FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
DEPARTMENT OF CHEMICAL ENGINEERING
HARMATTAN SEMESTER EXAMINATION, 2019/2020 SESSION
CHE 403 – PARTICULATE FLUID SYSTEMS
INSTRUCTION: ANSWER QUESTION ONE AND ANY OTHER FOUR QUESTIONS TIME: 3HOURS

1a. List four assumptions made in deriving the equation for the settling velocity of spheres.
b. Starting from the first principle, derive the terminal velocity for a one-dimensional motion of a particle in a fluid under the action of the gravitational force.
c. What causes Loading and Flooding of a system?
d. List five ways in which Loading and Flooding can be prevented.

2. The size distribution of a dust as measured by a microscope is as follows:

Size range (μm)	0 – 2	2 – 4	4 – 8	8 – 12	12 – 16	16 – 20	20 –24
No. of particles in range (-)	2000	600	140	40	15	5	2

Convert these data to obtain the distribution on a mass basis and find the average volume diameter of the particles in the distribution. Density of dust particle = 2650kg/m^3 and volume shape factor = 2.

3a. In a particulate blending and mixing governed by diffusive mechanism, 100% mixing cannot be realized. Show from the first principle that $S^2 = n_g S_r^2$. Where S^2 is the variance of particles not mixed, S_r^2 is the variance of randomly mixed particles and n_g is the smaller number of particles unmixed which are localized as clusters in the mixture.
b. The performance of solids mixer was assessed by calculating the variance occurring in the mass fractions of a component amongst a selection of samples withdrawn from the mixture. The quality was tested at intervals of 30secs and data obtained are:

Sample variance (-)	0.025	0.006	0.015	0.018	0.019
Mixing time (s)	30	60	90	120	150

If the component analysed represent 20 percent of the mixture by mass and each of the samples removed contains approximately 100 particles, present the data above graphically and from your graph, find the maximum percentage degree of mixing/blending and the time at which it occurs.

4a. Define the following, (i) Voidage (ii) Specific surface area (iii) What is tortuosity?
b. A cylinder ical ion exchange bed composed of spherical particles 2 mm in diameter packed at a bed voidage of 0.45 is to be used to deionized a liquid of density and viscosity 1108 kg/ m^3 and 0.0075 Pa.s respectively. The design flow rate is 5m^3/hr and the bed height and diameter are 2 and 0.2 m respectively, calculate, (i) the pressure drop using Carman Kozeny equation (ii) the modified Reynolds number.

5. A packed tower is to be designed for counter contact of benzene nitrogen mixture with kerosene to wash out benzene from the gas. The circumstances are: Gas in = 1.0m^3/sec containing 6mol% benzenee at 25°C and 1.2 × 10^{5}N/m^2. Liquid in = 5.0kg/s, density = 800kg/m^3, viscosity = 0.0023kg/m.s. The packing will be 400mm (2in) metal pallings. Determine the gas mixture rate at which the tower gets flooded with gas. Recall,

$$\left[\frac{G^2 C_f \mu^{0.1} J}{\rho_G (\rho_L - \rho_G)}\right] g_c = 0.24$$

6a. Discus the principle 0f gas-solid fluidization system, describing the regimes and the effect of velocity.
b. Derive an equation to show the relationship between the bed porosity and bed height.
c. Solid particles having diameter of 0.15mm and density of 1000kg/m$_3$ are to be fluidized using air at 3atm abs. and 25°C abs. at viscosity of 1.965 × 10^{-5}Pa.s and density of fluid at 2.374 kg/m^3. Given that the porosity at minimum fluidization condition is 0.37, calculate the minimum height of the fluidized bed if the cross-sectional area of the empty bed is 0.26m^2 and the bed contains 200kg of solids.