

BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI  
(END SEMESTER EXAMINATION)

CLASS: BTECH  
BRANCH: CHEMICAL

SEMESTER : IV  
SESSION : SP/2023

SUBJECT: CL205R1 MECHANICAL OPERATIONS

TIME: 3 Hours

FULL MARKS: 50

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----|----|
| Q.1(a) Define sphericity. Calculate the sphericity of a hemisphere of diameter D                                                                                                                                                                                                                                                                                                                                                                                      | [3] | 1  | 1  |
| Q.1(b) Highlighting the various types of equipment used for conveying solid in chemical industry? Explain the principle of belt conveyer.                                                                                                                                                                                                                                                                                                                             | [4] | 2  | 2  |
| Q.1(c) Define angle of repose. Name the different method of solid storage.                                                                                                                                                                                                                                                                                                                                                                                            | [3] | 2  | 1  |
| Q.2(a) <b>Propose</b> size reduction devices suitable for following materials: (i) sticky frozen feed (ii) feed to be reduced to fixed dimensions (iii) heat sensitive. Justify the selection                                                                                                                                                                                                                                                                         | [2] | 4  | 6  |
| Q.2(b) (i) <b>Estimate</b> the Power required to convert feed particles of 51 mm dia to 3.2 mm dia particles. Let mass flow rate be 100 ton/hr and $W_i$ is 12.74<br>(ii) In a grinding mill, time taken to diminish 20% of a feed material with initial mass fraction of '0.0251' is '106 s'. Estimate grinding-rate function                                                                                                                                        | [3] | 1  | 5  |
| Q.2(c) <b>Identify</b> and explain with figures, the salient features of size reduction machines associated with the following terms: (i) V-opening (ii) machine with in-built screen                                                                                                                                                                                                                                                                                 | [5] | 3  | 3  |
| Q.3(a) Draw a characteristic graph of Differential Settling process. <b>Analyze</b> and detail the <b>inferences</b> from the graph and <b>list</b> solutions to avoid mixed fractions                                                                                                                                                                                                                                                                                | [3] | 5  | 4  |
| Q.3(b) Determine the settling velocity of 60 $\mu\text{m}$ & 10 $\mu\text{m}$ particles in a fluid of density 1.2 $\text{kg/m}^3$ for two conditions: (i) free settling of particles (ii) settling velocity of fine particle if settling of one particle affects settling of another. Particle Density = 1280 $\text{kg/m}^3$ and viscosity of fluid = 1.8 $\times 10^{-5}$ $\text{Ns/m}^2$ .                                                                         | [3] | 1  | 5  |
| Q.3(c) Explain the working principles of Disk & Nozzle-discharge centrifuges with figures, salient points and applications                                                                                                                                                                                                                                                                                                                                            | [4] | 5  | 2  |
| Q.4(a) Data for the laboratory filtration of $\text{CaCO}_3$ slurry in water at 25 $^\circ\text{C}$ reported in following table at constant pressure drop ( $\Delta p$ ) 300kN/m $^2$ . The filter area of single plate and frame filter press was 0.05m $^2$ . Slurry concentration was 25kg/m $^3$ . The viscosity at 25 $^\circ\text{C}$ is 8.9 $\times 10^4$ Pa.s. Calculate the specific cake resistance and filter medium resistance.<br>(Graph paper required) | [6] | 5  | 5  |

Time, s	Filter Volume $\times 10^3$ m $^3$
5	0.48
10	1.1
15	1.4
20	2.01
40	2.52
60	3.1
80	3.45
100	4.1
120	5.02

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|---|---|
| Q.4(b) Illustrating the compressibility coefficient of cake? How do you calculate it?                                                                                                                                                                                   | [4] | 4 | 4 |
| Q.5(a) Write a short note on forth flotation techniques.                                                                                                                                                                                                                | [2] | 3 | 4 |
| Q.5(b) A wastewater treatment plant has a flow rate of 0.5 m $^3$ /sec. The settling tank at the plant has dimensions of 20 m long, 3 m tall and 6 m wide. If the settling velocity is 0.0035 m/sec, how much percent of the particles will be removed?                 | [3] | 5 | 5 |
| Q.5(c) Briefly <b>summarize</b> working principles of (i) Spiral Concentrators (ii) Tabling and (iii) Jigging. Also, outline the expression for overall efficiency of screen and explain the main difference of Hydroseparators compared to other separation processes. | [5] | 5 | 2 |