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) A flow behaviour index greater than 1 implies a
(a) Dilatant fluid (b) Newtonian Fluid
(c) Pseudoplastic fluid (d) Bingham Plastic fluid

(ii) Reynolds number is the ratio of
(a) Viscous force to Surface Tension force (b) Inertial force to Centrifugal force
(c) Surface tension force to Inertial force (d) Inertial force to Viscous force

(iii) In case of laminar flow of a Newtonian fluid in a pipe, kinetic energy correction factor is approx.
(a) (3/2) (b) 1 (c) (1/2) (d) 2

(iv) Bernoullie's equation deals with the law of conservation of
(a) mass (b) momentum (c) energy (d) all of these

(v) For supersonic flow, Mach number is
(a) equal to 1 (b) more than 1 (c) less than 1 (d) zero

(vi) The expansion angle of the diffuser of venturimeter is usually
(a) 15^0 to 25^0 (b) 10^0 to 15^0
(c) 5^0 to 7^0 (d) none of these

(vii) Corrosive liquids are pumped by
(a) Centrifugal pump (b) Diaphragm pump
(c) Gear pump (d) Piston pump

(viii) The drag force on a smooth spherical body in creeping flow is given by
(a) Newton's law (b) Stokes law
(c) Darcy's law (d) Ergun equation

(ix) During fluidization of a packed bed, the bed height
(a) Increases, then becomes constant (b) Increases, then decreases
(c) Decreases, then increases (d) Decreases, then becomes constant

(x) Rotameter is a

(a) transducer (b) variable head meter

(c) variable area meter (d) mass flow meter

Fill in the blanks with the correct word

(xi) For a pseudoplastic fluid, the apparent viscosity _____ with shear rate.

(xii) For _____ flow, streamlines, streaklines, pathlines coincide.

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

(xiv) _____ equation is applicable for determining pressure drop during laminar flow of fluid in a pipe.

(xv) The difference between NPSHA and NPSHR is called _____.

Group - B

2. (a) An inclined tube manometer is connected to a piping system carrying water. The diameters of the manometer vessel and the manometer tube are 20 cm and 1 cm respectively. The tube inclination is 15° and the linear deflection of water level in the inclined tube is 10 cm. What is the pressure difference measured by the manometer, if the density of water is 1000 kg/m^3? *[(CO2)(Apply/IOCQ)]*

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

8 + 4 = 12

3. (a) A fluid flowing between two horizontal plates separated by a distance 1 mm, exerts a shear stress of 2 Pa on the top plate, which is moving at 2 m/s. The bottom plate is fixed. When the gap is reduced to 0.25 mm, the shear stress exerted on the top plate is 3 Pa, for a plate velocity of 1 m/s. What is the rheological nature of the fluid? *[(CO1)(Evaluate/HOCQ)]*

(b) Determine the ratio of the inertial forces and viscous forces acting on a liquid flowing through a 30 mm diameter pipeline, at a volumetric flow rate of 2 m^3/hour. The density and viscosity of the liquid are 800 kg/m^3 and 3×10^{-3} Pa.s. *[(CO3)(Analyse/IOCQ)]*

6 + 6 = 12

Group - C

4. (a) A pump (efficiency 55%) draws a solution (sp. Gravity 1.84) from a storage tank through a pipe of 75 mm inside diameter. The velocity in the suction line is 0.9 m/s. The pump discharges through a pipe having 50 mm inside diameter. The end of discharge pipe is 14.5 m above the level of solution in the storage tank. Friction losses in the entire system are 29 J/Kg.

(i) What is the power of the pump?

(ii) What pressure must the pump develop? *[(CO3)(Evaluate/HOCQ)]*

(b) Derive an expression of the velocity profile in case of Coutte flow with pressure gradient. *[(CO3)(Analyze/IOCQ)]*

9 + 3 = 12

5. (a) Derive Equation of Continuity. *[(CO3)(Analyse/IOCQ)]*

(b) Air at 25^0 C and 2.2 atm. absolute pressure enters a finned-tube steam heater through a 50-mm tube at an average velocity of 12 m/s. It leaves the heater through a 65-mm tube at 90^0C and 1.5 atm. absolute. What is the average air velocity at the outlet? *[(CO3)(Evaluate/HOCQ)]*

(c) Obtain the equivalent diameter for flow between two parallel plates when the distance between them **b** is much smaller than the width of the plate **a**. *[(CO3)(Apply/IOCQ)]*

4 + 6 + 2 = 12

Group - D

6. (a) A vertical venturimeter has an area ratio of 5. It has a throat diameter of 1.2 cm. When oil of specific gravity 0.86 flows through it the mercury in the differential gauge indicates a difference of 21 cm. Find the discharge through the venturimeter. Take coefficient of discharge of the venturimeter as 0.98. *[(CO4)(Evaluate/HOCQ)]*

(b) Discuss the working principle of rotameter. Name two insertion meter for measurement of fluid flow. *[(CO4)(Remember/LOCQ)]*

7 + 5 = 12

7. (a) What is the importance of priming in a centrifugal pump? *[(CO4)(Analyse/IOCQ)]*

(b) Why is the suction line diameter more than the discharge line diameter in case of a centrifugal pump? *[(CO5)(Analyse/IOCQ)]*

(c) A centrifugal pump is connected to a water reservoir at atmospheric pressure. The water level in the reservoir is 1.5 m above the pump suction. The friction loss in the suction line is 4 kPa and the velocity of water in the suction line is 5 m/s. The suction line is a 1" schedule 40 steel pipe. The vapour pressure of water at this temperature is 25 kPa and the density is 997 kg/m^3. Determine the available NPSH in this system. *[(CO4)(Evaluate/HOCQ)]*

3 + 3 + 6 = 12

Group - E

8. (a) A fluidized bed reactor employs spherical solid catalysts of 150 μm diameter. The void fraction in the bed is around 0.6. The fluidizing medium has a density of 1 kg/m^3 and a viscosity of 3×10^{-6}Pa.s. The solid particle has a specific gravity of 1.8. Determine the minimum fluidization velocity in this system. *[(CO6)(Apply/IOCQ)]*

(b) Why does the bed height of packed bed increase with respect to the original bed height, after fluidization is stopped? *[(CO6)(Analyze/IOCQ)]*

8 + 4 = 12

9. (a) What do you mean by streamlining? What is its practical use? *[(CO6)(Analyse/IOCQ)]*

(b) A liquid of density 1000 kg/m^3 is flowing at a velocity of 3 m/s over a solid sphere of radius 2 cm. The drag force on the sphere is 8 kN. Determine the drag coefficient. *[(CO6)(Apply/IOCQ)]*

(2 + 4) + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	5.21	59.37	35.42