



**NAMIBIA UNIVERSITY  
OF SCIENCE AND TECHNOLOGY**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF MINING & PROCESS ENGINEERING**

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| <b>QUALIFICATIONS: BACHELOR OF ENGINEERING IN METALLURGY &amp; CHEMICAL ENGINEERING</b> |  |
| <b>QUALIFICATION CODE: 08BEMT &amp; 08BECE</b>  | <b>LEVEL: 8</b>  |
| <b>COURSE CODE: PPD710S</b>   | <b>COURSE NAME: PROCESS PLANT DESIGN &amp; ECONOMICS 315</b> |
| <b>SESSION: JUNE 2022</b>   | <b>PAPER: THEORY</b>   |
| <b>DURATION: 3 HOURS</b>  | <b>MARKS: 100</b>  |

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|--|-------------------------------|
| <b>SECOND OPPORTUNITY QUESTION PAPER</b> |                               |
| <b>EXAMINER:</b>                         | <b>Mr. Thomas Moongo</b>      |
| <b>MODERATOR:</b>                        | <b>Prof. Vusimuzi Sibanda</b> |

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| <b>INSTRUCTIONS</b>  |
| <ol style="list-style-type: none"><li>1. Answer all questions.</li><li>2. Read all the questions carefully before answering.</li><li>3. Marks for each question are indicated at the end of each question.</li><li>4. Please ensure that your writing is legible, neat, and presentable.</li></ol> |

**PERMISSIBLE MATERIALS**

1. Examination paper.
2. Calculator and stationery.

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



**SECTION A**

**[30 marks]**

**Question 1**

**[5 marks]**

Explain how and why HAZOP analysis is used during process plant design?

**Question 2**

**[5 marks]**

What does the below piping and instrumentation diagram symbols represent?



(a)



(b)



(c)



(d)



(e)

**Question 3**

**[9 marks]**

Give a detailed explanation of different sample division methods that you could apply when evaluating a copper ore.

**Question 4**

**[6 marks]**

Name and explain two particle size distribution models that can be applied during crushing and screening circuit design. In your discussion provide the mathematical equations for these models and define all relevant terms.

**Question 5**

**[5 marks]**

Define the following terminologies.

- (a) Economics
- (b) Net Present Value (NPV)
- (c) Internal rate of return (IRR)
- (d) Return on investment (ROI)
- (e) Payback Period (PBP)



**SECTION B****[70 marks]****Question 1****[10 marks]**

Rosh Pinah Zinc Mine requires mass balance to be conducted as one of the steps done during process design. Their plant is processing a complex ore of Lead and Zinc that contains 7.3% Pb and 8.4% Zn and the ore is treated on a 1000 tons/day basis in a flotation circuit. In a day, two separate concentrates amounting to 109 ton of Lead concentrate and 148 ton of Zinc concentrate are produced. For the Lead concentrate, Lead (Pb) recovery is 94.8% and the zinc loss is 2.1%. For the Zinc concentrate, zinc (Zn) recovery is 88.3% and the Pb loss is 1.8%. Carry out the mass balance balance after sketching the problem using an appropriate diagram (show all your calculations) and complete the Table below.

*Table 1: Mass balance summary for Rosh Pinah Zinc Mine*

| Streams        | Tonnages (tpd) | Pb Assays (%) | Zn Assays (%) |
|----------------|----------------|---------------|---------------|
| Feed           |                |               |               |
| Pb concentrate |                |               |               |
| Zn concentrate |                |               |               |
| Tailings       |                |               |               |

**Question 2****[10 marks]**

Namib Lead and Zinc Mine is considering undertaking experiments to improve process efficiencies. First, they are considering determining the minimum quantity of a sample required for metallurgical testwork for a lead ore assaying 5% Pb which must be routinely sampled for assay to a confidence level of  $\pm 0.1\%$  Pb, 95 times out of 100. Galena is essentially liberated from the quartz gangue at a particle size of  $150\mu\text{m}$ . Assume that the sample will be collected during crushing to a top size of 25 mm. The mean density of Galena and Quartz is  $7.50\text{ g/cm}^3$  and  $2.65\text{ g/cm}^3$ .

**Question 3****[10 marks]**

Rössing Uranium Mine is considering developing a model for simulating the fraction of product size class  $i$  for a perfectly mixed mill. As a process design student who is well versed with milling kinetics simulation, derive the equation for modelling the fraction of product size class  $i$  for a perfectly mixed mill and for size class 1, 2 and 3. Give a sketch of the mill labelled with all critical symbols to be used in your formulas and define them.



