop equation of continuity for isothermal,incompressible fluid flow system .Can equation of continuity be applied to nuclear reactions? (10)

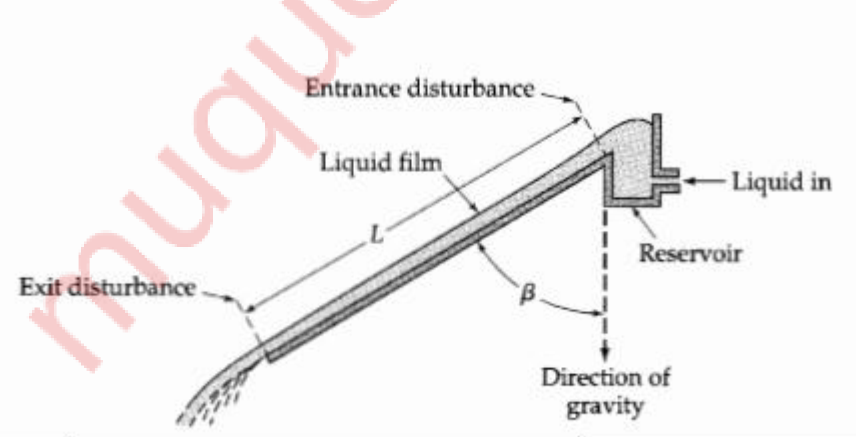
(b) Find the radius of capillary tube from following data:

1) Length of capillary tube :50.02 cm
2) Kinematic viscosity of liquid :4.03×10^{-5} Pa
3) Density of liquid :0.9552×10^{3} kg/m^{3}
4) Pressure drop in horizontal tube :4.829×10^{-5} Pa
5) Mass flow flow flow through tube : 2.997×10^{-3} kg/s (10)

Q.3. (a):A Newtonian,incompressible fluid is flowing over a inclined flat plate of length L and width W.Take a shell momentum balance and derive equation for

(i) Shear stress distribution (ii) Velocity distribution

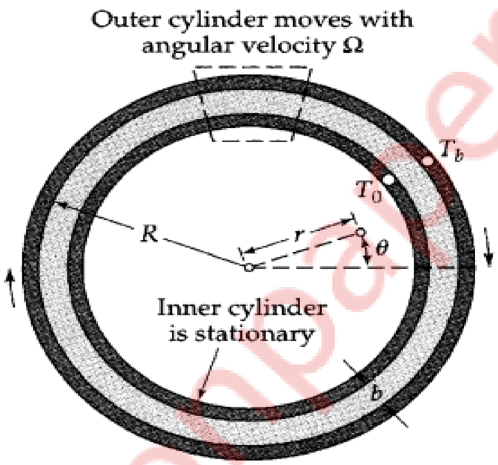
(iii) Average velocity (iv) Maximum velocity (16)



(b) Estimate thermal conductivity of molecular oxygen at 300 K and low pressure. Following data is given. (04)

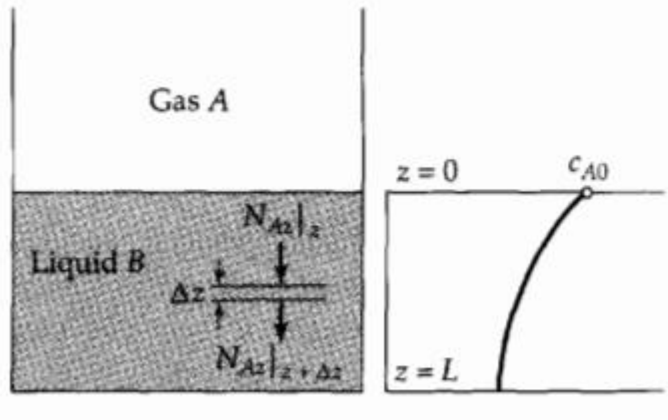
Molecular weight – 32 $\sigma(^0 A) = 3.433$
$\mathcal{E}/k = 113$ K $\Omega = 1.074$
Cp - 7.019 cal/ gmole.K Use Eucken approximation .

Q.4. (a): Consider the flow of an incompressible Newtonian fluid between two coaxial cylinders . The surfaces of the inner and outer cylinders are maintained at T = To and T = Tb, respectively. As the outer cylinder rotates, each cylindrical shell of fluid "rubs" against an adjacent shell of fluid. This friction between adjacent layers of the fluid produces heat due to "viscous dissipation". Derive equation for temperature gradient. Make suitable assumptions.(15)



(b) A pipe with inside diameter 2.067 inch and wall thickness of 0.154 inch carrying steam is insulated with 2 inch of 85% magnesia covered in turn with 2 inch cork.Estimate the amount of heat loss per hour per foot of pipe if inner surface of pipe is at 250 F(121.11 ^{0}C) and outer surface of cork is at 90 F(32.22^{0}C). The thermal conductivities (in Btu/hr.ft.F) of substance concerned are : k of steel = 26.1 & k of 85% magnesia = 0.04 & k of cork = 0.03 (05)

Q.5.(a) Gas A dissolves in liquid B in a beaker and diffuses isothermally into the liquid phase. As it diffuses, A also undergoes an irreversible first-order homogeneous reaction:
A + B gives AB. Assume the reaction to be first order. Take shell mass balance, make suitable assumptions and find out expressions for: (i)Concentration profile (ii)Average concentration in the liquid phase. (16)



(b) An oil is flowing down a vertical plate as a film 1.7 mm thick. The oil density is 820 kg /m^3 and viscosity is 0.20 Pa.s.Calculate Γ(mass flow rate per unit width of wall) and reynolds number. Also calculate average velocity. (04)

Q.6. (a) Estimate cD_{AB} for the system CO-CO_2 at 296.1 K and 1 atm total pressure (10)

a = 2.754 x 10^{-4} b = 1.823

Label	Gas	M	T(K)	Pc(atm)
A	CO	28.01	133	34.5
B	CO_2	44.01	304.2	72.9

(b) An electric current with current density I amp/cm^2 is flowing through an electric wire of circular cross section with radius R and electrical conductivity ke(ohm^{-1} cm^{-1}). The rate of heat production per unit volume is given by the expression $Se = I^2/ke$

The quantity Se is the heat source resulting from electrical dissipation. The surface of the wire is maintained at temperature To. Take shell energy balance and find expression for
(Heat flux distribution)
(ii) Temperature distribution
(iii)Maximum temperature rise
(iv)Average temperature rise (10)
