B.TECH/BT/4TH SEM/BIOT 2202/2019
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 cylindrical portion of short length, which connects converging and diverging section of venturimeter, is called as
(a) diffuser (b) connector (c) throat (d) manometer tube.

(ii) If viscosity of fluid is more, the thickness of boundary layer is
(a) more (b) less (c) not affected by change in viscosity
(d) unpredictable.

(iii) Boundary layer thickness is the distance from the boundary to the point where velocity of the fluid is
(a) equal to 10% of free stream velocity
(b) equal to 50% of free stream velocity
(c) equal to 90% of free stream velocity
(d) equal to 99% of free stream velocity.

(iv) Parallel flow heat exchanger is preferred for
(a) rapid initial cooling (b) uniform cooling
(c) gradual cooling (d) none of the above.

(v) At critical speed, n_c, in a tumbling mill,
(a) $\cos\alpha=1$ (b) $\cos\alpha=0$ (c) $\cos\alpha=1/2$ (d) $\cos\alpha=\sqrt{3}/2$.

(vi) The devices used for flow obstruction is/are
(a) orifice plate (b) venturi tube
(c) flow nozzle and dall flow tube (d) all of these.

(vii) Mechanism of size reduction in hacksaw is
(a) cutting (b) compression (c) impact (d) attrition.

(viii) Particle shape is expressed as its
(a) length (b) diameter (c) sphericity (d) equivalent diameter.

(ix) An ideal crusher should
(a) have a large capacity
(b) require a small power input per unit of product
(c) yield a product of single size or desired size distribution
(d) all the above.

(x) A blinded screen means
(a) a solid plugged with solid particles
(b) a screen folded at two ends
(c) a vibrating screen
(d) a dismantled screen.

Group – B

2. Air (ρ = 1.22 Kg/m^3, $\mu = 1.9 \times 10^{-5}$ 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**

3. (a) It is planned to install a steel pipe with an ID 20 cm to transfer 1000 kg/min molasses having viscosity 500cP and density 1.6 gm/cc. The line is to be 1000 m long and delivery end is to be 5 m higher than the intake. Calculate pressure drop due to friction (Kg/Cm^2). If the overall efficiency of pump is 80%, what is the power required by the pump.

(b) Differentiate between skin friction and form friction. **9 + 3 = 12**

Group – C

4. (a) A venturimeter is fitted in a pipe of 30 cm diameter inclined at 40° to the horizontal to measure the flow rate of petrol having a specific gravity of 0.8. The ratio of areas of main pipe and throat is 5 and the throat is at 1 m from the inlet along its length. The difference in manometer head is 40 mm of mercury. Assuming the coefficient of discharge as 0.96, calculate the discharge through the venturimeter and the pressure difference between the throat and the entry point of the venturimeter.

(b) Why is the discharge coefficient of orifice meter less than that of venturimter? **(6 + 3) + 3=12**

5. (a) Calculate the net positive suction head (NPSH) of a pump handling 10,000 kg/hr water flow coming from an atmospheric storage tank. The water temperature is 25°C and pipe dia is 15 cm. The pump suction nozzle is 0.4 m above the ground level. The tank is elevated on a 1m high platform. The minimum liquid level in the tank is 300 mm. Pipe length is 0.02 km. Note, frictional loss is 1.3 bar/km and water vapour pressure at 25°C is 3.2 KPa.

(b) Explain the working principle of rotameter. **6 + 6 =12**

Group – D

6. Benzene is cooled from 60.6°C to 31.1°C in the inner pipe of a DPHE having h_{di}= 5680 W/m²°C. Cooling water flows counter-currently to the benzene, entering the jacket at 18.3°C and leaving at 23.9°C. The exchanger consists of an inner pipe of 11mm BWG 16 copper tubing jacketed with 38.1mm schedule 40 steel pipe. The linear velocity of benzene is 1.52m/sand that of water is 1m/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 × 10^{-3}m, Outer diameter of inner tube, D_{ot}= 0.011m, Inner diameter of jacket= 0.02m, density of benzene= 0.852kg/m³, Heat capacity of benzene= 1.82 KJ/kg.K, Heat capacity of water= 4.184 KJ/kg. K, thermal conductivity of copper inner pipe= 399W/m.K, viscosity of benzene= 0.436×10^{-3}Ns/m² and viscosity of water=1 × 10^{-3} Ns/m².
Nu= 0.023(Re)$^{0.8}$.(Pr)$^{1/3}$ where Nu is the Nusselt's Number and Re is Reynold's Number and Pr is Prandtl Number.

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7. Saturated steam at 267°F is flowing inside a ¾ in. steel pipe having an ID of 0.824in. and an OD of 1.05in. The pipe is insulated with 1.5in. of insulation on the outside. The convective coefficient for the inside steam surface of the pipe is estimated as h_i=1000 Btu/h.ft². °F, and the convective coefficient on the outside of the lagging is estimated as h_0=2 Btu/h.ft².°F. The mean thermal conductivity of the metal is 26 Btu/h.ft. °F and 0.0337 Btu/h.ft.°F for the insulation. Calculate the heat loss for 1ft pipe if the surrounding air is at 80°F.

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Group – E

8. Data for the laboratory filtration of $CaCO_3$ slurry in water at 298K are reported as follows at a constant pressure drop of 338KN/m². The filter area of the plate and frame press was A= 0.0439m² and the slurry concentration was C_s = 23.74kg/m³. Calculate the constants α and rm from the experimental data given, where t is time in s and V is filtrate volume collected in m³. (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
Vx10^3(m³)	0.498	1.00	1.501	2.0	2.498	3.002	3.506	4.004	4.502
t/Vx10^{-3} (s/m³)	8.83	9.5	10.86	12.3	13.9	15.35	16.83	18.38	19.85

12

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

(b) State Bond's law. Define work index.

4 +4 + (2 + 2) = 12