

BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
First Semester 2007-2008

CHE UC431 Selected Chemical Engineering Operations

Comprehensive Examination
(Closed Book)

DURATION: 3 hours

DATE: 27-12-07
MAXIMUM MARKS: 110

Instructions:

1. Attempt ALL questions.
2. Make suitable assumptions wherever necessary and state them clearly.
3. Be brief and precise. Illegibility will cost you marks.
4. Some useful correlations are given at the end of question paper.
5. Assume missing data, if any, reasonably.

1. (a) What is the objective of crushing and grinding? Why smaller particles are desired. (2+2)
(b) A certain crusher accepts a feed material having a volume-surface mean diameter of 19mm and gives a product of volume-surface mean diameter of 5mm. The power required to crush 15 tonnes per hr is 7.5 KW. What will be the power consumption if the capacity is reduced to 12 tonnes per hr? (08)
(c) Calculate the operating speed of the ball mill from the data given below. Diameter of ball mill = 800 mm, dia of ball = 60 mm. If (i) operating speed is 55% less than the critical speed, (ii) critical speed is 40% more than the operating speed. (08)
2. (a) Name the equipments which are under centrifugal sedimentation process. (3)
(b) The data in the table were taken in a constant-pressure (15000 kg/m²) filtration of slurry of CaCO₃ in water. The laboratory filter press has 6 frames with an area of 0.225 m²/frame. The mass fraction of solids in the feed to the press was 0.08. The filtrate was collected in a tank having 0.4 m² area. Calculate the value of filter media resistance and cake resistance. (16)

Time, Sec	113	126	139	151	162	174	184	196	209
Ht of the filtrate tank, cm	47	51	55	59	63	67	71	75	79

3. (a) Define Lyophilization.

(3)

(b) 1400 kg (bone dry) of granular solid is to be dried under the constant drying conditions from a moisture content of 0.2 kg/kg dry solid to a final moisture content of 0.02 kg/kg dry solid. The drying surface is given as 0.0615 m²/kg. Under the same conditions, the following rates were previously known. Calculate the time required for drying.

(16)

X, Kg/Kg dry solid	0.3	0.2	0.14	0.096	0.056	0.046	0.026	0.016
Rate, Kg/(m ² h)	1.71	1.71	1.71	1.46	1.29	0.88	0.54	0.376

4. Adsorption using 6×10 mesh activated carbon is being considered to treat dye solution having initial concentration of 600 ppm at 25°C and 1 atm. The above experiment is carried out in laboratory shaker with 50ml content for each batch and the data is shown in the table. Determine the Freundlich parameters from the following data. (16)

Mass, mg	50	100	200	300	600	800
Equilibrium Conc, ppm	300	200	100	50	15	10

5. (a) Discuss in detail about the flow patterns in membrane separators and separator arrangement. (4+4)

(b) A hollow-fiber permeator with $d_o = 200 \mu\text{m}$ and $d_i = 300 \mu\text{m}$ gives a average water flux of $5 \times 10^{-4} \text{ cm/sec}$ with 0.1 M NaCl solution at 20°C. Estimate the exit velocity and the pressure drop within the fibers, if the fiber length is 2.5 m and assuming viscosity of water is 1 Cp. (6+6)

6. (a) Discuss briefly about the spurious nucleation. (6)

(b) Assume that sodium chloride is to be crystallized with heterogeneous nucleation is consistent with an apparent interfacial tension of 2.5 ergs/cm², the density of crystal is 2.16 g/cm³. Determine the nucleation rate as a function of s at a temperature of 273 K. (10)

Some useful equations:

$$\text{Filter medium resistance} = \frac{A \times \Delta P \times b}{\mu}$$

$$\text{Specific Cake Resistance} = \frac{2 \times A^2 \times \Delta P \times a}{\mu \times c}$$

$$\bar{V} = \frac{4 \times J_w \times L}{D}$$

$$\Delta P_s = \frac{32 \times \mu \times L \times \bar{V}}{2 \times D^2}$$

$$B^0 = 10^{25} \exp \left[- \frac{16 \times \Pi \times V_m^2 \times N_a \times \sigma_a^3}{3(RT)^3 \times v^2 \times s^2} \right]$$

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Test - 2

(Open Book)

DURATION: 50 MINUTES

MAXIMUM MARKS: 45

Note: Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1. A molecular sieve adsorbent used for air separation has a maximum capacity for N₂ of 46 g/g at 30°C, and data can be fitted to a Langmuir isotherm with $K = 0.5 \text{ lit/mg}$.
(a) What is the saturation capacity when the adsorbent is exposed to air at 10 mg/lit and 30°C? (b) Calculate the ideal adsorption time (minutes) for the above condition for a bed 10 m deep operating with a superficial velocity of 20 cm/hr. The pellet density is 1.3 g/cc.
(8+9 marks)
2. Define LUB and GPU. (5 marks)
3. How to concentrate maple syrup? (2 marks)
4. Rotating discs make use of _____ energy of atomization. (2 marks)
5. _____ dryer is commonly used for wet filter cakes and wet lumpy solids. (2 marks)
6. A 100 kg bath of granular solids containing 30% moisture is to be dried in a tray dryer to 16% moisture by passing a current of air at 350K across its surface at a velocity of 1.8m/s. If the constant rate of drying under these conditions is $0.7 \times 10^{-3} \text{ kg/(m}^2\text{s)}$ and the critical moisture content is 15% calculate the drying time. The drying surface is $0.03 \text{ m}^2/\text{kg dry weight}$.
(17 marks)

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Test - 1
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DURATION: 50 MINUTES

MAXIMUM MARKS: 45

Answer all the questions

1. In a cement industry ball mills are used to crush the cement clinker. Calculate the power required to crush 1200 ton/day of cement clinker if 80 percent of the feed passes a 100 mm screen and 80 percent of the product a 25 mm. (4 marks)
2. What is filter aid? Give some examples. (4 marks)
3. In a laboratory, gravel is crushed using jaw crusher. The screen analysis is shown in the table. The density of the particle is 3g/cc, $\phi_s = 0.6$, volume shape factor is 0.8 and feed consist of 250 gm. For the material between 4 mesh and pan, calculate the flowing and give comments on the results. (16 marks)
 - a) Volume surface mean diameter
 - b) Mass mean diameter
 - c) Volume mean diameter
 - d) N_i for 36/pan increment

Mesh number	4	5	6	7	10	14	18	25	30	36	pan
Mesh opening mm	4.75	3.35	2.8	2	1.7	1.18	0.85	0.6	0.5	0.425	-
Wt in gm	0	5	12	9	30	34	30	20	24	4	82

4. Air carrying particles of density 1800 kg/m³ and an average diameter of 20 μ m enters a cyclone at an angular velocity of 18m/s. The diameter of the cyclone is 600mm, calculate the separation factor for this cyclone. (4 marks)
5. Explain the working principle of fluid energy mill. Write the difference between hammer mill and ball mill. (6 marks)
6. Mention the types of blades used for cohesive mixing. (3 marks)
7. What are the basic patterns for size reduction of particles? (4 marks)
8. Define classifier and clarifier. (4 marks)