Group – E

8. (a) A material is crushed in a Blake Jaw crusher and the average size of particles is reduced from 5 cm to 1.3 cm, with consumption of energy at the rate of 37 watt.h/ton. Determine the energy required to crush the same material of average size of 8 cm to an average size of 3 cm using (i) Rittinger's law and (ii) Kick's law (The mechanical efficiency remains unchanged.)

(b) What is the difference between differential and cumulative screen analysis? Explain with an example.

(4 + 4) + 4 = 12

9. Data for the laboratory filtration of $CaCO_3$ slurry in water at 298 K are reported as follows at a constant pressure drop of 338 KN / m^2. The filter area of the plate and frame press , A = 0.0439 m^2 and the slurry concentration , C_s = 23.74 kg / m^3. Calculate the constants α and r_m from the experimental data given, where t is time in s and V is filtrate volume in m^3.(Given: viscosity of water at 298K is 8.937 × 10^{-4} kg/m.s

t (s) 4.4	9.5	16.3	24.6	34.7	46.1	59.0	73.6	89.4	107.3
V × 10^3(m^3)	0.498	1.00	1.501	2.0	2.498	3.002	3.506	4.004	4.502
t / V × 10^{-3} (s/m^3)	8.83	9.5	10.86	12.3	13.9	15.35	16.83	18.38	19.85

12

TRANSFER OPERATION - I
(BIOT 2202)

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 terminal settling velocity of a small spherical particle settling in a viscous fluid varies
- (a) inversely with fluid viscosity
- (b) inversely with square of particle diameter
- (c) directly with first power of particle diameter
- (d) directly with square of the difference in specific weights of solid & fluid.

(ii) For a parallel flow heat exchanger hot water inlet temperature is 80°C and outlet temperature is 38°C and cold fluid inlet temperature is 8°C and outlet temperature is 18°C. The driving force for heat transfer is
(a) 40.6°C (b) 44°C (c) 26°C (d) 46°C.

(iii) The dynamic viscosity of a liquid is 1.2 × 10^{-4} Ns/m^2, whereas, the density is 600 kg / m^3. The kinematic viscosity in m^2/s is
(a) 72 × 10^{-3} (b) 20 × 10^{-8} (c) 7.2 × 10^3 (d) 70 × 10^6.

(iv) At high Reynolds number
- (a) inertial forces control and viscous forces are unimportant
- (b) viscous forces predominate
- (c) inertial forces are unimportant and viscous forces control
- (d) none of these.

(v) What causes cavitation in centrifugal pump?
- (a) Low barometric pressure
- (b) High suction pressure
- (c) Low suction pressure
- (d) High suction velocity.

(vi) Drag coefficient in hindered settling is _____ that in free setting.
(a) less than (b) more than (c) equal to (d) comparatively negligible.

(vii) The net positive suction head (NPSH) of a centrifugal pump is defined as the sum of the velocity head and the pressure head at the
(a) discharge
(b) suction minus vapor pressure of the liquid at suction temp
(c) suction
(d) discharge minus vapor pressure of the liquid at the discharge temperature.

(viii) Mechanism of size reduction in nut cracker is
(a) cutting (b) compression (c) impact (d) attrition.

(ix) Bond's constant is
(a) $0.3162W_i$ (b) $3.163W_i$
(c) $1/0.3162W_i$ (d) inversely proportional to work index.

(x) Rate of filtration depends on
(a) pressure drop (b) viscosity of filtrate
(c) cake resistance (d) all the above.

Group – B

2. (a) Define flow behaviour and flow consistency index for power low fluid. Establish that the flow behaviour index for pseudoplastic fluid is less than 1.

(b) What is the difference between skin friction and form friction in case of fluid flowing through pipe?

(c) State the operating principle of fluidised bed reactor.

(3 + 3) + 3 + 3 = 12

3. Air ($\rho = 1.22\ Kg/m^3$, $\mu = 1.9 \times 10^{-5}\mu$ pa.s) is flowing in a fixed bed of a diameter 0.5 m and height 2.5 m. The bed is packed with spherical particles of diameter 10 mm. The void fraction is 0.38. The air mass flow rate is 0.5 kg/s. Calculate the pressure drop across the bed of particles.

12

Group – C

4. (a) Sulphuric acid of sp gr. 1.3 is flowing through a pipe ID 5 cm. A thin tipped orifice of 1 cm diameter ID fitted in the pipe and the differential pressure shown by mercury manometer is 10 cm. Assuming that the leads to the manometer are filled with acid, calculate the weight of acid flowing through pipe per hour. (Assume that the value of C_o as 0.61.)

(b) What is pitot tube? How does it work?

6 + (2 + 4) = 12

5. Water is to be pumped from a pond to the top of a tower 1829 cm above the water level in the pond. It is desired to deliver 0.34 m^3/min of water at a pressure of 2.08 kg/cm^2 absolute. The absolute pressure on the top of surface of pond is 1.033 kg/cm^2. The pipe line consists of 122 m length of straight pipe 7.62 cm ID with 8 elbows and 4 gate valves. Calculate the power required of the pump having an efficiency of 80%.
(Data given, For elbow joint L / D = 32; For Gate valve L / D = 7; $\mathbf{f = \frac{0.046}{R_e^{0.32}}}$ for turbulent flow)

12

Group – D

6. (a) Derive an expression for heat transfer through a composite wall of three different layers.

(b) Methyl alcohol flowing in the inner pipe of a DPHE is cooled with water flowing in the jacket. The outside diameter of the inner pipe is 25 mm. The thermal conductivity of steel is 45 W/ m ^{0}C. Given data: Alcohol side heat transfer coefficient, h_i = 1020 W/m^2 ^{0}C, water side heat transfer coefficient, h_0 = 1700 W/m^2 ^{0}C, inside fouling factor, hd_i = 5680 W/m^2 ^{0}C, outside fouling factor, hd_0 = 2840 W/m^2 ^{0}C, D_i = 13.11mm, D_0 = 16.44mm and thickness = 1.665mm. What is the overall coefficient based on the outside area of inner pipe?

5 + 7 = 12

7. Benzene is cooled from 60.6 ^{0}C in the inner pipe of a DPHE having h_{di} = 5680 W/m^2 ^{0}C cooling water flows counter-currently to the benzene, entering the jacket at 18.3^{0}C and leaving at 23.9^{0}C. The exchanger consists of an inner pipe of 11 mm BWG 16 copper tubing jacketed with 38.1 mm schedule 40 steel pipe. The linear velocity of benzene is 1.52 m/s. Neglecting the resistance of the wall and scale films and assuming L/D > 150 for both pipes, compute the film coefficients of the benzene and water and the overall coefficient based on the outside area of the inner pipe. Given data:
Inner diameter of inner tube, $D_{it} = 9.3125 \times 10^{-3}$m, outer diameter of inner tube, D_{ot} = 0.011m, inner diameter of jacket = 0.02m, density of benzene = 0.852 kg/m^3, heat capacity of benzene = 1.82 KJ / kg.K, heat capacity of water = 4.184 KJ/kg. K, viscosity of benzene = 0.436×10^{-3} Ns/m^2 and viscosity of water = 1×10^{-3} Ns/m^2.
Nu = 0.023 $(Re)^{0.8}$. $(Pr)^{1/3}$ where Nu is the Nu is the Nusselt Number and Re is Reynolds Number and Pr is Prandtl Number.

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