**B.E. CHEMICAL ENGINEERING SECOND YEAR SECOND SEMESTER
EXAMINATION 2022**

MECHANICAL OPERATIONS

Time: Three hours   Full marks 100

(50 marks for each Part)

Use Separate Answer Script for each Part.

PART I

Answer any five questions

Assume any data missing

1. A rock of nearly 5cm is fed to a gyratory crusher, which requires 12kW power on no load. The differential screen analysis of the product is given below under column A. The power requirement for crushing is 432kW/ton. By reducing the clearance between the crushing head and the cone, the differential screen analysis of the product becomes as shown in column B. Calculate the power requirement for the second operation using Kicks Law.   10

Mesh No	Size of the opening (mm)	Weight A	% retained B
4	4.7	-	-
6	3.33	3.1	-
8	2.36	10.3	3.3
10	1.65	20	8.2
14	1.17	18.6	11.2
20	0.83	15.2	12.3
28	0.59	12.0	13.0
35	0.42	9.5	19.5
48	0.30	6.5	13.5
65	0.21	4.3	8.5
100	0.15	0.5	6.2
150	0.10	-	4
-150	-	-	0.3

2. Show that log f_D = log24 –log R_e when flow of solids through fluid is laminar. 10

3. State and discuss energy-size reduction laws given by Bond and Rittenger. And also define work index. 10

4. Discuss about "sedimentation" and its importance in chemical process industry. 10

5. A thickener produces a thickened limestone sludge whose concentration is 550 kg/m^3 . The feed of slurry (limestone-water) to the thickener is 12.626 kg/sec. Initial slurry concentration is 236 kg/m^3. For these conditions find the thickener area taking the results of batch settling test is as follows. 10

t(sec)	Interface height (m)
0	0.36
900	0.324
1800	0.286
3600	0.210
6300	0.147
10800	0.123
17100	0.116
43200	0.098
72000	0.088

6. Ruth and Kempe reported the results of laboratory filtration tests on a precipitate of CaCO$_3$ suspended in water. A specially designed Plate and Frame Press with a single frame was used. The frame had a filtering area of 0.283 ft^2 and thickness of 1.18inch. All tests were conducted at 66^{0}F and ΔP=40 psi=constant with a slurry containing 0.0723 weight fraction CaCO$_3$. The density of the dried cake was 100lb/ft^3.The test results for one run are given below

Vol of filtrate(lit)	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8
Time (S)	1.8	4.2	7.5	11.2	15.4	20.5	26.7	33.4	41	48.8	57.7	67.2	77.3	88.7

Determine the filtrate volume equivalent in resistance to the filter medium and piping (Ve), the specific cake resistance, and cake porosity and the cake specific surface taking sp.gr. 2.93. 10

7. What do you understand by a positive displacement pump? What is the function of the air
    Chamber which is provided to the discharge line of a reciprocating pump?   6+4=10

8. A pump draws a solution of specific gravity 1.84 from a storage tank of large section through
    8 cm id pipe. The velocity in the suction pipe is 1m/s. The pump discharges through 5cm id
    pipe to an overhead tank. The end of discharge line is 15m above the level of solution in the
    tank. Friction loss in the entire system may be taken as 3m of solution. What pressure must
    the pump developed and what is theoretical HP required doing this pumping.   10

Che/PC/B/T/225/2022

B.E. CHEMICAL ENGINEERING SECOND YEAR SECOND SEMESTER - 2022
2nd Year, 2nd Semester
MECHANICAL OPERATIONS

Assume any missing data

PART II

Answer any **five (5)** questions

1. A mixture of quartz and lead glance particles is to be separated into pure components by hindered settling process. The particles are in the size range 15-75 μm, what should be the minimum apparent density of the fluid that will ensure their complete separation. Assume that the shapes of the quartz and lead glance are similar. Discuss the effect of viscosity of the fluid on the minimum required density. Density of quartz: 2650 kg/m^3, Density of lead glance: 7560 kg/m^3.

