



**NAMIBIA UNIVERSITY  
OF SCIENCE AND TECHNOLOGY  
FACULTY OF ENGINEERING**

**DEPARTMENT OF MINING AND PROCESS ENGINEERING**

<b>QUALIFICATION : BACHELOR OF ENGINEERING IN METALLURGY, CHEMICAL ENGINEERING &amp; MINING ENGINEERING</b>	
<b>QUALIFICATION CODE: BSc.</b>	<b>LEVEL: 7</b>
<b>COURSE CODE: MPT721S</b>	<b>COURSE NAME: MINERAL PROCESSING TECHNIQUES AND APPLICATIONS 324</b>
<b>SESSION: OCTOBER, 2022</b>	<b>PAPER: THEORY</b>
<b>DURATION: 3 HOURS</b>	<b>MARKS: 100</b>

<b>FIRST OPPORTUNITY QUESTION PAPER</b>	
<b>EXAMINER(S)</b>	<b>Dr. Clement K. Owusu Mr. Thomas Moongo</b>
<b>MODERATOR:</b>	<b>Prof. Godfrey Dzinomwa</b>

<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 questions 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.

**THIS QUESTION PAPER CONSISTS OF 3 PAGES (Including this front page)**

### Question 1

- a) Discuss the stages involved in the manufacturing process of unattractive rough diamond to final glittering polished. (15 marks)
- b) Explain the relevance of process mineralogy in the extraction of value minerals from ores. (10 marks)
- c) Discuss the impact of carbonaceous matter on gold cyanidation process and mention two possible control and management techniques used by mining companies to ensure improved gold recovery (9 marks)

### Question 2

- a. Explain the effect of pulp pH on collector adsorption (Remember to support with chemical equations) (10 marks)
- b. A CIL gold processing plant receives its feed from the thickener after thickening of the hydrocyclone overflow. After thickening, 95% of the solids in the thickener feed reported to the underflow while 80% of the water in the pulp reported to overflow. The overflow pulp volumetric flow rate is 452 m<sup>3</sup>/hr and the pulp density is 1.05 t/m<sup>3</sup>. The solids density is 2.57 t/m<sup>3</sup>
- i. Sketch and label the circuit. (5 marks)
- ii. Estimate the mass of solids (on dry basis) entering the thickener and mass of water entering the thickener (15 marks)

### Question 3

- a) Discuss briefly 3 possible causes for the failures of the tailings dam. (6 marks)
- a) 100 tph of zinc ore containing 8.5% sphalerite and 91.5% gangue is treated in a processing plant. Recovery of the sphalerite and the gangue in the concentrate are 92% and 2.5%. Calculate flowrates of concentrate and tailing, assay of sphalerite and gangue in concentrate and tailing. (25 marks)
- b) A single cell in a given bank of flotation cells gives copper recovery of 55% for a residence time of 6 minutes. What is the number of similar sized cells in a continuous flotation bank required to achieve a total recovery of 97%? (5 marks)

End



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<b>FIRST OPPORTUNITY MEMORANDUM PAPER</b>	
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### Solution

#### Q1a.

*Manufacturing as applied in diamond processing looks at processes involved in the transformation of unattractive rough diamonds to glittering polished diamonds. The process involves acid cleaning, sorting cutting and polishing.*

- *Acid cleaning: it involves the removal/cleaning of dirt from the rough diamond surfaces through the use of an acid and washing. This is done to ensure effective sorting process. (3 marks)*
- *Sorting: the cleaned rough diamonds are sorted based on size (carat weight shape, colour and clarity). At this stage, the gem quality diamonds are separated from the industrial diamonds. (3 marks)*
- *Cutting and polishing entail processes such as marking, sawing, bruting and girdling and blocking (3 marks)*

*Marking: The marker sets rough diamond on system's sample stage and selects the faceting proportions that the diamond should be cut into. (1.5 marks)*

