Name : ....

Roll No. : ....

Invigilator's Signature : ....

CS/B.TECH (CHE-NEW) /SEM-8/CHE-801/2011

2011
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 ratio of the thermal boundary layer thickness to the concentration boundary layer thickness is proportional to

a) Nu b) Le
c) Sh d) Pr.

ii) Normal stress can be related to pressure (P) as

a) + P b) P^n
c) – P d) $\sqrt{P}$.

iii) A steady flow field of an incompressible fluid is given by $\vec{V} = (Ax + By)\,\vec{i} - Ay\,\vec{j}$, where $A = 1\ s^{-1}$, $B = 1\ s^{-1}$, and x, y are in metres. The magnitude of the acceleration $(\text{in}\,\text{m/s}^2)$ of a fluid particle at (1, 2) is

a) 1 b) $\sqrt{2}$
c) $\sqrt{5}$ d) $\sqrt{10}$.

iv) If $\vec{v} = \vec{w} \times \vec{r}$, where $\vec{w}$ is a constant vector, then $\vec{w}$ is

a) $^1/_2$ curl $\vec{v}$ b) $^1/_2$ grad $\vec{v}$

c) curl $\vec{v}$ d) div curl $\vec{v}$.

v) For heat transfer in free convection, Nusselt number is related to

a) Reynolds number, Prandtl number

b) Reynolds number, Grasshoff number

c) Grasshoff number, Prandtl number

d) Reynolds number, Graetz number.

vi) Combined momentum flux tensor is symbolized by

a) Φ b) τ

c) π d) None of these.

vii) Toothpaste is

a) Thixotropic fluid   b) Bingham plastic fluid

c) Rheopectic fluid   d) Pseudoplastic fluid.

viii) Momentum is a

a) first order tensor   b) second order tensor

c) third order tensor   d) zero order tensor.

ix) Continuity equation is

a) mass balance equation

b) momentum balance equation

c) both mass and momentum balance equation

d) none of these.

x) The mass diffusivity for a binary system is a function of

a) temperature and pressure

b) temperature and concentration

c) temperature, pressure and concentration

d) temperature only.

xi) Creeping flow around a sphere is defined, when particle Reynold's number is .

a) <2100 b) $< 0 \cdot 1$

c) $2 \cdot 5$ d) 500.

xii) For falling film system average velocity is

a) 2/3 of the maximum velocity

b) 3/4 of the maximum velocity

c) 1/2 of the maximum velocity

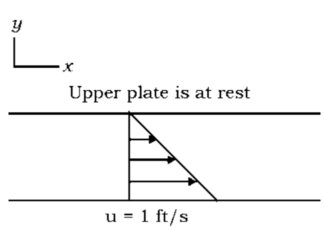
d) 3/5 of the maximum velocity.

GROUP – B

(Short Answer Type Questions)

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

2. The space between two parallel plates is $0 \cdot 001$ ft apart, is filled with oil of viscosity $\mu = 0 \cdot 7$ cp. Calculate the steady state momentum flux τ_{yx} in lb_f/ft^2, when lower plate velocity is 1 ft/s in the x direction as shown in the figure below :



3. A copper wire has a radius of 2mm and length of 5m. For what voltage drop would the temperature rise at the wire axis is 10°C, if surface temperature of wire is 20°C ?

4. Carbon monoxide content in off gas from combustion chamber is 2%. In order to reduce CO content, the gas is passed through an absorption tower at 20°C and $1 \cdot 01325 \times 10^{-5}$ Pa. If Henry's law constant for CO solvent system is $5 \cdot 0 \times 10^{9}$ Pa (moles of CO per total mole of solution at saturation). Density of solvent is 1500 kg/m^3 and molecular weight 20.

5. The head loss in 70 metre of 14 cm diameter pipe is known to be $6 \cdot 0$ metre when oil (specific gravity = $0 \cdot 8$) of viscosity $0 \cdot 04$ Newton sec/ m^2 flows at $0 \cdot 08\ m^3/\text{sec}$. Determine the centreline velocity and the shear stress at the wall of the pipe.
   Data : friction factor $f = 0 \cdot 034$, and $\dfrac{u}{u_{\max}} = \dfrac{1}{1 + 1 \cdot 33\sqrt{f}}$

6. If $\vec{\nabla} \cdot \vec{E} = 0$, $\vec{\nabla} \cdot \vec{H} = 0$, $\vec{\nabla} \times \vec{E} = \dfrac{\partial \vec{H}}{\partial t}$, $\vec{\nabla} \times \vec{H} = \dfrac{\partial \vec{E}}{\partial t}$, then show that $\vec{E}$ and $\vec{H}$ satisfy $\vec{\nabla}^2 u = \dfrac{\partial^2 u}{\partial t^2}$.

GROUP – C

(Long Answer Type Questions)

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

7. a) What do you mean by alternating unit tensor ? Explain why the parameter becomes very important in order to describe the cross product of two vectors. 5

   b) Show that $\nabla \times v$ is twice the local angular velocity (w), where v is the velocity vector of the fluid. 5

   c) Prove that $I : v = \nabla \cdot v$, where I is a unit tensor. 5

8. 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

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

9. a) A fluid is flowing over a flat horizontal surface under laminar and straight stream line flow conditions. Calculate the mass flow rate when kinematic viscosity is $3 \cdot 15 \times 10^{-4}$ m^2/sec, density $0 \cdot 75 \times 10^{-3}$ kg/m^3, and film thickness $3 \cdot 4$ mm. Check the Re. No. for the validity of flow condition. 3

b) Consider the flow of a viscous isothermal liquid film under the influence of gravity. The falling film is in a inclined plane. Density is constant but viscosity is varying as $\mu = \mu_0 e^{-\alpha(x/\delta)}$ where α is constant; μ changes as x changes and μ_0 is viscosity at surface of the film, δ is film thickness. Deduce an expression for average velocity. Also deduce the expression when $\alpha = 0$. 10

c) Write a note on Eyring Model. 2

10. a) Heat is flowing through annular wall of inside radius r_0 and radius r_1. The thermal conductivity varies linearly with temperature from k_0 at T_0 to k_1 at T_1. Develop an expression for heat flow through the wall. 8

b) Show that if $(r_1 - r_0)/r_0$ is very small then :

$$Q = 2\pi r_0 L \left(\frac{k_0 + k_1}{2}\right)\left(\frac{T_0 - T_1}{r_1 - r_0}\right)$$ 7

11. a) Derive an expression for the heat flux distributions in the fissionable sphere and in the spherical-shell cladding.

    b) How does mass diffusivity depend on temperature and pressure ?

    c) Define the term "momentum diffusivity". How does momentum diffusivity take part in transport of mass and heat ? 8 + 3 + 4