BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
First Semester 2017-2018
CHE F313 Separation Processes – II
Comprehensive Examination
(Closed Book)

Date: 11.12.2017 **Time: 3 Hours** **Maximum Marks: 120**

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1. **(30 Marks)** Give precise answers to the following questions:
   (a) Show the solubility curve, eutectic point and different phases in the naphthalene-benzene binary system.
   (b) How does a cluster grow into a crystal?
   (c) What is the mechanism by which transport of gases take place through dense (nonporous) polymeric membrane?
   (d) What is breakthrough curve? Sketch a breakthrough curve corresponding to different concentration profiles in a fixed bed at different time
   (e) Explain how washing time is calculated in filter press and leaf filter.
   (f) Outline the steps involved in designed a rotary dryer.
   (g) Derive the expression for wet bulb depression.
   (h) Derive the equation for continuous filtration in a rotary drum.
   (i) Describe how supersaturation can be generated?
   (j) What are the units used for permeance and permeability? Define them.

2. **(15 Marks)** A hot solution containing 2000 kg of $MgSO_4$ and water at 57^oC and with a concentration of 30 wt% $MgSO_4$ is cooled to 20^oC and $MgSO_4.7H_2O$ crystals are removed. The solubility at 20^oC is 35.5 kg $MgSO_4$ per 100 kg water. The average heat capacity of the feed solution is 2.93 kJ/kg. ^oC. The heat of solution at 20^oC is -13.31×10^3 kJ/kgmol crystal ($MgSO_4.7H_2O$). Calculate the yield of crystals. State whether heat is absorbed in or removed from the process. Atomic weights of Mg, S, O, and H are 24, 32, 16 and 1, respectively.

3. **(15 Marks)** A leaf filter with 1.865 m^2 of filtering area has the following data during filtration at constant pressure difference of 3.3 atm.

t (min)	15	30	45	60	90
V (m^3) volume of filtrate	2.848	4.643	6.067	7.349	9.542

   The viscosity of filtrate is 0.9 cP and 23.5 kg of solid deposited in the filter per m^3 of liquid filtrate collected. Obtain the values of specific cake resistance and filter medium resistance in m/kg and m^{-1} respectively.

4. **(15 Marks)** Screen analysis of a sample of sand particles is shown below:

Aperture Size Dpi, mm	0.181	0.152	0.125	0.104	0.089	0.076	Pan
Mass fraction, xi	0	0.0041	0.0236	0.4830	0.4000	0.0593	0.0300

   Calculate: a) Volume-surface mean diameter, and b) Volume mean diameter.

[PTO]

5. **(15 Marks)** Granular activated carbon impregnated with Sulphur is used to remove mercury vapor from air. The adsorption is irreversible. Assuming that the adsorption rate for removal of mercury from air is controlled by external mass transfer, calculate the overall mass transfer coefficient $K_c a$ for a bed of carbon with average particle size of 4 mm at 20°C and a superficial velocity of 75 cm/s. If the inlet concentration is 10 µg/Nm^3 and the treated gas must contain less than 0.001 µg/Nm^3, what is the minimum bed length?
Given:
For air: viscosity = 0.018 cP, density = 1.2 g/L; For mercury vapor diffusing through air: Diffusivity = 0.125 cm^2/s; For mass transfer in packed beds: Sh = 1.17 Re$^{0.585}$ Sc$^{1/3}$, bed porosity = 0.40.

6. **(15 Marks)** A wet filter cake 70 cm square and 5 cm thick was dried with air at a wet-bulb temperature of 26.6°C and a dry-bulb temperature of 50°C. The moisture content (dry basis) of the cake was reduced from an initial value of 22% to a final value of 1.5%. The density of the cake was 1920 kg/m^3. Air flows parallel with faces of the cake at a velocity of 60 cm/s. The critical moisture content was 10% (dry basis) and the equilibrium moisture content was negligible. The heat transfer coefficient (in J/m^2.h.°C) is given by

$$h_y = 120(G)^{0.8}$$

Where G is the mass velocity of air in kg/h.m^2. If the filter cake was dried from both sides, what was the total time of drying? Assume linear falling rate. Given Latent heat of vaporization of water as 2.43x10^6 J/kg.

7. **(15 Marks)** The following experimental data for equilibrium adsorption of pure methane gas on activated carbon at 296K were obtained:

W, cm^3 (STP) of CH_4/ g carbon	45.5	91.5	113	121	125	126	126
Partial pressure p, psia	40	165	350	545	760	910	970

Fit the data to (a) Freundlich Isotherm and (b) Langmuir Isotherm.

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