*Sawing: is the separation of a rough diamond into different pieces, to be finished as separate gems. The marked rough diamond is then placed on a sawing spindle, with a blade made from copper layered with a mixture of oil and diamond powder. The rough diamond is then lowered to the blade and cut where the marker has marked the stone. It is the diamond powder that physically cuts the diamond, not the copper blade – diamonds are the hardest known mineral to man, and only a diamond will cut another diamond. (1.5 marks)*

*Bruting gives the diamond its basic shape. This is achieved by rotating one diamond against another diamond that may also be rotating or stationary, and the two diamonds are progressively ground away by mutual abrasion. (1.5 marks)*

*Blocking is the final stage whereby diamonds are polished into the stone using cast-iron disc surface coated with oil and diamond dust. (1.5 marks)*

**Q1b.**

*Process mineralogy: bridges the gap between mineral processing and traditional mineralogy. It provides minerals processing engineers with information on the characteristics of minerals in an ore to optimize the process of recovering valuable minerals from the waste rock or gangue. Information obtained from process mineralogy is applied in minerals exploration, determine the best processing route for treating an ore and how process can be optimised. Also, out of process mineralogy, one can preempt the benefits that can be harnessed, or limitations that need to be catered during ore processing. Furthermore, it provides hint about sides reactions likely to take place during processing, quality of concentrate and by-product to be expected, and possible environmental impacts.* (10 marks)

**Q1c.**

*Carbonaceous material can reduce the recovery of gold by restricting the release of gold from the carbonaceous matrix, or by adsorbing dissolved gold from the leach liquor (preg-robbing). Because of their soft nature, they can cause smearing/coating of Au particles during grinding process. The treatment of these ores involves;* (4 marks)

- *Roasting-where the carbonaceous matter is burnt off from the ore* (1 mark)
- *Isolating through flotation using depressants* (1 mark)
- *CIL approach – to compete with carbonaceous matter for Au. CIL is however not effective for highly preg-robbing ores* (1 mark)
- *Chlorination* (1 mark)
- *Application of Blinding/blanking agents (e.g., Diesel, Kerosene and Heavy machine oils) in combination with CIL –* (1 mark)

**Question 2**

- a. Explain the effect of pulp pH on collector adsorption (Remember to support with chemical equations) (10 marks)
- b. A CIL gold processing plant receives its feed from thickener after thickening of the hydrocyclone overflow. After thickening, 95% of the solids in the thickener feed reported to the underflow while 80% of the water in the pulp reported to overflow. The overflow pulp volumetric flow rate is 452 m<sup>3</sup>/hr and the pulp density is 1.05 t/m<sup>3</sup>. The solids density is 2.57 t/m<sup>3</sup>
  - i. Sketch and label the circuit. (5 marks)
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Solution

