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) Which of the following statements are correct:
(P) For a rheopectic fluid, the apparent viscosity increases with time under a constant applied shear stress
(Q) For a pseudoplastic fluid, the apparent viscosity decreases with time under a constant applied shear stress
(R) For a Bingham plastic, the apparent viscosity increases exponentially with the deformation rate
(S) For a dilatant fluid, the apparent viscosity increases with increasing deformation rate
(a) P & Q only (b) Q & R only
(c) R & S only (d) P & S only

(ii) Momentum conductivity is also known as
(a) Dynamic viscosity (b) Kinematic viscosity
(c) Eddy viscosity (d) Bulk viscosity

(iii) Viscous momentum flux is also known as
(a) Shear Rate (b) Shear Stress
(c) Kinematic Viscosity (d) Dilatational Viscosity

(iv) Convective acceleration in a flowing fluid arises due to
(a) Velocity variation with time
(b) Velocity variation with both time and position
(c) Velocity variation with position
(d) Viscous stresses

(v) Euler's equation is applied for analysing _____ flow
(a) Rotational (b) Viscous
(c) Turbulent (d) Potential

(vi) When the water is warm, the height to which it can be lifted by a pump
(a) Decreases due to reduced viscosity
(b) Decreases due to reduced vapor pressure
(c) Increases due to increased vapor pressure
(d) Decreases due to increased frictional resistance

(vii) What is the maximum theoretical suction lift (meters) of a reciprocating pump?
(a) 5 (b) 10
(c) 50 (d) 100

(viii) Which of the following facilitates close control of flow of fluids?
(a) Gate valve (b) Globe valve
(c) Butterfly valve (d) Check valve

(ix) The value of kinetic energy correction factor for laminar flow within a pipeline is
(a) 2 (b) 1
(c) 0 (d) ∞

(x) For calculation of pressure drop for flow of fluids through packed beds, if viscous forces predominate over inertial forces, _____ equation can be used as a simplification.
(a) Burke-Plummer (b) Kozeny-Carman
(c) Ergun (d) Darcy

Group - B

2. (a) Consider a tank filled with 3 immiscible liquids A, B and C at static equilibrium, as shown in the figure 1. At 2 cm below the liquid A – liquid B interface, a tube is connected from the side of the tank. Both the tank and the tube are open to the atmosphere.

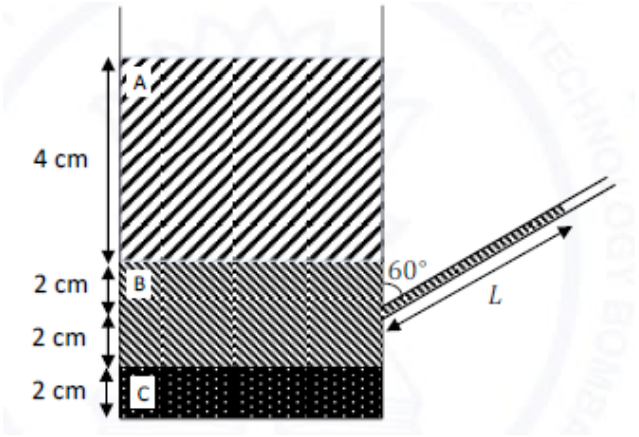

Fig. 1

At the operating temperature and pressure, the specific gravities of liquids A, B and C are 1, 2 and 4, respectively. Neglect any surface tension effects in the calculations. Determine L. [(CO2) (Apply/IOCQ)]

(b) A 2-D velocity field is given by the expression $V = Axi - Ayj$. Here i and j are the unit vectors along the x and y directions respectively. Determine the equation for the streamlines in this flow-field. [(CO3) (Apply/IOCQ)]

7 + 5 = 12

3. (a) A Newtonian fluid of viscosity μ flows between two parallel plates due to the motion of the bottom plate, which is moved with a velocity V along the x direction. The vertical gap between the two plates (y-direction) is **b**. The top plate is stationary. Determine the force/unit area that must be exerted on the bottom plate to maintain the flow. [(CO1) (Apply/IOCQ)]

(b) An incompressible fluid is flowing through a contraction section of length L and has a 1-D (x-direction) steady state velocity profile given by $u = u_0\left(1 + \frac{2x}{L}\right)$. If u_0 = 2m/s and L = 3m, determine the convective acceleration of the fluid at L. [(CO3) (Apply/IOCQ)]

5 + 7 = 12

Group - C

4. (a) A centrifugal pump delivers water at the rate of 0.22 m^3/s from a reservoir at ground level to another reservoir at a height H, through a vertical pipe of 0.2 m diameter. Both the reservoirs are open to atmosphere. The power input to the pump is 90 kW and its efficiency is 75%. The Fanning friction factor is 0.004. Take the density of water as 1000 kg/m^3. Neglecting other head losses, determine the height H upto which water can be delivered. [(CO3) (Apply/IOCQ)]

