CHEMICAL ENGINEERING FLUID MECHANICS
(CHE2102)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) An example of a Thixotropic fluid is
(a) Paint (b) Alcohol
(c) Sunflower oil (d) Cornstarch suspension.

(ii) The shear stress on the x-plane in the z direction is given by
(a) τ_{zz} (b) τ_{zx} (c) τ_{xz} (d) τ_{xx}

(iii) The equivalent diameter for fluid flow through a square cross-section channel of side x is given by
(a) x (b) 0.5x (c) 2x (d) 4x

(iv) A Newtonian fluid (density = ρ, viscosity= μ) is flowing with an average velocity ν in a tube of diameter 'D'. Let Δp be the pressure drop across the length 'L'. For a laminar flow, Δp is proportional to
(a) $L \rho \nu^2/D$ (b) $L \mu \nu/ D^2$ (c) $\mu \nu/L$ (d) $D \rho \nu^2/L$

(v) The dimension of dynamic viscosity is
(a) $ML^{-1}T^{-1}$ (b) $ML^{-1}T^{-2}$ (c) MLT^{-1} (d) MLT^{-2}

(vi) Power loss in an orificemeter _____ that in a venturimeter
(a) is less than (b) is same as
(c) is more than (d) may be more or less than

(vii) The periodic flow reversal in a compressor is called
(a) Cavitation (b) Stonewall (c) Air-binding (d) Surge

(viii) The pressure drop through a packed bed in the turbulent flow regime is given by
(a) Fanning equation (b) Hagen Poiseuille equation
(c) Burke Plummer equation (d) Kozeny carman equation

(ix) During laminar flow through a packed bed, the main contributor to the pressure drop is
(a) Viscous resistance (b) Inertial effects
(c) Surface tension (d) All of the above.

(x) For turbulent flow, the minimum fluidization velocity is proportional to
(a) $D_p^{0.3}$ (b) $D_p^{0.5}$ (c) D_p (d) D_p^2

Fill in the blanks with the correct word

(xi) For the continuum assumption to be valid, the Knudsen number has to be _____.

(xii) In case of laminar flow of fluid in a pipe, kinetic energy correction factor is approx _____.

(xiii) In case of fluid flow in a tube, local velocity can be measured by _____.

(xiv) Priming is not necessary for a _____ pump.

(xv) The projected area of a cube of side length A is _____.

Group - B

2. (a) A U-tube manometer is connected to a pipeline carrying water at 20°C, flowing at 1 m/s. The manometric fluid is mercury with a specific gravity of 13.6. The difference in the two arms of the manometer is 30 cm. The density of water at this temperature is around 997 kg/m^3. Determine the water pressure drop across the manometer. *[(CO2)(Apply/IOCQ)]*

(b) Where are inclined tube manometers preferred over u-tube manometers? *[(CO2)(Analyse/IOCQ)]*

8 + 4 = 12

3. (a) The velocity vector of a flow field is given by $\mathbf{V = iAx + j2Ay^2/x}$. $\mathbf{A}$ = 2s^{-1}. Determine the equation of the streamlines passing through the point (1,3). *[(CO3)(Apply/IOCQ)]*

(b) If a fluid particle is at (1,3) at t = 0 s, what will be the coordinate of the particle at t = 10 s? *[(CO3)(Apply/IOCQ)]*

(c) Determine the equation of the pathline at t=0 and (1,3), and compare the equation with the streamline equation. *[(CO3)(Apply/IOCQ)]*

5 + 3 + 4 = 12

Group - C

4. (a) A Newtonian fluid is confined between two broad parallel, vertical plates, separated by a distance B. The plate on the left is stationary, that on right is moving vertically upward at a constant velocity $\mathbf{V_0}$. Assuming that the flow is laminar, find the equation for the steady state velocity profile in the fluid. *[(CO3)(Analyse/IOCQ)]*

(b) Water (density=1000 kg/m^3) at 20^{0}C is flowing steadily through a 5.5 cm diameter and 6 m long pipe at a rate of 2.6 litres per minute. Find the shear stress on the internal wall of the pipe. The viscosity of water is 0.001 Pa-s. *[(CO3)(Evaluate/HOCQ)]*

(c) Define Prandtl mixing length. How is it related to shear stress? *[(CO3)(Apply/IOCQ)]*

5 + 5 + 2 = 12

5. (a) The velocity distribution in a circular pipe is given by

$$\frac{u}{u_{\max}} = (1 - \frac{r}{R})^n$$

where u is the velocity at a distance r from the centre, $u_{\max}$ is the maximum velocity at the centre of the pipe and R is the pipe radius. Find the ratio of average velocity of flow in the pipe to the maximum velocity. *[(CO3)(Evaluate/HOCQ)]*

(b) Define momentum correction factor. Also obtain its expression for a Newtonian fluid flowing through a smooth, round tube. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) Discuss the working principle of rotameter. *[(CO4)(Analyse/IOCQ)]*

(b) An orifice meter with orifice diameter 12 cm is inserted in a pipe of 24 cm diameter through which an oil of density 850 kg/m^3 is flowing. A differential mercury U-tube manometer is connected to the two sides of the orifice meter to measure the pressure difference. The manometer shows a deflection of 20 cm. If the coefficient of discharge for the orificemeter is 0.61, find the discharge through the pipe. *[(CO4)(Remember/LOCQ)]*

(c) What is 'vena contracta'? *[(CO4)(Apply/IOCQ)]*

5 + 5 + 2 = 12

7. (a) It is proposed to pump 10000 kg/h of toluene at 114°C and 1.1 atm pressure (absolute) from the reboiler of a distillation tower to a second distillation unit, without cooling the toluene before it enters the pump. If the friction loss in the suction line is 7 kPa and the density of toluene is 866 kg/m^3, how far above the pump must the liquid level in the reboiler be maintained to get a NPSH of 2.5 m? *[(CO4)(Evaluate/HOCQ)]*

(b) What are some measures that can be taken to obtain increased NPSH in a pumping system during the operating phase? *[(CO5)(Analyse/IOCQ)]*

(c) Why are intercoolers required for multi-stage compressors? *[(CO4)(Analyse/HOCQ)]*

6 + 2 + 4 = 12

Group - E

8. (a) There are two reactions, one with ΔH = - 3120 kJ/mol, another with ΔH = - 89561 kJ/mol. Two reactors are available, one a packed bed reactor and the other a fluidized bed reactor. Which reactor would you choose for which reaction? Justify your choice. *[(CO6)(Evaluate/HOCQ)]*

(b) One packed bed has a void fraction of 0.35, another has a void fraction of 0.6. You are to fluidize both beds using water. In which case will the pumping cost of water be higher? Explain. *[(CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

9. (a) A liquid of density 1000 kg/m^3 is flowing at a velocity of 3 m/s over a solid cube of side length 2 cm. The drag force on the cube is 6 kN. Determine the drag coefficient. *[(CO6)(Apply/IOCQ)]*

(b) Water is flowing over a smooth sphere of diameter 10 mm at a speed of 5 m/s. The viscosity of water is 0.001 Pa.s. Assuming Stokes law to be valid, calculate the drag force on the sphere. *[(CO6)(Apply/IOCQ)]*

(c) On what parameters do the pressure drop through a packed bed depend for turbulent flow within the bed? *[(CO6)(Understand/LOCQ)]*

5 + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	8.3	57.3	34.4