

**Group – E**

8. (a) Particles of sphalerite are settling by gravity in CCl<sub>4</sub> at 20°C. The specific gravity of CCl<sub>4</sub> is 1.594. The particle diameter is 0.10 mm. The volume fraction of sphalerite in CCl<sub>4</sub> is 0.2. The viscosity of CCl<sub>4</sub> at this temperature is 1.03 cP. What is the settling velocity of sphalerite assuming free settling conditions?
- (b) Differentiate between skin drag and form drag. Which type of drag is predominant on an aeroplane when it flies through the atmosphere? Justify.  
**5 + (3 + 4) = 12**
9. (a) Derive the continuity and total energy balance equations for the flow of a compressible fluid.
- (b) Why the speed of sound is taken as a standard for defining compressible flow?  
**8 + 4 = 12**

**CHEMICAL ENGINEERING FLUID MECHANICS  
(CHEN 2102)****Time Allotted : 3 hrs****Full Marks : 70***Figures out of the right margin indicate full marks.**Candidates are required to answer Group A and  
any 5 (five) from Group B to E, taking at least one from each group.**Candidates are required to give answer in their own words as far as  
practicable.***Group – A  
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) The hydraulic diameter of an annulus of inner and outer radii  $R_i$  and  $R_o$  respectively is  
(a)  $4(R_o - R_i)$  (b)  $\sqrt{R_o - R_i}$  (c)  $2(R_o - R_i)$  (d)  $R_o + R_i$ .
- (ii) The head loss due to sudden expansion  
(a)  $\frac{V_1^2 - V_2^2}{2}$  (b)  $\frac{(V_1 - V_2)^2}{2}$  (c)  $\frac{V_1 - V_2}{2}$  (d)  $V_1^2 - V_2^2$ .
- (iii) Dimension of kinematic viscosity is  
(a)  $MLT^{-1}$  (b)  $L^2T^{-1}$  (c)  $L^2T$  (d)  $L^2.T^{-2}$
- (iv) In case of laminar flow of fluid in a pipe, kinetic energy correction factor is  
(a) 2 (b)  $\frac{1}{2}$  (c) 1 (d)  $\frac{3}{2}$ .
- (v) The friction factor for turbulent flow in a hydraulically smooth pipe  
(a) depends only on Reynolds number  
(b) does not depend on Reynolds number  
(c) depends on roughness  
(d) cannot be predicted.
- (vi) Blood is a ..... fluid.  
(a) Bingham plastic (b) Pseudoplastic  
(c) Newtonian (d) Dilatant

- (vii) For flow control in a large diameter pipeline you need a  
 (a) butterfly valve (b) needle valve  
 (c) ball valve (d) check valve.
- (viii) For pumping corrosive liquids generally.....pump is used.  
 (a) lobe (b) piston (c) gear (d) diaphragm.
- (ix) For very low volumetric flowrate, pressure drop through a packed bed can be calculated from  
 (a) Darcy equation (b) Ergun equation  
 (c) Burke Plummer equation (d) Kozeny-Carman equation.
- (x) The propagation of sound waves through air is an.....process.  
 (a) isentropic (b) isenthalpic  
 (c) isothermal (d) isochoric.

### Group – B

2. (a) Define streak line.  
 The velocity components in a flow field are given as follows:  $u=x(1+2t)$ ,  $v=y$  and  $w=0$ . A coloured dye is injected at the point A (1,1) in the flow field at  $t=0$ . Find the equation of streak line passing through the point A at  $t=1$ .
- (b) The right limb of a simple U-tube manometer containing mercury (specific gravity: 13.6) is open to the atmosphere while the left limb is connected to a pipe in which a fluid of sp.gr. 0.9 is flowing. The centre of the pipe is 12 cm below the level of mercury in the right limb. Find the pressure of fluid in the pipe if the difference of mercury level in the two limbs is 20 cm.
3. (a) In case of submerged vertical surface, obtain the relation between centre of pressure and centre of gravity.
- (b) A thin plate of very large area is placed in a gap of height  $h$  with oils of viscosities  $\mu_1$  and  $\mu_2$  ( $\mu_1 < \mu_2$ ) and densities  $\rho_1$  and  $\rho_2$  ( $\rho_1 > \rho_2$ ) on the two sides of the plate. The plate is pulled at a constant  $V$ . Assuming linear variations of velocity, determine the position of the plate so that the shear force on the two sides of the plate is equal.
- (c) Write down continuity equation for an incompressible fluid.

$$(2 + 4) + 6 = 12$$

$$6 + 5 + 1 = 12$$

### Group – C

4. (a) A kerosene storage tank drains by gravity to a tank truck. The length of the pipeline between the tank and truck is 61 m and its internal diameter is 25 mm. Kerosene has a viscosity of 0.0005 Pa s and a density of 800 kg/m<sup>3</sup>. Both tank and truck are open to the atmosphere, and the flow rate is 0.81 lit./s. Calculate the difference between the level in the tank and that in the truck.  
 Given:  $f = 0.079Re^{-0.25}$ , where  $f$  is friction factor.
- (b) Define 'momentum correction factor'? Obtain its value for laminar flow of a fluid through a pipe.

$$8 + 4 = 12$$

5. (a) A Newtonian fluid is confined between two broad, parallel, vertical plates separated by a distance  $B$ . The plate on left is stationary, that on right is moving vertically upward with a constant velocity  $u_0$ . Assuming that the flow is laminar, find the steady-state velocity profile in the fluid.
- (b) What is the significance of kinetic energy correction factor? Find out the value of 'kinetic energy correction factor' for a Newtonian fluid flowing through a smooth circular straight tube in laminar condition.

$$6 + (2 + 4) = 12$$

### Group – D

6. (a) A three stage reciprocating compressor is to compress 306 m<sup>3</sup>/h of methane from 0.95 atm to 61.3 atm absolute pressure. The inlet gas temperature is 26.7°C. For the expected temperature range the average properties for methane are:  $C_p = 38.9$  J/gmol°C and  $C_p/C_v = 1.31$ . Calculate the total power requirement.
- (b) Explain the working principle of a steam jet ejector with a diagram.
7. (a) A venturimeter of 150 mm × 75 mm size is used to measure the flow rate of oil having specific gravity of 0.9. The reading shown by the U tube manometer connected to the venturimeter is 150 mm of mercury column. Calculate the coefficient of discharge for the venturimeter if the flow rate is 1.7 m<sup>3</sup>/min.
- (b) Draw the characteristic curve for a centrifugal pump. What is the significance of affinity laws for a centrifugal pump?

$$6 + 6 = 12$$

$$5 + (4 + 3) = 12$$