(b) What do you mean by a "hydraulically smooth pipe"? [(CO3)(Understand/LOCQ)]

(c) "When the water pipelines in a flow network become old, the pumping cost increases". Evaluate the correctness of this statement. [(CO4) (Evaluate/HOCQ)]

7 + 2 + 3 = 12

5. (a) Water flows through a smooth circular pipe under turbulent conditions. In the viscous sub-layer, the velocity varies linearly with the distance from the wall. The Fanning friction factor is defined as:

$$f = \frac{\tau_w}{\rho u^2/_2}$$

where τ_w is the shear stress at the wall of the pipe, ρ is the density of the fluid and u is the average velocity in the pipe. Water (density = 1000 kg m^{-3}, viscosity = 1×10^{-3} kg m^{-1} s^{-1}) flows at an average velocity of 1 m s^{-1} through the pipe. For this flow condition, the friction factor *f is* 0.005. Calculate the velocity of water at a distance of 0.05 mm from the wall of the pipe (in the viscous sub-layer). [(CO3) (Apply/IOCQ)]

(b) In a steady incompressible flow, the velocity distribution is given by V = 3xi- Pyj + 5zk, where, V is in m/s and *x, y,* and *z* are in m. In order to satisfy the mass conservation, what should be the value of the constant P? [(CO3) (Apply/IOCQ)]

8 + 4 = 12

Group - D

6. (a) Define NPSH. Describe the difference between uniform flow and non-uniform flow. [(CO4) (Remember/LOCQ)]
   (b) Describe the classification of pump. [(CO4) (Analyze/IOCQ)]

(2 + 4) + 6 = 12

7. (a) State advantages and disadvantages of gear pump and Screw pump. [(CO4) (Remember/LOCQ)]
   (b) Why Cavitation will occur in Centrifugal Pump and not in Displacement Pump? [(CO3, CO4) (Understand/LOCQ)]
   (c) State the basic difference between single stage and multi stage centrifugal pump. [(CO4) (Remember/LOCQ)]

(3 + 3) + 2 + 4 = 12

Group – E

8. (a) Two packed beds are available, one with a void fraction of 0.3, the other with 0.5. Water is to be pumped through these beds at the rate of 20 kg/hour. In which bed will the pumping cost be higher? [(CO5) (Evaluate/HOCQ)]
   (b) A bed of spherical glass beads (density 3000 kg/m^3, diameter 1 mm, void fraction 0.5) is to be fluidized by a liquid of density 1000 kg/m^3 and viscosity 0.1 Pa.s. If the particle Reynolds number is small compared to 1, then find the minimum velocity required to fluidize the bed. [(CO5) (Apply/IOCQ)]

5 + 7 = 12

9. (a) "Liquids will cause particulate fluidization while gases will cause bubbling fluidization". Justify, with reasons, whether this is a correct statement. [(CO5) (Evaluate/HOCQ)]
   (b) Seawater is passed through a column containing a bed of resin beads.
   Density of seawater = 1025 kg m^{-3}
   Density of resin beads = 1500 kg m^{-3}
   Diameter of resin beads = 40 μm
   Void fraction of the bed at the onset of fluidization = 0.4
   Acceleration due to gravity = 9.81 m s^{-2}
   Determine the pressure drop per unit length of the bed at the onset of fluidization. [(CO5) (Evaluate/HOCQ)]
   (c) Two chemical reactions take place in a processing unit. Reaction 1 has ΔH = - 27647 kJ/mol, while reaction 2 has ΔH = - 257 kJ/mol. There are two reactors in the plant, one with a fixed bed, another with a fluidized bed. Which reactor should you choose for carrying out reaction 1 and why? [(CO5) (Evaluate/HOCQ)]

3 + 4 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	20.83	58.33	20.83

Course Outcome (CO):

After the completion of the course students will be able to

1. Analyze the rheological behavior of fluids and classify them as Newtonian or non-Newtonian fluids.
2. Determine force on submerged bodies and apply the working principle of manometric devices for pressure-drop measurement.
3. Apply continuity equation, momentum balance equation, Bernoulli's equation to solve engineering problems on fluid flow.
4. Categorize different flow measuring devices/fluid moving devices and determine the optimum operating conditions for pumps/blowers/compressors based on the given requirements.
5. Estimate pressure drop in a packed bed as well as minimum fluidization velocity for a given fluidized bed.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

Department & Section	Submission Link
CHE	https://classroom.google.com/c/NDA1MTgxOTgzMDA4/a/MjI3ODkwMjEyNjAw/details