NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF MINING & PROCESS ENGINEERING

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

FIRST OPPORTUNITY QUESTION PAPER	
EXAMINER:	**Mr. Thomas Moongo**
MODERATOR:	**Prof. Vusimuzi Sibanda**

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. Calculator and stationery.

THIS QUESTION PAPER CONSISTS OF 7 PAGES (Including this front page)

SECTION A **[30 marks]**

Question 1 **[5 marks]**

Design a simplified P&ID for a water tank with a tank level control system. Clearly show all relevant instruments and equipment required to control the tank level.

Question 2 **[5 marks]**

How would you describe a process flow diagram (PFD)? Give at least four (4) features of the PFD and four (4) aspects that should be considered for characterizing process streams.

Question 3 **[5 marks]**

During metallurgical testwork the ore must go through mineralogical and chemical analysis. Write the following ore characterization techniques in full.

a) QUEMSCAN

b) SEM

c) AAS

d) ICP - OES

e) ICP - AES

Question 4 **[5 marks]**

By means of a table, give five (5) factors you would consider when making a decision whether to apply a jaw crusher and a gyratory crusher onto your design. The table should compare the two crushers.

Question 5 **[5 marks]**

Give names of appropriate models that you can apply when designing the following unit processes or equipment listed in the table below by completing the table.

Unit process/equipment	Model name
(a) Particle size distribution	1.
	2.
(b) Sizing of screens	3.
(c) Hydrocyclone	4.
(d) Sedimentation velocity	5.

Question 6 **[5 marks]**

Write the following economics abbreviations in full and define them.

a) TVM

b) DCF

c) CAPEX

d) EBITDA

e) MIRR

SECTION B [70 marks]

Question 1 [10 marks]

The designed green hydrogen pilot plant is expected to experience the cash flows shown in the table below. As a design engineer working on the green hydrogen project you were tasked with determining the profitability index of this project at 5% and 10% discount rate. What criteria would you use to conclude on which discount rate will be acceptable and what is your conclusion?

Year	Cash flow (N$)
0	-10 000
1	2 000
2	2 000
3	2 000
4	2 000
5	5 000

Question 2 [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) Dundee Precious Metal Tsumeb copper smelter that produces blister copper. [5 marks]

(b) AfriTin's Uis Tin Mine concentrator. [5 marks]

Question 3 [10 marks]

Chemical and Metallurgical Engineers with an entrepreneurial mindset have established a Process Design Company. These design engineers are interested in winning a tender for designing the entire gold processing plant for the Twin Hills gold deposit that was recently discovered by an exploration company named Osino Resources northeast of Karibib town. You have been requested by the project manager to design a detailed process flow diagram (PFD) for the entire gold ore processing plant that will produce gold bars. The design should have at least ten (10) labelled unit processes or equipment, all the streams should be clearly shown, and standard equipment icons should be utilized.

Question 4 **[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 150μm. 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 g/cm^3 and 2.65 g/cm^3.

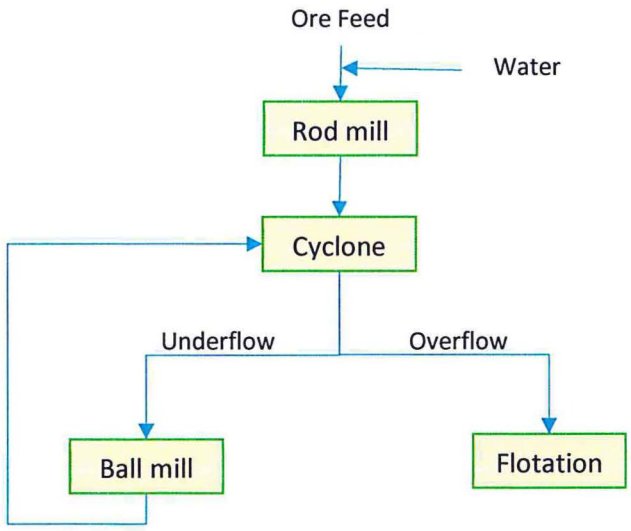
Question 5 **[10 marks]**

Uis Tin Mine is assessing if they should replace the existing mill motor after they installed a newly designed mill. In this case, a jaw crusher product is milled such that 80% passes a 500-micron sieve down to a size at which 80% passes an 88-micron sieve. A 5hp motor is sufficient for the required throughput and for grinding. If the requirements are changed after the new mill was installed such that grinding is now done to 80% passing a 125-micron sieve, but the throughput will be increased by 50%, is the existing motor sufficient to operate the mill? Assume Bond's equation applies.

Question 6 **[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^3). 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%	+250μm
Ball mill discharge	4.9%	+250μm
Cyclone feed	13.8%	+250μm



As an expert in process plant design, advice 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 7 **[10 marks]**

Rosh Pinah Zinc Mine is considering re-designing its flotation circuit due to mineralogical changes observed in the ore. As a student who is well versed with the design of flotation circuits you were given a responsibility to derive the following:

(a) Derive the first-order flotation rate equation for batch flotation. [5 Marks]

(b) Derive the equation for the number of similar size cells (N) in a continuous flotation bank given residence time (τ), total recovery (R) and flotation rate constant (k). [5 Marks]

List of Equations

Power (P) = K(J)ρL$D^{2.5}\frac{N}{N_{crit}}Sin\theta$

C = fg$l$m

p_iP = f_iP + W$\sum_{\substack{j=1 \\ i>1}}^{i-1} b_{ij}S_j w_i$ - $S_i w_i$W

Present value = $\frac{Cash\ flow}{(1+i)^n}$

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

$$R = R_\infty\left(1 - e^{-kt}\right)$$

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

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

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

P = E (kWh/t) × F (t/h)

$$R = 1 - (1 + k\tau)^{-N}$$

F = U + O

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

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

Ff = Cc + Tt

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

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

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

THE END