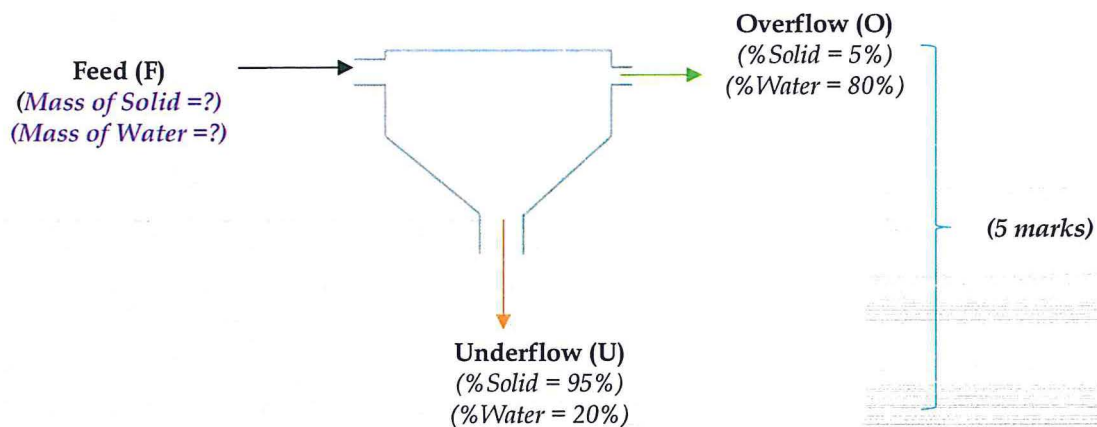
Q2 a

The adsorption mechanism of collector on to mineral surface is influenced by the pulp pH because it controls the adsorption of a collector by the electron transfer mechanism. Generally, during collector adsorption, oxidation of the collector occurs at the anode leading to the release of electrons. For example, in terms of xanthate the reaction shown in equation 1 occurs. The corresponding cathodic reaction involves the reduction of oxygen which leads to the production of hydroxyl ions as shown in equation 2.



Raising the pH increases the concentration of  $OH^-$  ions will slow or even stops the reaction of a collector with the mineral due to the shift in chemical equilibrium. When this occurs, the collector no longer adsorbs onto the mineral surface. Also, at too high a pH, metal hydroxides can precipitate and form coatings on the surface of a mineral, thereby blocking the mineral surface and making the surface hydrophilic. This subsequently preventing collector interaction with the mineral surface. If the collector type considered is xanthate, at acidic pH, it becomes unstable. Thus, it breaks down to xanthic acid. (10 marks)

Q2b



$$\% \text{solids} \left( \frac{w}{w} \right) = \frac{\rho_s(\rho_p - \rho_w)}{\rho_p(\rho_s - \rho_w)} \times 100$$

(2 marks)

where  $\rho_s$ ,  $\rho_p$  and  $\rho_w$  represent respectively solid density, pulp density and density of water

$$\rightarrow \frac{2.57(1.05-1)}{1.05(2.57-1)} \times 100 = 7.795\%$$

(2 marks)

$$\text{Pulp density} = \frac{\text{Mass of pulp}}{\text{Volume of pulp}} \rightarrow \text{Mass of pulp} = \text{pulp density} \times \text{volume of pulp}$$

$$\text{Mass of pulp} = 1.05 \text{ t/m}^3 \times 452 \text{ m}^3/\text{h} = 474.6 \text{ t/h} \quad (3 \text{ marks})$$

$$\begin{aligned} \text{Mass of solids in overflow} &= \text{percent solids} \times \text{Mass of pulp} \\ &= 7.795\% \times 474.6 \text{ t/h} \\ &= 36.995 \text{ t/h} \end{aligned} \quad (2 \text{ marks})$$

$$\text{Mass of solids in overflow} = 5\% \times \text{mass of feed}$$

$$\begin{aligned} \text{Therefore; mass of feed} &= \text{mass of solids in overflow}/5\% \\ &= 36.995 \text{ t/h}/5\% = 739.898 \text{ t/h} \end{aligned} \quad (2 \text{ marks})$$

$$\text{Mass of overflow pulp} = \text{mass of solids in overflow} + \text{mass of water in overflow}$$

$$\begin{aligned} \text{Therefore, mass of overflow water} &= \text{mass of overflow pulp} - \text{mass of solids in overflow} \\ &= 474.6 \text{ t/h} - 36.995 \text{ t/h} = 437.6 \text{ t/h} \end{aligned} \quad (2 \text{ marks})$$

$$\text{Remember, mass of water in overflow} = 82\% \times \text{mass of water in feed}$$

$$\begin{aligned} \text{Thus; Mass of water in feed} &= \text{mass of water in overflow}/82\% \\ &= 437.6 \text{ t/h}/0.82 = 538.92 \text{ t/h} \end{aligned} \quad (2 \text{ marks})$$

### Question 3

- Discuss briefly 3 possible causes for the failures of the tailings dam. (6 marks)
- 100 tph of zinc ore containing 8.5% sphalerite and 91.5% gangue is treated in a processing plant. Recovery of the sphalerite and the gangue in the concentrate are 92% and 2.5%. Calculate flowrates of concentrate and tailing, assay of sphalerite and gangue in concentrate and tailing. (25 marks)
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### Solution

