GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

INTRODUCTION TO MINERAL PROCESSING

EMG 3103

Final Examination Paper

December 2024

This examination consists of 5 printed pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Mr. N.N. Dube

INSTRUCTIONS

1. This paper contains **SIX** questions.
2. Answer any **FIVE** questions.
3. Each question carries 20 marks.
4. Where a question contains subdivisions, the mark value of each subdivision is shown in brackets.
5. Answer each question on a new page and write as eligible as possible.

ADDITIONAL REQUIREMENTS

1. Graph Paper
2. Scientific Calculator

QUESTION ONE

a) Express the Rittinger, Kick and Bond's theories of comminution in mathematical form, and discuss their applicability, highlighting their strengths and weaknesses. **[9]**

b) A mining operation currently uses a jaw crusher for primary crushing of granite of feed size 600mm. The mine plans to increase production from 500 to 1500 tonnes per hour.

   i) Explain the operating principles of the jaw crusher **[4]**

   ii) Explain the operating principles of a gyratory crusher **[4]**

   iii) Provide a justified recommendation for whether the operation should switch to a gyratory crusher, considering capital and operating costs, maintenance requirements, throughput capabilities and feed size handling. **[3]**

QUESTION TWO

a) The P80 of a new ore sample after grinding is 0.106 mm from a F80 of 1.26 mm. Another ore sample of known Work Index of 17.6 KWh/t is ground under the same conditions. Its F80 was measured as 960 microns and a P80 of 87 microns was achieved after grinding. Calculate the Work Index of the new ore sample in KWh/t**.** **[5]**

b) An entrepreneur engages you for advice about her plans for a quarry to produce aggregates of different size fractions, namely +5mm – 10mm, +10mm – 20mm, +20mm – 30mm. Assuming the feed rock has been mined and initially sized to -800mm, draw a flowsheet illustrating what crushing and screening equipment she would require. Show the arrangement of the equipment and indicate the aperture sizes of the screens. **[5]**

c) A sample of an alluvial ore containing metal M was subjected to float and sink analysis to pre-concentrate. The separated fractions were then assayed and the results are shown in the Table 1.

Table 1 Float and sink results of M

Specific gravity of test (S.G)	Fraction weight (%wt.)	Assay (% M)	Cumulative % wt.	Metal (M) units	% M distribution	% M cumulative distribution
+ 2.70	2.4	0.05				
> 2.70 + 2.75	6.9	0.53				
> 2.75 + 2.80	8.1	0.16				
> 2.80 + 2.85	10.5	0.27				
> 2.85 + 2.90	3.7	0.63				
> 2.90 + 2.95	2.1	0.92				
> 2.95 + 3.00	4.6	1.10				
> 3.00 + 3.05	5.4	3.04				
> 3.05 + 3.10	8.6	4.26				
> 3.10	47.7	8.85				

i) Complete the missing data as shown on Table 1. **[4]**

ii) Plot on the appropriate graph paper, the S.G against the % M cumulative distribution and determine the effective separation density d_{50}. **[4]**

iii) How much of the feed material would report to the sinks at a S.G of 2.85? **[2]**

QUESTION THREE

a) An ore sample is floated to produce Zn and Pb concentrate. The assay results are presented in the Table 2:

Table 2 Assay results of an ore sample

Stream	Throughput(tph)	Assay	
		Pb (%)	Zn (%)
Feed	250	5.5	6.5
Pb concentrate	-	72.0	6.0
Zn concentrate	-	1.5	55.5
Tailings	-	0.35	0.4

Calculate:

i) the tonnage (tph) of Pb concentrate. **[4]**

ii) the tonnage (tph) of the Zn concentrate. **[4]**

iii) the tonnage (tph) of tailings. **[4]**

iv) the recovery (%) of Pb in Pb concentrate. **[4]**

v) the recovery (%) of Zn in Zn concentrate. **[4]**

QUESTION FOUR

a) Briefly discuss the key steps that you would take to design a gold processing plant for installation at a new mine 10km south east of Kadoma town, starting from the exploration stage until the plant is ready for construction. **[5]**

b) Draw a basic flowsheet (block flow diagram) that you may develop for the extraction of gold starting from ROM up to the final product of gold bullion. **[5]**

c) A gold ore containing 20 g/t Au was fed to a ball mill in a concentrator at a rate of 200 tph. The concentrate and tailings assayed 400 g/t and 0.15 g/t Au respectively.

i) Calculate the tonnage per hour of Au concentrate produced. **[2]**

ii) Calculate the tonnage per hour of Au tailings produced. **[2]**

iii) Calculate the recovery (%) of Au in the Au concentrate. **[2]**

d) Explain the importance of screening in a comminution circuit, and also highlight the impact of selecting either larger or smaller sizes (than required) of screen apertures on downstream processes or product. **[4]**

QUESTION FIVE

a) Discuss the difference between magnetic and electrical separation. **[5]**

b) Describe pressure filtration and vacuum filtration in dewatering processes. **[5]**

c) Discuss the importance of selecting the correct filter medium for a filtration unit for the dewatering of flotation concentrates. **[5]**

d) Explain the following terms:

i) Dense medium separation. **[1]**

ii) Coagulation. **[1]**

iii) Flocculation. **[1]**

iv) Magnetic separation. **[1]**

v) Gravity separation. **[1]**

QUESTION SIX

a) You are provided with an ore mixture of alluvial mineral sands containing quartz (SG 2.65), garnet (S.G 3.95), zircon (SG 4.6), rutile (S.G 4.25), ilmenite (S.G 4.5-5.0), monazite (S.G 4.9-5.3) and tantalite (S.G 6.5). The minerals of interest are Quartz, Zircon, Rutile, Ilmenite, Monazite and Tantalite. You conduct magnetic and electrostatic test work 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. **[8]**

b) A mining company has recently acquired two separate mining operations: a coal mine producing both thermal and coking coal, and a diamond mine in a kimberlite deposit. As the lead metallurgical engineer:

i) Both operations use Dense Medium Separation (DMS). Explain why different separation densities are used in processing of both minerals **[2]**

ii) Design and draw basic flowsheets (block flow diagram) for both operations, clearly showing all major unit operations from ROM to final product. Include a circuit for dense medium recovery. **[8]**

iii) What are key differences between coal and diamond recovery by DMS? **[2]**

THE END!!!!!!!