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#### MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, APPLIED SCIENCES AND TECHNOLOGY

**DEPARTMENT: MINING AND MINERAL PROCESSING ENGINEERING**

**MODULE: MINERAL PROCESSING II**

**CODE: ENGM 323 / HMIE 321**

### SESSIONAL EXAMINATIONS

**OCTOBER 2023**

**DURATION: 3 HOURS**

**EXAMINER: ENG M S. MULAKAZUWA**

## INSTRUCTIONS

1. *This paper contains* ***ONE*** *section and* ***FIVE*** *questions*
2. *Answer Question* ***ONE*** *and any other* ***THREE*** *questions.*
3. *Each question carries a total of* ***25 marks.***
4. *Start each question on a new page.*

***Additional material(s): Calculator***

**Question One**

1. An alluvial ore containing Gold (SG 19.0) and Quartz (SG 2.65) is to be separated by a density based method in water (SG 1.0) whose viscosity is 0.001Pa s. Determine the concentration criterion and discuss whether a density based process is appropriate. **(3 marks)**
2. Applying Stoke’s law, derive the expression for the settling velocity **vt** of a solid particle of radius **r** and specific gravity **ρs** in a fluid of specific gravity **ρf** and viscocity **μ.** State any assumptions that you make. **(3 marks)**
3. Determine the terminal velocities of spherical particles of quartz and ilmenite in water for particles of size 38 um and 10 mm diameter. The densities of quartz, ilmenite and water are 2650 kg/m3, 4600 kg/m3 and 1000 kg/m3 respectively. Viscosity of water is 0.001 Pa s. **(3 marks)**
4. You are provided with an ore mixture of alluvial mineral sands containing quartz (SG2.65), garnet, zircon (SG 4.6), rutile (SG 4.25), ilmenite (SG 4.5-5.0), monazite (SG 4.9 – 5.3) and tantalite (SG 6.5). The minerals of interest are Quartz, Zircon, Rutile, Ilmenite, Monazite and Tantalite. You conduct magnetic and electrostatic testwork and find that Zircon and Rutile are non-magnetic while Tantalite, Ilmenite and Monazite are magnetic; and Zircon and Monazite are non-conductive while Tantalite, Rutile and Ilmenite are conductive. Using gravity, magnetic and electrostatic separation techniques, develop a process flowsheet to separate the required minerals. **(9 marks)**
5. You are operating a dense medium separation plant to pre-concentrate diamonds, and starting up from a long shutdown. Calculate the mass in tonnes of ferrosilicon compound that must be added to 20 tonnes of water to make a slurry with a pulp density of 3.0 t/m3. Assume the density of ferrosilicon compound is 6.5 t/m3 and that of water is 1 t/m3. **(7 marks)**

**Question Two**

1. The graph below shows results from flotation by size experiments conducted on a milled galena ore containing marmatite and siliceous gangue. 

(i) Discuss and explain the recovery profile for the galena mineral. **(3 marks)**

(ii) Discuss and explain the recovery profile for the gangue. **(3 marks)**

b) A single cell in a given bank of flotation cells gives a given metal recovery of 45% for a residence time of 4.5 minutes. Find the number of similar sized cells and residence time in a continuous flotation bank that would give a total recovery of 85%. **(5 marks)**

(c) You are given the flowsheet below, for the recovery of zinc sulphide concentrate.

 

Analyse the flowsheet and describe the modifications you would make in order to;

(i) minimize the loss of metal values to tailings, thus improving metal recovery

 **(5 marks)**

(ii) improve the grade of the final concentrate **(5 marks)**

(d) Explain the main causes of tailings dam failures and how they can be avoided. What are the likely environmental and socio – economic impacts of such failures ?

 **(4 marks)**

**Question Three**

a) A plant is being fed with metallic ore assaying 4.0 %Cu producing a concentrate product assaying 45 %Cu and tailings assaying 0.45 %Cu.

(i) What is the recovery of Cu? **(2 marks)**

(ii) What is the mass pull? **(2 marks**)

(iii) What effect would increasing the mass pull have on the recovery? **(3 marks)**

(iv) The transportation costs to the smelter for the (concentrate) product after processing a 15 000 tonne batch of ore given that the transportation charge is $50/t. **(3 marks)**

b) The measured tonnages and average grades during two shifts are shown in Table 1. Complete the missing values in the tables and prepare a metallurgical balance for the combined performance during the two shifts. **(3 marks)**

 Table 1



c) When evaluating an ore for economic cut point, the various floats and sinks

fractions **𝑤𝑡𝑖** are assayed for metal content **𝑎𝑖** and the distribution of metal in

the various density fractions **𝑖** is tabulated, and plotted. The separation density which gives optimum economic returns is selected from the results. Considering the tabulated data given below, determine the cut point density for tin ore. **(8 marks)**

 

 (d) Discuss what the characteristics of the Tromp curve for a more efficient or ideal separation than the above should be. **(4 marks)**

**Question Four**

You are given the following data collected from a Concentrator that produces Copper and Zinc concentrates from a complex ore.

Table 2



Using the three-product formula, calculate;

(a)

(i) the recovery of Pb in Lead concentrate. **(4 marks)**

(ii) the recovery of Zn in Zinc concentrate. **(4 marks)**

(iii) the tonnage (tph) of the Zinc concentrate. **(3 marks)**

(iv) the recovery (loss) of Lead in Tailings. **(3 marks)**

(v) the tonnage (tph) of Pb and Zn in Tailings. **(3 marks)**

(b) Screens and hydrocyclones are fundamental classification equipment utilized in the mineral processing industry, briefly explain the main differences in the principle of their operations. **(4 marks)**

(c) Dense medium separation, though generally more expensive than gravity concentration methods due to cost of media and the ancillary recovery equipment, has considerable edge in the mineral processing industry. In concise, highlight and explain briefly its major applications. **(4 marks)**

**Question Five**

(a) A copper sulphide ore is fed at 750 tph through a jaw crusher. The Bond Work Index of the ore is 13.5 kWh/t. The largest particle in the feed that can pass through the crusher is 1.2 m and the crusher set is 150 mm. A screen analysis on feed and product shows that 80% of the feed passes 350 mm, and that 80% of the product passes 75 mm.

Estimate

 (i) the energy. **(2 marks)**

(ii) the power required for size reduction. **(2 marks)**

(b) A copper sulphide ore was wet screened and dried. The sieve fractions were assayed for zinc, giving the results in the Table below.

Table 3



i. Determine the percentage of ore with a grain size less than 180 microns? **(3 marks)**

ii. Deduce the copper assay of the ore fraction whose grain size is less than 180 microns? **(3 marks)**

iii. Calculate the Cu assay of the ore fraction whose grain size is above 180 microns. **(3 marks)**

iv. What is the grade of the ore (unscreened)? **(3 marks)**

(c) Develop a flowsheet for processing of a complex ore containing a mixture of copper sulphide and free gold minerals, showing and explaining the key features up to and including the production of copper concentrate and gold concentrate ready for smelting. **(9 marks)**

 **END OF EXAMINATION**