**Q3a. (Any 3 for 6 marks)**

**Liquefaction;** - Earthquakes are associated with the release of seismic waves which cause increase in shear stress on the embankment; and Pore pressure in saturated tailings. Tailings in the impoundment may be liquefied during seismic events

Liquefaction may also be caused by mine blasting or nearby motion and vibrations of heavy equipment. (2 marks)

**Rapid increase in dam wall height;** - If an upstream dam is raised too quickly, very high internal pore pressure are produced within the tailings. High pore pressures decrease the dam stability and may lead to dam failure. (2 marks)

**Foundation failure;** - If the base below the impoundment is too weak to support the dam, movement along a failure plane will occur. (2 marks)

**Excessive water levels;** - The beach width between the decant pond and dam crest becomes too small. Flood inflow, high rainfall and improper water management of the mill operators may cause excessive water level within the impoundment. This may lead to overlapping and collapse of the embankment. (2 marks)

**Excessive seepage;** - Seepage within or beneath the dam causes erosion along the seepage flow path. Excessive seepage may result in failure of the embankment. (2 marks)

**Q3b.**

Given

$$\text{Feed flow rate} = F = 100 \text{ tph}$$

$$\% \text{ sphalerite in feed} = f = 8.5\%$$

$$\% \text{ gangue in feed} = 91.5\%$$

$$\% \text{ recovery of sphalerite in concentrate} = 92\%$$

$$\% \text{ recovery of gangue in concentrate} = 2.5\%$$

$$\text{Sphalerite recovery} = \frac{C_c}{Ff} \times 100 = 92 \Rightarrow \frac{C_c}{100 \times 8.5} \times 100 = 92$$

$$\Rightarrow C_c = 782 \quad (3 \text{ marks})$$

$$\text{Gangue recovery} = \frac{C(100 - c)}{F(100 - f)} \times 100 = 2.5 \Rightarrow \frac{100C - C_c}{F(100 - f)} \times 100 = 2.5$$

$$\Rightarrow \frac{100C - 782}{100 \times (100 - 8.5)} \times 100 = 2.5 \Rightarrow C = 10.1 \text{ tph} \quad (6 \text{ marks})$$



Concentrate flow rate =  $C = 10.1$  tph

Solids balance  $F = C + T \Rightarrow 100 = 10.1 + T$  (6 marks)  
 $\Rightarrow T = 89.9$  tph

Tailing flow rate =  $T = 89.9$  tph

$Cc = 782 \Rightarrow c = \frac{782}{10.1} = 77.4\%$  (4 marks)

Assay of sphalerite in concentrate =  $c = 77.4\%$

Assay of gangue in concentrate =  $100 - 77.4 = 22.6\%$  (2 marks)

Sphalerite balance  $Ff = Cc + Tt \Rightarrow 100 \times 8.5 = 782 + 89.9t$   
 $\Rightarrow t = 0.76\%$  (2 marks)

Assay of sphalerite in tailing =  $t = 0.76\%$

Assay of gangue in tailing =  $100 - 0.76 = 99.24\%$  (2 marks)

### Q3c

#### Data

Recovery for a single cell ( $R_1$ ) = 55%

The residence time ( $\tau$ ) = 6 min

$R_1(1 + k\tau) = k\tau \rightarrow 0.55(1 + 6k) = 6k$  by making  $k$  the subject;

$k = 0.204/\text{min}$  (3 marks)

$R = 1 - (1 + k\tau)^{-N}$  therefore at 98% recovery

$0.97 = 1 - (1 + 0.205 \times 6)^{-N}$  by simplifying;

$2.22^{-N} = 0.03 \rightarrow$  applying log on both side and solving

$N = 3.82691 \sim 4$ , thus the number of cells required is 5. (2 marks)

End

