NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

DEPARTMENT OF CIVIL, MINING AND PROCESS ENGINEERING

QUALIFICATION : BACHELORS OF ENGINEERING IN METALLURGICAL & CHEMICAL ENGINEERING	
QUALIFICATION CODE: BMET & BCHEM	LEVEL: 7
COURSE CODE: PPD710S	COURSE NAME: PROCESS PLANT DESIGN & ECONOMICS 315
SESSION: JUNE 2023	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

FIRST OPPORTUNITY EXAMINATION	
EXAMINER(S)	Prof Vusumuzi Sibanda
MODERATOR:	Prof Godfrey Dzinomwa

INSTRUCTIONS

1. Answer all questions.
2. Read all the questions carefully before answering.
3. Marks for each question are indicated at the end of each question.
4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.
2. Two Graph Papers
3. Mathematical Instruments

THIS QUESTION PAPER CONSISTS OF 6 PAGES (Including this front page)

SECTION A [50 MARKS]

Question 1 [2 marks]

How would you define Design Engineering? [2 marks]

Question 2 [8 marks]

Give examples of constraints that need to be factored in process design to transition from;

i. Region of ALL designs to a region of POSSIBLE designs

ii. Region of POSSIBLE designs to a region of PLAUSIBLE designs

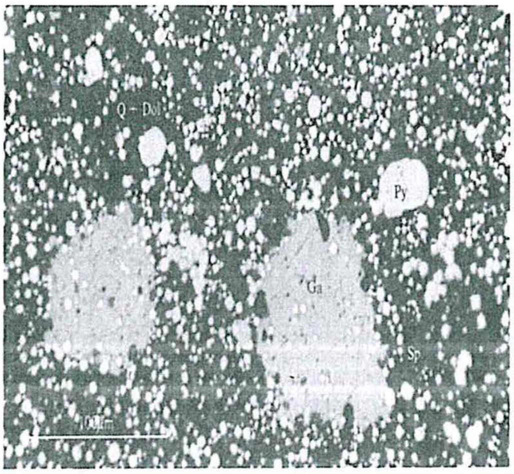
[8 marks]

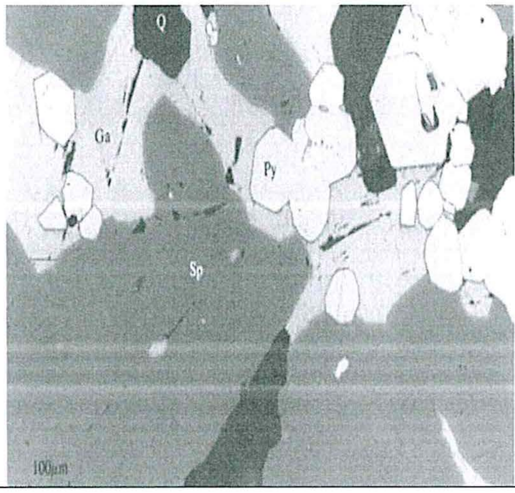
Question 3 [10 marks]

State the main building blocks of a Process Plant Design [10 marks]

Question 4 [10 marks]

Mineralogical analysis was done on 2 samples of ore from two areas of the same ore deposit as part of metallurgical test-work required to develop a flowsheet to process a newly discovered Zinc-Lead ore. Shown below are 2 micrographs derived from mineralogical analysis of Ore A and Ore B which are both Galena – Sphalerite – Pyrite ores hosted in siliceous gangue.





Micrograph - Ore A | Micrograph – Ore B

Ore A and Ore B are Galena – Sphalerite – Pyrite ores hosted in siliceous gangue

i. What do you understand by the term "mineral texture". [2 marks]

ii. Describe the mineral textures of Ore A and Ore B. [4 marks]

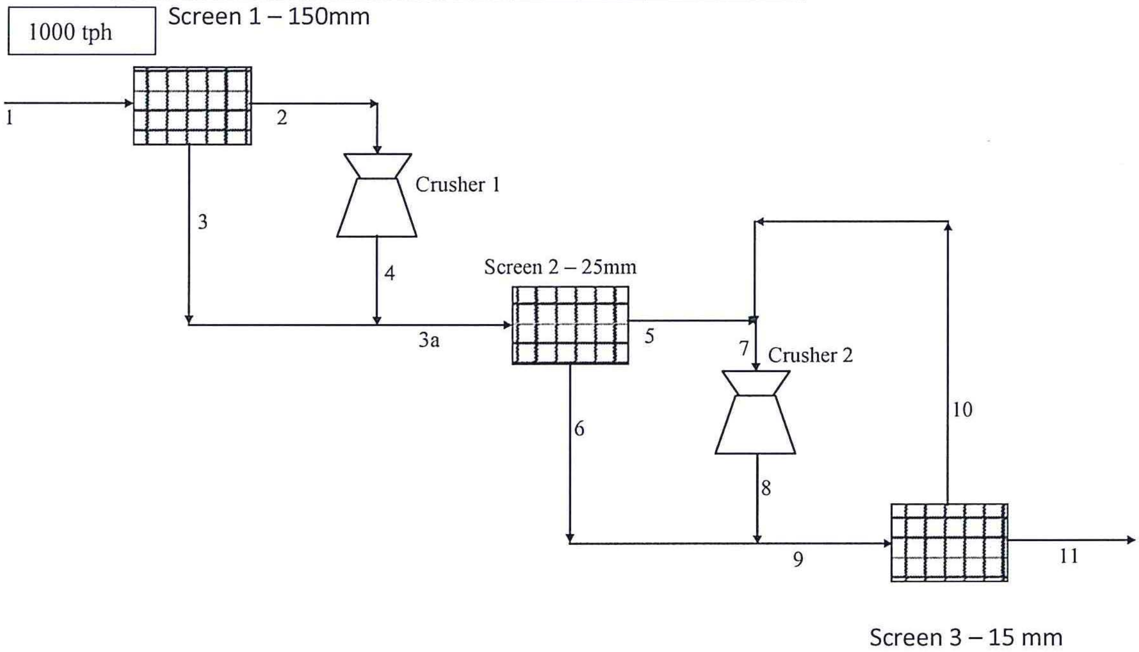
iii. Process mineralogy is very important in Process Plant Design. Explain how the mineralogy of Ore A and Ore B will affect the design of the comminution plant. [4 marks]

