Birla Institute of Technology and Science, Pilani
Semester I Session: 2023-24
CHE F313 Separation Process-II
Mid-Semester Test

Date: 11/10/2023 (FN1) **Full Marks: 90**

Closed Book

Instructions: **Answer all parts of a question together. *State and justify if you make any assumptions. *Clearly write the nomenclature used. *Your answers must include appropriate units. *Clearly mention the question number. * Be to the point and specific. * No exchange of calculators is allowed. *Refer to the reference booklet for the formulas and values.*

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1. A solar dryer was used to dry a sample of wet solid from a free moisture content of 0.4 (kg moisture/kg dry solid) to 0.04 (kg moisture/kg dry solid). Weight of the dry solid is 500 kg and area of the top drying surface is 20 m^2. It is estimated its critical free moisture content is 0.2 (kg moisture/kg dry solid), while constant drying rate is 1.5 kg moisture/h. m^2. For the other period, following data points of rate versus free moisture content are available:

Moisture Content (kg H_2O/kg dry solid)	*Rate (kg H_2O/h. m^2)*
0.2	1.5
0.15	1.2
0.1	0.9
0.07	0.7
0.05	0.4
0.04	0.3

Calculate the total time (in hours) required for drying the sample by the solar dryer. **[20]**

2. Feed, containing mixture of two ores (Ore A and Ore B) must be separated by a hydraulic classifier, using water (density: 1000 kg/m^3) under free and laminar settling conditions. Finally, the feed was separated into three size fractions containing (i) pure ore A, (ii) pure ore B and (iii) mixture having particles of ore A and ore B. Specific gravity of ore A is 8, while that of ore B is 3. Size analysis of the feed reveals that it lies in the range between 5 μm and 20 μm. Assuming the particles to be spherical, find the size ranges of the two materials, i.e., ore A and B in those three fractions, i.e., (i), (ii) and (iii). **[20]**

3. Consider the diffusion of an organic solvent (molecular weight: 46) in air (diffusivity: 1.38×10^{-5} m^2/s). Initially, air is kept at 303 K and does not contain any solvent. The properties of air which are known at 303 K are as follows- density:1.165 kg/m^3; viscosity: 1.85×10^{-5} Ns/m^2; specific heat capacity: 1.006 kJ/kg. K; thermal conductivity: 0.025 W/m. K. Heat of vaporization of the organic solvent is 42.4 kJ/mol. Establish an equation between the wet bulb temperature and the vapor pressure of the organic solvent. Also, estimate its wet bulb temperature at 2 kPa and 4 kPa of vapor pressure. **[20]**

4. Define the following terms with proper mathematical notations, wherever possible: (i) Sphericity, (ii) Mixing index, (iii) Humidity, (iv) Dew Point and (v) Free Moisture **[2×5=10]**

5. A crusher (efficiency of 30%) and a grinder (efficiency unknown) are placed in series, which draw power from the same source. 10 tonnes (1 tonne=1000 kg) of an ore material were reduced to fine powder using this series connection of crusher and grinder in an hour. Surface area of this ore is 5 m^2/kg, while that of the product from the crusher and grinder are 150 m^2/kg and 1000 m^2/kg, respectively. The power required by the source is 50 kW. Assuming the Rittinger's number of this ore is 100 m^2/kJ, find the efficiency of the grinder. **[10]**

6. During screening analysis of a powdered material, it was observed that its size distribution follows a straight-line trend against weight percentage. For example, 2 wt.% of the sample has an average size of 2 µm, while 90 wt.% of the sample has an average size of 95 µm. Using this data, calculate the Sauter mean diameter of the powdered material. Consider calculating various average size for the interval between 10 wt.% and 100 wt.%, to arrive at the final answer. **[10]**

All the best 👍

Advance wishes for the festive season ahead ☺

Necessary Equations

$$t = \frac{Ms}{A}\int_{X_1}^{X_2}\frac{dX}{R}$$

$$\frac{D_1}{D_2} = \sqrt{\frac{\rho_2 - \rho_f}{\rho_1 - \rho_f}}$$

$$\frac{\mathcal{H} - \mathcal{H}w}{T - Tw} = -\frac{Cp}{\lambda w}\left(\frac{Sc}{Pr}\right)^m$$

$$[m = \tfrac{2}{3}]$$

$$Saturation\ Humidity = \frac{Molecular\ Weight\ of\ Solvent}{Molecular\ Weight\ of\ Air}\left(\frac{Vapor\ Pressure\ of\ the\ Solvent}{Atmospheric\ Pressure - Vapor\ Pressure\ of\ the\ solvent}\right)$$

$$\frac{P}{\dot{m}} = K_R\left[\frac{1}{\overline{D}_p} - \frac{1}{\overline{D}_f}\right]$$

$$\overline{D_s} = \frac{1}{\sum_{i=1}^{n}\frac{x_i}{\overline{D_{pi}}}}$$

Symbols have their usual significance
