M. TECH. –I (CHEMICAL) (2011COURSE) CHOICE BASED CREDIT SYSTEM : WINTER - 2017

SUBJECT : ADVANCED TRANSPORT PHENOMENA

Day : **Wednesday**
Date : **17/01/2018**

Time : **11.00 AM TO 02.00 PM**
Max. Marks : 60

W-2017-3017

N. B. :

1) All questions are **COMPULSORY**.
2) Figures to the right indicate **FULL** marks.
3) Both the sections should be written in the **SEPARATE** answer books.
4) Use of non-programmable calculator is **ALLOWED**.
5) Draw neat and labeled diagram **WHEREVER** necessary.
6) Assume suitable data, if necessary.

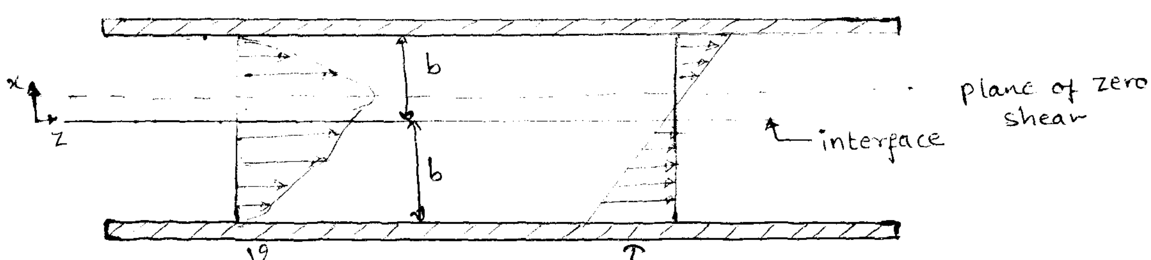
SECTION - I

Q. 1 Define Total and substantial time derivative **(10)**

Derive the equation of continuity in terms of substantial time derivative and show that: $\frac{D\rho}{Dt} = -\rho\left(\nabla \cdot v\right)$

OR

Two immiscible, incompressible liquids are flowing in the Z direction is a horizontal thin slit of length L and width W under the influence of a horizontal pressure gradient $\frac{\left(p_o - p_L\right)}{L}$. The fluid flow rates are adjusted so that the slit is half filled with fluid I (more dense) and half filled with fluid II (less dense). **(10)**



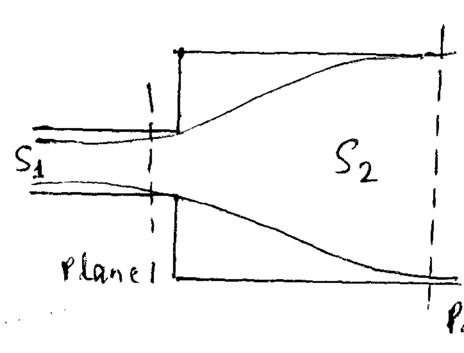
Find the momentum flux and velocity distribution.

Q. 2 Discuss in detail friction factors for flow around spheres. **(10)**

OR

An incompressible fluid flows from a small circular tube into a large tube in turbulent flow as shown in figure. Obtain an expression for the pressure change between plane 1 and 2 and for the friction loss associated with the sudden enlargement in cross section. **(10)**

Let $\beta = S_1 / S_2 < 1.0$



P. T. O.

Q. 3 For free convection between two large parallel walls maintained at different temperatures, show that temperature distribution is: **(10)**

$$T = \bar{T} - \frac{1}{2} \Delta T \frac{y}{B} \text{ and}$$

velocity distribution is:

$$v_z = \frac{(\bar{\rho} g \bar{\beta} \Delta T) B^2}{12\mu} \left[\left(\frac{y}{B}\right)^3 - \left(\frac{y}{B}\right) \right]$$

OR

A standard schedule 40, 2-inch steel pipe (inside diameter 2.067 in and wall thickness 0.154 inch) carrying steam is lagged (i.e. insulated) with 2 inch of 85 % magnesia covered in turn with 2 in. of cork. Estimate the heat loss per hour per foot of pipe if inner surface of pipe is at 250 °F and the outer surface of the cork is at 90 °F. The thermal conductivities of the substances concerned are : **(10)**

Steel : 26.1 Btu/hr ft °F
85 % magnesia = 0.04 Btu/hr ft °F
Cork = 0.03 Btu/hr ft °F

SECTION - II

Q. 4 Explain the concept of unsteady state heat conduction in solids. **(10)**
A solid material occupying the space form y = 0 to y = ∞ is initially at temperature T_0. At time t = 0, the surface at y = 0 is suddenly raised to temperature T_1 and maintained at that temperature for t > 0. Find the time dependent temperature profile T (y, t) for heating of the semi-infinite slab.

OR

Discuss in detail heat transfer coefficient for forced convection in tubes. **(10)**

Q. 5 For diffusion and chemical reaction inside a porous catalyst. Show that concentration profile is **(10)**

$$\frac{C_A}{C_{AR}} = \left(\frac{R}{r}\right) \frac{\sinh \sqrt{k_1'' a / D_A}\, r}{\sinh \sqrt{k_1'' a / D_A}\, R}$$

OR

Extend the equation of change for pure liquids and give the equation of change for a non isothermal multicomponent fluid of n chemical species. Include the following: **(10)**

i) Equation of continuity

ii) Equation of motion

iii) Equation of energy

Q. 6 Describe in detail mass transfer in creeping flow through a packed bed. **(10)**

OR

Study the effect of the reaction on the rate of mass transfer at the wall for steadily driven turbulent flow in a tube, where the wall (of material A) is slightly soluble in the fluid (a liquid B) flowing through the tube. Material A dissolves in liquid B and then disappears by a first order reaction. **(10)**

Describe the enhancement of mass transfer by a first order reaction in turbulent flow.