**Question 4****[10 marks]**

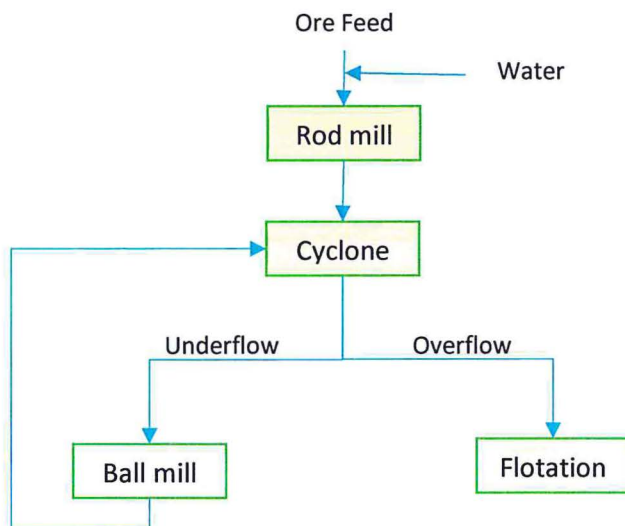
All design engineers should be able to communicate with other technical experts by using appropriate diagrams. For the following operations, develop an appropriate block flowsheet with at least five (5) major unit processes each of the following operations:

- (a) Namdeb's diamond processing plant. [5 marks]  
 (b) Namib Lead and Zinc concentrator. [5 marks]

**Question 5****[10 marks]**

Kombat Copper Mine seek advice from process design consultants regarding the below proposed design modification in their processing plant. The rod mill is fed at the rate of 20tph with dry solids (density 2900 kg/m<sup>3</sup>). The cyclone feed contains 35% solids by weight and size analysis on the rod mill discharge, ball mill discharge and cyclone feed gave the following:

| Circuit equipment   | Analysis by weight | Size analysis |
|---------------------|--------------------|---------------|
| Rod mill discharge  | 26.9%              | +250 $\mu$ m  |
| Ball mill discharge | 4.9%               | +250 $\mu$ m  |
| Cyclone feed        | 13.8%              | +250 $\mu$ m  |



As an expert in process plant design, advise Kombat Copper Mine management on what should be the volumetric flowrate of the feed stream to the cyclone. Draw a sketch of the problem and show all your work.





**Question 6****[10 marks]**

Swakop Uranium Mine process engineers designed a hydrocyclone which is fed with a pulp/slurry having a specific density of  $1.25 \text{ t/m}^3$  at a mass flowrate of 40tph for dry solids. The underflow stream has an L/s ratio of 0.85 and the overflow stream has 10% solids. Given that the dry solid specific density is 2.55. Calculate the following:

(a) Mass flowrate of the hydrocyclone underflow and overflow streams in tph. [5 marks]

(b) Volumetric flowrate of the pulp in the underflow stream in  $\text{dm}^3/\text{s}$ . [5 marks]

**Question 7****[5 marks]**

Okorusu Flourspar processing plant was designed to treat 500t of solids per hour. The feed pulp, containing 40% solids by weight is conditioned for 5 minutes with reagents before pumping it to the flotation cells. For design purpose, calculate the volume of the conditioning tank required. Assume solids density to be  $2700 \text{ kg/m}^3$ .

**Question 8****[5 marks]**

A homogeneous leaching reaction  $A \rightarrow 3R$  has a reported rate at  $215^\circ\text{C}$  and 5 atm of

$$-r = 10^{-2} C_A^{1/2} \text{ (mol/L.s)}$$

Find the residence time needed for 80% conversion of a feed to a PFR, given that

$$C_A^0 = 0.0625 \text{ mol/L}$$



## List of Equations

$$\text{Power (P)} = K(J)\rho LD^{2.5} \frac{N}{N_{crit}} \sin\theta$$

$$C = fglm$$

$$\text{Critical Speed} = N_{crit} = \frac{42.3}{\sqrt{D-d}}$$

$$Y = 100\left(\frac{x}{k}\right)^m$$

$$Q = 60L_T v W (2L_{MIN} + L_T) \left(\frac{R}{R-1}\right)$$

$$M = \frac{Cd^3}{s^2}$$

$$P = E \text{ (kWh/t)} \times F \text{ (t/h)}$$

$$F = U + O$$

$$\log\log\left(\frac{100}{R}\right) = m \times \log(x) + c$$

$$C_1 = 12.13(A_T)^{0.32} - 10.3 \text{ for } A_T < 51 \text{ mm}$$

$$m = \frac{1-a}{a} [(1-a)r + at]$$

$$E = E_s (1 - \varepsilon^2) \left(\frac{M_B}{M_B + M_s}\right)$$

$$p_i P = f_i P + W \sum_{j=1}^{i-1} b_{ij} S_j W_i - S_i W_i W$$

$$\text{Screen area} = \frac{\text{Feed rate (tph)}}{\text{Standard screen capacity (t/hm}^2\text{)}}$$

$$l = \left(\frac{L}{d}\right)^{\frac{1}{2}}$$

$$E = 10W_i \left(\frac{1}{\sqrt{P_{80}}} - \frac{1}{\sqrt{F_{80}}}\right)$$

$$Y = 100 - 100 \exp\left[-\left(\frac{x}{R}\right)^b\right]$$

$$F' = Uu' + Oo'$$

$$C_2 = 0.34(A_T) - 14.41 \text{ for } A_T \geq 51 \text{ mm}$$

$$\log(y) = m \times \log(x) + k$$

THE END

