Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (BT-OLD)/SEM-4/CHE-414/2012

2012

TRANSFER OPERATIONS - I

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 the following : $10 \times 1 = 10$

   i) Thermal resistance of a solid system is given by

      a) B/k b) $1/k$

      c) $B/\bar{k}$ d) k/B.

   ii) Parallel flow is effectively used in the heat exchanger of type

      a) Single pass exchanger

      b) Multipass exchanger

      c) Double pipe heat exchanger

      d) Plate type heat exchanger.

   iii) LMTD should be used for a heat exchanger

      a) when U change appreciably

      b) thick wall heat exchanger pipe

      c) counter current flow

      d) Jacketed tubular reactor.

iv) Viscosity correction is introduced in the Dittus - Boiletr equation for

a) turbulent flow

b) laminar flow

c) cooling a viscous liquid

d) heating a viscous liquid.

v) jH factor *vs* NRe with values of L/D should be plotted for

a) laminar flow

b) turbulent flow

c) transition region

d) for the flow above NRe = 6000.

vi) The value of friction factor (*f*) for laminar flow is

a) 16/NRe b) 24/NRe

c) 32/NRe d) NRe/28.

vii) Rubber latex is an example of

a) Newtonian fluid b) Bringham plastic

c) Pseudoplastic d) Dilatant fluid.

viii) Which of the following pumps is useful for biological fluid transport ?

a) Piston pump b) Centrifugal pump

c) Peristaltic pump d) Gear pump.

ix) Fine flow control can be done by

a) globe valve b) butterfly valve

c) needle valve d) ball valve.

x) Ratio of average velocity to maximum velocity for a Newtonian fluid flowing in lamimar condition through circular pipe is

a) 0·5 b) 2

c) 1·5 d) 2/3.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Power required to drive the impeller installed in a stirred tank fermenter depend on rotational speed of the impeller (n), diameter of the impeller (*Di*), gravitational acceleration (*g*), density of the fermentation broth (ρ*f*), viscosity of the fermentation broth (μ*f*). Obtain the dimensionless form of functional relationship using Buckingham -Pi theorem.

3. Show that the velocity profile of a Newtonian fluid flowing through a circular pipe under laminar flow condition is a parabola.

4. a) Differentiate between particulate fluidization and bubbling fluidization.

   b) Explain the condition of fluidization by showing the graphical relationship of pressure drop and bed heights *vs* superficial velocity of fluid. 2 + 3

5. a) Water flows through an orifice 25 mm diameter in a 100 mm pipe at the rate of 630 cm^3/sec. What is the level of a water manometer connected across the orifice ? The discharge coefficient may be taken as 0·62 and the viscosity of water is 1cP.

b) Mention one advantage and one disadvantage of orifice meter of measuring flow through a pipe. 3 + 2

6. Give the definition of the following : 5 × 1

a) Potential flow

b) Bringham plastic

c) Thixotropic fluid

d) Skin friction

e) Fee turbulence.

7. A standard 1 inch schedule 40 steel pipe (OD 1·315 inch, ID 1·049 inch) carries saturated steam at 150°C. The pipe is lagged with a 2 inch layer of 85% magnesium (k1 = 0·065 W/m°C) followed by a $\frac{1}{2}$ inch layer of cork (k2 = 0·055 W/m° C). The outside temperature of the cork is 45°C. The thermal conductivity of steel, k = 400 W/m°C. Calculate the heat loss from 20 m of pipe in wall.

8. Derive an expression for log mean temperature difference (LMTD) for a heat exchanger with countercurrent flow.

9. Carbon tetrachloride flowing at 19,000 kg/hr is to be cooled from 85°C to 40°C using 13,500 kg/hr of cooling water at 20°C. The film coefficient for carbon tetrachloride outside the tube is 1700 W/ m^2 °C. The wall resistance is negligible. But h_i on the water side including the fouling factor is 11,000 W/ m^2 °C. What area is needed for counter flow exchanger ?

10. What is the Colburn j factor ? State the Colburn analogy between heat transfer and fluid friction for turbulent flow $f = 0 \cdot 046(DG/\mu)^{-0 \cdot 2}$? 2 + 3

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

11. a) A pump draws a solution of specific gravity 1·84 from store tank of large cross-sectional area through a pipe of ID 0·08 m . The average velocity in the suction line is 3m/sec. ID of the discharge line is 0·065 m. The end of the discharge line is 35 m above the level of the solution in the feed tank. Frictional losses in the system is 4·7 m of the solution. What pressure must the pump develop in $kg\,m^2$? Assuming the overall efficiency 60%, calculate the energy requirement in kWH.

    b) Draw and explain the characteristics curves of centrifugal pump.

    c) Describe the working principle of piston pump.

    d) Differentiate between gate valve and globe valve.

    8 + 3 + 2 + 2

12. a) Prove that the following numbers are dimensionless :

    (i) Nusselt number

    (ii) Froud number

    (iii) Power number

    (iv) Grashof number.

b) State the equation of continuity for fluid flow.

c) Write down Haggen - Poiseuille equation and state its application.

d) Write down the Bernoullis equation mentioning the significance of each of the terms.

e) Define streamline and sphericity.

f) Calculate the hydraulic mean diameter of the annular space between 40 mn and 50 mm tube.

4 + 2 + 2 + 3 + 2 + 2

13. a) The following data were obtained in a constant pressure filtration of yeast suspension.

t (min)	4	20	48	76	120
V (lit filtrate)	115	365	680	850	1130

Characteristics of filter cake : $A = 0{\cdot}28\ m^2$, $C = 1920\ kg/m^3$, $\mu = 2{\cdot}9 \times 10^{-3}$, $\alpha = 4m/kg$.

Determine :

(i) Pressure drop across the filter

(ii) filter medium resistance (r_m)

(iii) size of the filter to process 4000 lit 12 of cell suspension in 20 minute. 12

b) Define work index and derive the relation between Bond coefficient (Kb) and work index (Wi). 3

14. a) Derive an expression for overall heat transfer coefficient based on the inside diameter of the pipe in terms of individual heat transfer coefficient (*hi*, *ho*) and thermal conductivity of the wall (*k*).

    b) Oil is flowing through a 75 mm ID iron pipe at 1m/sec. It is being heated by steam outside the pipe, and the steam film coefficient is 11,000 W/ m^2°C. At a particular point along the pipe the oil is at 50°C, its density is 880 kg/ m^3, viscosity = 2·1 cP, thermal conductivity *k* =0·35 W/m°C, specific heat cp = 217 J/g°C. What is the overall heat transfer coefficient at this point based on the inside area of the pipe. Given $(h/CpG)(N_{Pr}^{\frac{2}{3}}) = 0 \cdot 23\ NRe^{-0 \cdot 2}$. 5 + 10

15. a) Draw 1-2 parallel counter flow shell and tube heat exchanger with a schematic diagram and explain its mode of action.

    b) What is the radiation law for radiation between surfaces ? Explain the different terms used in the heat transfer equation by radiation ? 10 + 5

16. a) Deduce the expression for unsteady state heat transfer in a semi-infinite solid bar.

    b) Indicate the steps for a analytical solution by an separation of variables. 10 + 5