Question 5 [15 marks]

The crushing circuit below was developed to crush both the Galena – Sphalerite – Pyrite ores above in order to generate feed material ball milling (Ore A) and SAG milling (Ore B) before the ore undergoes sequential flotation. The crushing plant has been sized to process 1000 tph of ore and the apertures on the screen panels of the three screens are; Screen 1 (150mm), Screen 2 (25mm) and Screen 3 (15mm) respectively.

The table below gives the size distribution by mass of stream 1 and stream 4.

Size (mm)	200	150	100	50	25	10
Cum % passing for stream 1	95	55	45	35	25	15
Cum % passing for stream 4	100	75	65	55	45	35



Assuming the screens to be 100% efficient and the bond work index of the ore is 16.5 KWh/t,

i. Calculate the energy required to crush the ore in Crusher 1. What is the power required by the Crusher? [5 marks]

ii. What is the reduction ratio for this crusher? [3 marks]

iii. What type of crusher will be suitable for this application and why? [2 marks]

iv. What is the size distribution of stream 3a? [5 marks]

Question 6 [5 marks]

As seen in the crushing circuit discussed in Question 3 classification (screening) is an integral part of comminution circuits. What is the importance of classification in comminution circuit design? Draw a sketches of a flowsheets where (i) screens (ii) cyclones are used.

[5 marks]

SECTION B [50 MARKS]

Question 1 [10 Marks]

What are the main assumptions for the following reactor models;

i. Plug flow reactor model (PFR)? [3 marks]

ii. Continuous stirred tank reactor model (CSTR)? [3 marks]

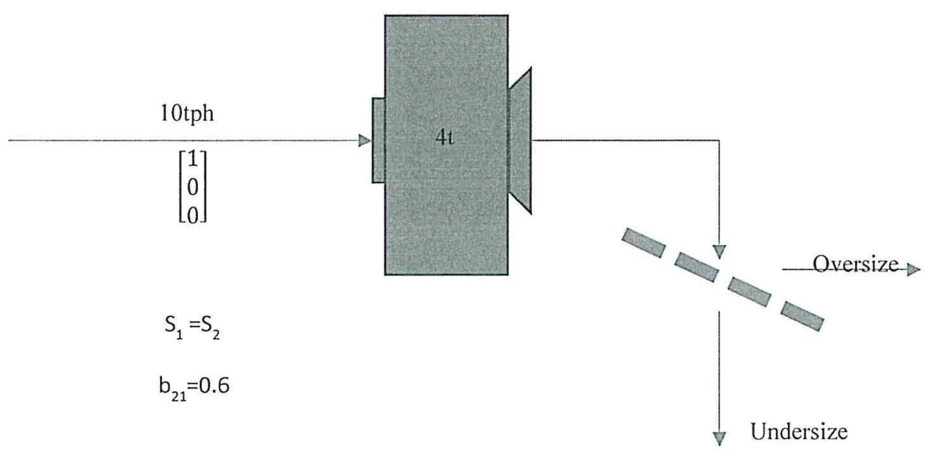
iii. Sketch and explain the Residence Time Distribution profiles for an ideal PFR and CSTR

[4 marks]

Question 2 [25 Marks]

(i) The Bond Work index is so popular for ore characterisation. Discuss why and state one disadvantage that is associated with this method. [3 marks]

(ii) The circuit below shows a SAG (pancake) mill used to mill Ore B and the mill discharges on a single deck screen that sends all the class 1 size to oversize and all class 2 and class 3 to the undersize. The feed rate is 10tph comprising of only size class 1. Holdup mass is 4t. The selection function $S_1 = S_2$ and the breakage function $b_{21} = 0.6$. Under these conditions, 40% of the product reports to the oversize as illustrated.



(a) Why does a SAG mill have a "short length" and "wide diameter" while a ball mill has a "longer length" and "smaller diameter"? [5 marks]

(b) From the information provided calculate S2 and also provide the detailed composition of the undersize of this mill [12 marks]

(c) The feed size composition is changed to $\begin{bmatrix} 0.8 \\ 0.2 \\ 0.0 \end{bmatrix}$ and if operating conditions remain the same, calculate the composition of the undersize now. [5 marks]

Note for perfect mixed milling this general equation applies:

$$p_i = \frac{f_i + \tau \sum_{j=1}^{i-1} b_{ij} S_j w_j}{1 + \tau S_i}$$

Question 3 [15 marks]

What do you understand by the following in the context of economic evaluation of a mineral beneficiation project

a. Net Present Value (NPV) [3 marks]
b. Payback period [3 marks]
c. Internal Rate of Return (IRR) [2 marks]
d. Salvage value [2 marks]
e. Direct Field costs [2 marks]
f. Fixed and Variable operating costs [3 marks]

THE END