



Name :

Roll No. :

Invigilator's Signature :

CS/B.TECH(CHE)/SEM-8/CHE-801/2013

2013

TRANSPORT PHENOMENA

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as practicable.*

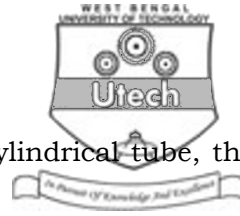
GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

$$10 \times 1 = 10$$

- i) The non-dimensional group that appears in viscous heating problem is
 - a) Brinkman Number b) Nusselt Number
 - c) Biot Number d) None of these.
- ii) Dimensional analysis of Equation of Energy (Heat transfer) results in generating
 - a) Prandtl number and Reynolds number
 - b) Prandtl number and Biot number
 - c) Biot number and Courant number
 - d) Reynolds number and Biot number.



- iii) In Hagen Poiseuille flow through a cylindrical tube, the radial profile of shear stress is
- a) constant b) cubic
- c) parallel d) linear.
- iv) Apparent viscosity increases with time for the fluid of
- a) Thixotropic b) Rheopectic
- c) Bingham plastic d) Newtonian.
- v) The continuity equation
- a) is independent of the compressibility
- b) is independent of the viscosity of the fluid
- c) represents the conservation of mass
- d) none of these.
- vi) Sewage sludge is an example of
- a) Bingham plastic b) Dilatant
- c) Pseudo plastic d) Newtonian fluid.
- vii) Molecular momentum flux tensor is
- a) τ b) $\rho \hat{u} u$
- c) $\tau + p\delta$ d) $\tau + p\delta + \rho \hat{u} u$



viii) Which of the following fluid forces are not considered in the Navier-Stokes equation ?

- a) Gravity forces b) Viscous forces
- c) Pressure forces d) Turbulent forces.

ix) A_{kl}^{qst} is the component of a mixed tensor of

- a) rank 2 b) rank 6
- c) rank 5 d) rank 3.

x) Diagonal component of a unit tensor is

- a) unity b) 0
- c) infinity d) - 1.

xi) Stokes law is valid when the particle's Re No. is

- a) greater than 1
- b) less than 1
- c) lies between 1 and 100
- d) greater than 100.

xii) Flow behaviour index (n) of pseudoplastic fluid is

- a) 0 b) < 1
- c) > 1 d) infinity.



GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. A horizontal annulus of 8m length has an inner radius of 0.0125m and an outer radius of 0.0279m. A 60% aqueous solution of sucrose is to be pumped through the annulus at 20°C. At this temperature the solution density is 1286 kg/m³ and viscosity is of 7187.2kg/m-s. Calculate the volumetric flow rate when the pressure difference is 37.162 kPa.

3. Parabolic velocity profile for the flow through a vertical circular tube of radius R and length L is given by

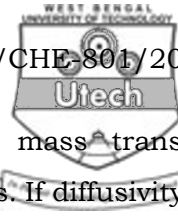
$$v_z = \frac{(\phi_0 - \phi_L) R^2}{4\mu L} \left[1 - \left(\frac{r}{R} \right)^2 \right]$$

where, ϕ is the combined effect of static pressure and gravity force, μ is the viscosity of the fluid then show that $v_{avg} = \frac{v_{max}}{2}$

4. Define boundary layer thickness.

Calculate the thickness of the boundary layer at a distance of 75mm from the leading edge of a flat surface over which water at 38°C ($\mu = 1$ cp) is flowing at a velocity 10.67 m/s.

5. A 10 cm long copper fin of diameter 6 mm is attached to a vertical wall at 500 K and projected in the room where air is at 300K. The heat transfer coefficient at the fin surface is 30W/m²K and conductivity of the fin material is 390W/mK. Calculate heat loss from fin and fin efficiency.



6. For CO_2 adsorption in a packed tower, mass transfer coefficient is measured as $k = 3.0 \times 10^{-3} \text{ cm/s}$. If diffusivity of CO_2 in water is $1.85 \times 10^{-5} \text{ cm}^2/\text{s}$, calculate average contact time based on penetration theory and surface renewal theory.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) Define the Kronecker delta symbol. Give the expression of a dyadic product of two vectors v and w . 4
- b) If α is symmetrical and β is anti-symmetrical, show that $(\alpha : \beta) = 0$ 5
- c) Using the continuity equation show that the flow defined by the velocity field
$$\vec{v} = (2t + 2x + 2y) \vec{i} + (t - y - z) \vec{j} + (t + x - z) \vec{k}$$
 is possible. 6
8. a) Find out the expressions of temperature profile and the maximum temperature in a long nuclear fuel element of spherical form, consisting of a sphere of a fissionable material with radius R^f , surrounded by a spherical shell of Aluminium cladding, having outer radius R^c . Temperatures of centre, inside and outside surfaces of the cladding are T^f , T^c , and T^o respectively. 9



- b) An oil is flowing down a vertical wall having density $0.78 \times 10^3 \text{ kg/m}^3$ and mass flow rate per unit width of the wall is $0.2 \text{ kg / (m) (sec)}$. The film thickness is 2.35 mm . Calculate the kinematic viscosity. Also check the Reynolds number. 6
9. An incompressible fluid (density 1.13 gm/cm^3) is flowing upward in steady state in the annular region between two coaxial circular cylinders of radii 25 mm and 60 mm .
- i) Draw the momentum balance and deduce the equation for velocity distribution and calculate the maximum velocity. 9
- ii) Also calculate the distance from the centre of the coaxial tube where the maximum velocity occurs.
- Data : Viscosity of the fluid = $1.30 \text{ gm / (cm) (sec)}$,
Pressure drop of fluid per metre
of tube = $7.0 \times 10^5 \frac{\text{dynes}}{\text{cm}^2}$ 6
10. In a gas absorption experiment a viscous fluid flows upward through a small circular tube and then downward in laminar flow on outside. Derive a relation for flow of a fluid film on outside of a circular tube.
- a) Show that the velocity distribution in falling film (neglecting end effects) is

$$v_z = \frac{\rho g R^2}{4\mu} \left[1 - \left(\frac{r}{R} \right)^2 + 2a^2 \ln \frac{r}{R} \right] \quad 8$$



- b) Obtain an expression for mass rate of flow in the film.

4

- c) Obtain mass flow rate when film thickness is very small.

3

11. a) A fluid with density ρ and viscosity μ is placed between two vertical walls a distance $2b$ apart. The heated wall at $y = -b$ is maintained at a temperature T_2 and cooled wall at $y = +b$ is maintained at a temperature T_1 . If β is volume expansion coefficient and $\eta = y/b$ then prove that final expression of the velocity distribution is given by :

$$V_z = \rho \cdot \beta \cdot g \cdot b^2 \cdot \Delta T \cdot (\eta^3 - \eta) / (12 \cdot \mu) \quad 10$$

- b) Calculate the radius of a capillary tube using the following data when a viscous fluid is flowing through the tube. Given data :

Length of capillary = 50.02 cm, Kinematic viscosity of fluid = $4.03 \times 10^{-5} \text{ m}^2 / \text{sec}$.

Density of fluid = $0.9552 \times 10^3 \text{ kg/m}^3$

Pressure drop across (horizontal) capillary tube

$$= 4.829 \times 10^5 \text{ newton} / \text{m}^2$$

Mass rate of flow through tube = $2.997 \times 10^{-3} \text{ kg/sec}$. 5

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