# MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

## FACULTY OF ENGINEERING, SCIENCE AND TECHNOLOGY

**DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING**

**MODULE: FLUID SOLID SYSTEMS**

**CODE: CHEP 313**

**SESSIONAL EXAMINATIONS**
**JUNE 2023**

**DURATION: 3 HOURS**

**EXAMINER: MRS C. MUHEZWA**

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**INSTRUCTIONS**

1. *Answer **All** questions.*
2. *Start a new question on a fresh page*
3. *Total marks 100*

***Additional material(s):*** *Graph paper, Calculator*

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## QUESTION 1

a. Define the term *particle characterisation*. [3]

b. Explain the meaning of the following terms as they are used in particle technology:

i. *Surface diameter,*

ii. *Surface-to-volume diameter,*

iii. *Martin's diameter,*

iv. *Feret's diameter.* [4x1]

c. A solid sample from an industrial plant has cubic particles with average edge length of 3.2 μm. Determine the

i. volume-equivalent sphere diameter ($D_{volume}$) [3]

ii. surface-equivalent sphere diameter ($D_{surface}$) [3]

iii. volume-surface equivalent sphere diameter (*Dsv*) of the particles [2]

d. i. State the forces that act on a particle that is falling in a liquid. [3]

ii. Hence derive the equation, of the terminal falling velocity of a particle of density $\rho_p$ in a fluid of density $\rho_f$ and viscosity $\mu$. Assume the particle's motion is under gravity, in equilibrium, and is in the Stoke's region. [7]

## QUESTION 2

a. Explain the following

i. *dense phase pneumatic conveying* [3]

ii. *saltation velocity* [2]

iii. *choking velocity* [2]

b. State **four** examples of particulate solids that can be transported by pneumatic conveying. [4]

c. The general relationship between gas velocity and pressure gradient $\Delta P/\Delta L$ for a horizontal transport line is shown in Fig 1. Line AB represents the curve obtained for gas only in the line, CDEF for a solids flux, $G_1$, and curve GH for a higher solids feed rate, $G_2$.

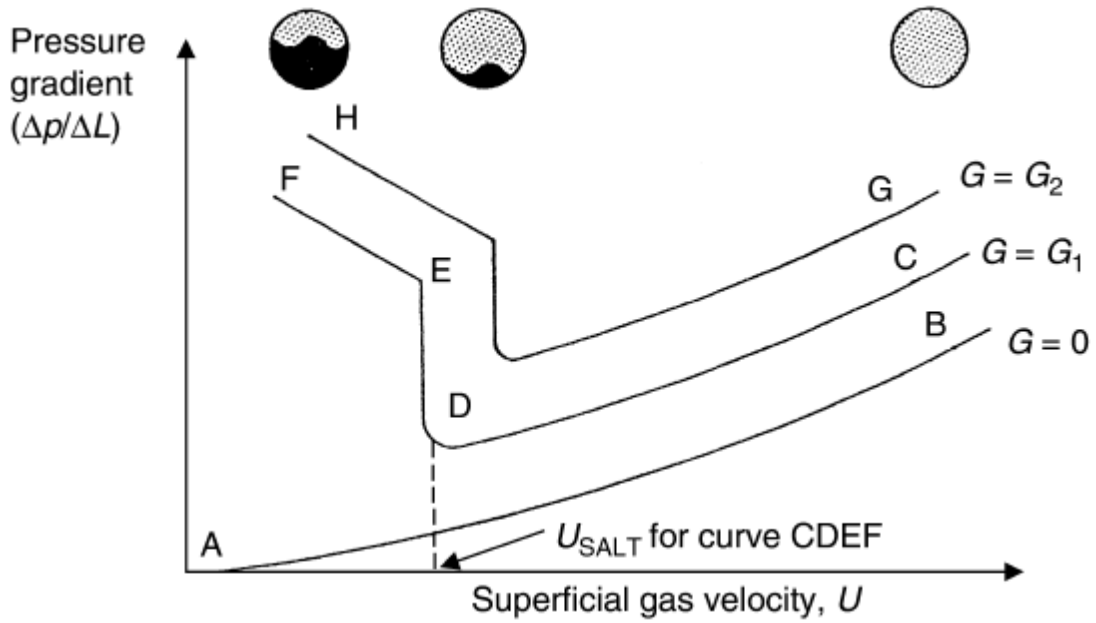


Fig. 1: Phase diagram for dilute phase horizontal pneumatic transport

i. Describe and explain what happens if the gas velocity is reduced whilst solids feed rate is kept constant at *G1* [8]

ii. Explain the shape of the graph when *G = 0* [3]

d. What are the advantages of pneumatic conveying over mechanical conveying in particulate technology? [3]

## QUESTION 3

a. Describe the principle behind the *elutriation* method of particle size measurement. [5]

b. What are the assumptions made in the sedimentation method of particle size measurement? [3]

c. Crystalline fertiliser solid particles are immersed in a liquid solvent of viscosity 10 Pa s, and density 40 kg/m$^3$. The density of the solid particles is 53 kg/m$^3$ and their final settling velocity 5.3 m/s.

   i. What is meant by the *'final settling velocity'* [2]

   ii. Determine the equivalent Stokes diameter ($D_s$) of the fertiliser particles? Assume Stoke's law apply. [3]

d. Explain the need for particle size reduction in particulate technology [2]

e. State Rittinger's law of the energy needed for particle size reduction [2]

f. A material is crushed in a Blake jaw crusher such that the average size of particle is reduced from 40 mm to 10 mm with the consumption of energy of 13.0 kW/(kg/s). What would be the consumption of energy needed to crush the same material of average size 85 mm to an average size of 15 mm:

   i. Assuming Rittinger's law applies? [3]

   ii. Assuming Kick's law applies? [3]

g. What are the factors that affect the choice of machine selected for a particular grinding operation? [2]

## QUESTION 4

a. Describe the procedure necessary to choose the right sampling method in powder technology (sampling workflow) [6]

b. Explain what is meant by *in situ* sampling [2]

c. What are the advantages of *in situ* sampling? [3]

d. Describe the principle behind the *coning and quartering* method of sampling [4]

e. Describe the following methods of particle size enlargement as they are used in particle technology

   i. Agglomeration [4]

   ii. Fluidized beds [4]

f. Differentiate between *differential* and *cumulative* particle size distributions [2]

**END OF EXAMINATIONS**