B.Tech. Seventh Semester (Chemical Engineering) (C.B.S.)

Transport Phenomena Paper - I

P. Pages : 2 **TKN/KS/16/7836**

Time : Three Hours * 0 2 7 2 * Max. Marks : 80

Notes : 1. All questions carry equal marks.
2. Answer **any four** questions.
3. Assume suitable data wherever necessary.
4. Diagrams and chemical equations should be given wherever necessary.

1. a) A Newtonian fluid is in laminar flow in a narrow slit formed by two parallel walls a distance '2B' apart. Make a differential momentum balance, and obtain the equations for shear stress & velocity distributions. Consider downward flow under pressure difference. **10**

b) Consider a steady, tangential, laminar flow of Newtonian fluid in the annular region between two coaxial cylinders. The outer cylinder is having radius 'R' & is rotating with angular velocity 'wo', whereas the inner cylinder having radius 'KR' is stationary. **10**

Obtain equation for torque correlating it viscosity at the wall of inner cylinder

The simplified continuity & motion equation for this case are as follows.

i) $-\rho\frac{v_\theta^2}{r}=-\frac{\partial p}{\partial r}$ ii) $\frac{d}{dr}\left(\frac{1}{r}\frac{d}{dr}(r v_\theta)\right)=0$.

2. a) A Newtonian fluid is flowing upward through a small circular tube and then downward in laminar flow on the outside of the tube. The radius of the tube can be considered as 'R', whereas the outer of the liquid film thickness measured from centre of the tube as 'aR'. Make a differential momentum balance and obtain equation for velocity distribution in the falling film as; **8**

$$V_z=\frac{\rho g R^2}{4\mu}\left[1-\left(\frac{r}{R}\right)^2+2a^2\ln\left(\frac{r}{R}\right)\right]$$

where ρ & μ are density & viscosity of the fluid respectively.

b) Draw a neat sketch & develop equation of motion for Cartesian system, starting from first principle. **12**

State all the assumption & all the terms involved.

3. a) An electric wire with radius 'R' having electrical conductivity 'K_e' ohm^{-1}cm^{-1} is carrying electric current of density 'I'amp/cm^2. The rate of heat production per unit volume due to conversion of electrical energy into heat is given by $S_e=\frac{I^2}{K_e}$. **10**

If the length of wire in 'L', its thermal conductivity 'K' w/mk & surface temperature of wire as 'T_o' then develop equation for estimation of radial temperature distribution within the wire.

b) A 1kw household iron having 0.5cm thickness & base area of 300 cm^2 is subjected to uniform heat flux, generated by resistance & electrical source. The outer surface loses heat to the surrounding at $T_\infty=20^oC$ by convection. Assuming 'K' of base plate as 15 w/(mk) & 'h' of plate to air as 80 w/(m^{2}k), Obtain an expression for temperature variation of base plate & evaluate the temperature at inner & outer surfaces. **10**

4. a) Consider a spherical nuclear fuel assembly consisting of fissionable material with '$R^{(F)}$' surrounded by a spherical shell of aluminium cladding having radius '$R^{(C)}$'. Assume that the energy generated due to fissionable reaction is as given below. **12**

$$S_n = S_{no}\left[1 + b\left(\frac{r}{R^{(F)}}\right)^2\right]$$

Where 'S_n' is in $cl/cm^3 \cdot S$, 'S_{no}' is at the centre, 'b' is dimension less constant. If the outer temperature is 'T_o', develop equation for temperature distribution in fuel & cladding, starting from first principle.

b) A Newtonian fluid is flowing in a laminar conditions in a circular pipe. Viscous dissipation of heat is as given below. **8**

$$q = \mu\left[\frac{du}{dr}\right]^2$$

Determine the expression for temperature distribution neglecting convective effects. The velocity distribution can be assumed as given by equation:

$$u = u_{max}\left[1 - \frac{r^2}{R^2}\right].$$

5. a) Consider a Stefen's tube containing initial liquid level z=z, of liquid 'A' which is evaporating into gas 'B'. **6**
Starting from first principles, develop equation for estimation of mole fraction of 'A' $i \cdot e \cdot 'X_A'$ in the diffusional path length from $z = z_1$ to $z = z_2$.
Assume constant temperature & pressure conditions.

b) Explain with neat sketches & appropriate equation the regimes for mass transfer with chemical reaction. **10**

c) A laminar jet is generally used to find out diffusion coefficient in water. A jet of water of 10cm long & 2mm in diameter is injected with velocity of 5 m/s in CO_2 gas at 1 atm. The solubility of CO_2 in water is $1.73 kg/m^3$ & the quantity absorbed is 3.5×10^{-7} kg/s. Find the diffusivity of CO_2 in water. **4**

6. a) Discuss various theories of mass transfer and derive expression for mass transfer coefficient for each. **10**

b) CO_2 diffuses through a 0.254 cm stagnant air film to NaOH solution where it instantaneously disappears by a chemical reaction. **10**
Estimate the rate of transfer across $0.1 m^2$ area if the temperature & pressure of the system are 20ºC & 1 atm respectively. The concentration of CO_2 at the outer edge of the layer is 6 mol %.
Determine the concentration profile also.
$D_{CO_2-air} = 0.14\ cm^2/s$.

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