10

OR

A rotary drum filter of area 3m^2 operated with an internal pressure of 30 kn/m^2 and with 30% of its surface submerged in the slurry. Calculate the rate of production of filtrate and thickness of cake when it rotates at 0.0083 Hz if filter cake is incompressible and filter cloth has a resistance equal to that of 1 mm cake.

It is desired to increase the rate of filtration by raising the speed of rotation of the drum. If the thinnest cake that can be removed from the drum has a thickness of 5 mm, what is the maximum rate of filtration which can be achieved and what speed of rotation of the drum is required?

(voidage of cake: 0.4, specific resistance of cake: 2x10^{12}/m^2, density of solids: 2000 kg/m^3, slurry concentration: 20% by mass of solids).

10

2. a) Differentiate propeller and turbine type impellers.

   b) Show that the shaft power required in an agitated vessel, P

$$P \propto \rho_f . N^3 . D a^5$$

where, ρ_f: density of fluid; N: speed of rotation; D_a: diameter of impeller

c) Mention few scale-up criteria of stirred or agitated vessel.

2+5+3

OR

A single stage compressor is to compress 7.56×10^{-3} kmol/sec of methane gas at 26.7°C from 137.9 kPa abs to 551.6 kPa abs. Calculate the power required if mechanical efficiency is 80% and compression is adiabatic. Is it higher than that required for isothermal operation?

10

3. **a)** A continuous grinder obeying Bond Crushing law grinds a solid at the rate of 1000 Kg/hr from the initial diameter of 10 mm to the final diameter of 1 mm. If the market now demands product particles of size 0.5 mm, what will be the output rate of the grinder for the same power input? In order to restore the output back to 1000 Kg/hr an additional grinder was installed. The two grinders can operate either in series or parallel. Which configuration is economical?

b) Distinguish between frothers and collectors used in froth floatation

8+2

4. Cyclones have proved to be very useful to separate solids from gases if particles are more than 5 μm. Discuss why?
Coarse to fine particulates are present in a gas stream. Suggest how Cyclone separators can be arranged to separate the particles.

10

5. **a)** Why closed circuit grinding is more favorable than open circuit grinding?

b) What do you mean by angle of nip and angle of bite of a roll crusher?

c) Distinguish between classification and jigging

d) Choose a suitable type of pump (Centrifugal/Rotary/Reciprocating) for the following applications:

i) Extremely high pressure service

ii) Extremely variable flow rate applications

iii)   For liquids with 50% volume of entrained gas

iv)   For liquids with abrasive solids

2+2+2+4

6. **a)** It is proposed to pump 10,000 kg/hr toluene at 114°C and 1.1 atm pressure from the reboiler of a distillation tower to a second distillation unit without cooling the toluene before enters the pump. If the friction loss in the line between the reboiler and pump is 7kN/m² and the density of toluene is 866 kg/m³, how far above the pump must the liquid level in the reboiler be maintained to give a net positive suction head of 2.5 m? Calculate the power required to drive the pump if the pump is to elevate toluene 10 m, the pressure in the second unit is atmospheric, and the friction loss in the discharge line is 35kN/m². The velocity in pump discharge line is 2 m/s.

    b) A pair of rolls is to take a feed equivalent to spheres of 3 cm of diameter and crush them to spheres having 1 cm diameter. If the coefficient of friction is 0.29, what would be the diameter of rolls?

8+2

7. Slurry is filtered in a plate & frame press containing 12 frames, each 0.3 m square and 25 mm thick. During the first 180 s, the filtration pressure is slowly raised to the final value of 400 kN/m² and during this period, the rate of filtration is maintained constant. After the initial period, filtration is carried out at constant pressure and the cakes are completely formed in further 900 s. the cakes are then washed with a pressure difference of 275 kN/m2 for 600 s, using thorough washing. What is the volume of filtrate collected per cycle and how much wash water is used?

10