**Exam. Code: 0909**
**Sub. Code: 6311**

**2063**
**B.E. (Biotechnology) Fifth Semester**
**BIO-514: Transport Phenomena**

**Time allowed: 3 Hours** **Max. Marks: 50**

***NOTE: Attempt <u>five</u> questions in all, including Question No. I which is compulsory and selecting two questions from each Section. State all assumptions.***

*x-x-x*

Q.1a). Explain the term "no-slip condition" with respect to momentum transport.

b). A plastic panel with an area 0.055 $m^2$ and thickness 0.01 m was found to conduct heat at a rate of 3 W at steady state with temperatures 25°C and 28°C imposed on the two surfaces. Calculate the thermal conductivity of the plastic.

c). Compare the temperature dependence of thermal conductivity for liquids and solids.

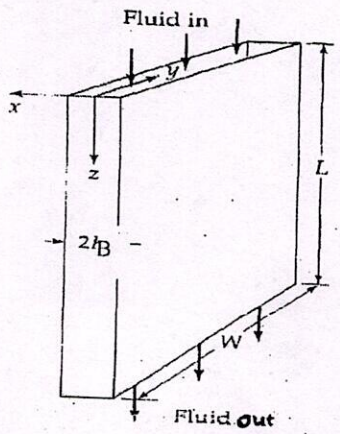
d). Give the equation of continuity for species β in a multicomponent reacting mixture.

e). A viscous fluid of density 780 kg/$m^3$ and kinematic viscosity is $2.2 \times 10^{-4}$ $m^2$/s is flowing down a vertical wall. Calculate the mass flow rate per unit width of wall required to form a film 2.2 mm thick on the wall. (10)

## SECTION-A

Q.2. A Newtonian fluid flows down an inclined plate of length L and width W. The plate is inclined at an angle β with the horizontal. The fluid forms a thin film of thickness δ on the surface of the inclined plate. From shell momentum balance obtain an expression for i) velocity distribution in the thin film ii) maximum velocity iii) average velocity. Assume steady state, density, and viscosity of the fluid to be constant, L>> δ, W>> δ. (10)

Q.3. A Newtonian fluid flows in a narrow slit formed by two parallel walls a distance 2B apart. The wall at x =B is moving in the positive z direction at a steady speed $\upsilon_o$. Make a differential momentum balance to obtain expressions for (i) shear stress distribution and (ii) velocity distribution in the slit. State all assumptions. (10)




P.T.O.

Q.4 a) A Newtonian fluid with a viscosity of 10 cP is placed between two large parallel plates. The distance between the plates is 5 mm. The lower plate is pulled in the positive x-direction with a force of 0.5 N, while the upper plate is pulled in the negative x- direction with a force of 1.5 N. Each plate has an area of 2 $m^2$. If the velocity of the lower plate is 0.1 m/s, Calculate the velocity of the upper plate.

b) Consider steady state evaporation of chloropicrin ($CCl_3NO_2$) liquid into air which may be considered a pure substance. The temperature is 25°C. The liquid chloropicrin is taken in a tube containing air. Calculate the rate of evaporation in gm/h of chloropicrin into air. Data given: Total pressure: 770 mm Hg, diffusivity ($CCl_3NO_2$-air): 0.088 $cm^2 sec^{-1}$, vapor pressure: 23.81 mm Hg, distance from liquid level to the top of the tube: 11.14 cm, density of $CCl_3NO_2$: 1.65 g $cm^{-3}$, surface area of liquid exposed for evaporation: 2.29 $cm^2$. (5,5)

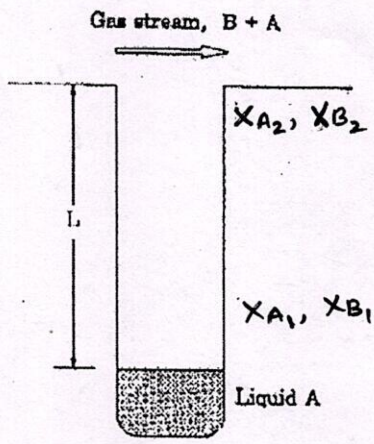
## SECTION-B

Q.5a). The mass of drops formed by a liquid discharging under gravity from a vertical tube is a function of tube diameter, liquid density, surface tension and the acceleration due to gravity. Determine the independent dimensionless groups that would allow the surface tension effect to be analyzed. Neglect any effects of viscosity.

b). Show that only one diffusivity is needed to describe the diffusional behavior of a binary mixture. (7,3)

Q.6. A heated sphere of radius R is suspended in a large, motionless body of fluid. The temperature of the fluid in contact with the surface of the sphere is $T_R$ and that at a large distance away from the sphere is $T_\infty$. Derive an equation describing the temperature T in the surrounding fluid as a function of r, the distance from the center of the sphere. Also obtain an expression for the heat flux at the surface of the sphere. Equate this result to the heat flux given by "Newton's law of cooling" and obtain the value of the Nusselt number, $Nu = \frac{hD}{k}$, where D is the diameter of the sphere. Assume k, thermal conductivity to be constant. (10)

Q.7. Derive an expression for the molar $N_{AZ}$ at the interface $Z=Z_1$ and the concentration profile for a binary system where liquid A is filled in a container as shown in the figure. This liquid evaporates into a stagnant gaseous atmosphere of B. Assume that the solubility of B in liquid A is negligible and that vapors of A and B form an ideal gas mixture. (10)




x-x-x