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INSTRUCTIONS:

1. ALL questions should be attempted.

2. Two answer books are provided. Label them Book A and Book B respectively. Answer Section A in Book A and Section B in Book B.

3. Any programmable or non-programmable calculator may be used provided it has been cleared of any information that would subvert the purpose of the examination.

4. Calculations must be shown in sufficient detail to illustrate your understanding of the procedure.

5. This examination question paper, together with all associated diagrams MUST BE HANDED IN TOGETHER WITH YOUR SCRIPT.

Student Number:
SECTION A

QUESTION 1

a) State three key steps in setting up a laboratory ball mill for a test work campaign? (3)

b) South Africa produces 3.3% of the world's annual total production of coal. Name two provinces and two companies where coal is produced in South Africa? (2)

c) Why is sampling and size analysis important in mineral processing? (2)

TOTAL /7/

QUESTION 2

a) Describe one of the typical methods used to mine coal deposits in South Africa? (4)

b) The classification system in mineral processing plant is being designed. The mill manager wants to put in screens but the mill product is all below 500 μm in size. What reasons would you give as operations manager for installing hydrocyclones instead of screens? (4)

c) Briefly perform a SWOT analysis of the mining and minerals sector in South Africa. (2)

TOTAL /10/
QUESTION 3

a) A laboratory milling test is conducted on gold-bearing quartz ore using a mill with length of 5 m and a diameter of 6 m. Quartz pebbles of 10 cm diameter are used to effect the comminution. The mill is currently being run at 16 rpm. Should this speed be altered and if so, why?  

(3)

b) If steel balls were used instead of the quartz pebbles (keeping the volumetric loading the same, and proportions of balls: slurry), what would have to be done to the throughput to keep the product passing size the same, and why?  

(5)

TOTAL /8/
QUESTION 4

A 3.35 m × 3.35 m ball mill has 9.5 t/h fed through it. The feed size distribution, the selection functions \((min^{-1})\) and breakage distribution functions \(B_{ij}\) are shown in the Table 4.1. Assume that the mill is charged at 45% filling capacity and the density of solid \(\rho_s\) is = 3,145 t/m³.

<table>
<thead>
<tr>
<th>Interval</th>
<th>Size [μm]</th>
<th>Mass Fraction in Feed</th>
<th>(S_i (min^{-1}))</th>
<th>(B_{ij})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+ 425</td>
<td>0.25</td>
<td>0.8</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>- 425 + 300</td>
<td>0.30</td>
<td>0.6</td>
<td>(B_{2,1} = 0.2)</td>
</tr>
<tr>
<td>3</td>
<td>-300 + 212</td>
<td>0.26</td>
<td>0.4</td>
<td>(B_{3,1} = 0.5)</td>
</tr>
<tr>
<td>4</td>
<td>- 212</td>
<td>0.19</td>
<td>-</td>
<td>(B_{4,1} = 0.3)</td>
</tr>
</tbody>
</table>

Table 4.1 Feed size distributions, selection functions and breakage distribution function of a ball mill

a) Use a population balance approach to predict the product size distribution from the mill.

\(\text{(9)}\)

b) Given the ore work index of 14.0 kWh/t for the feed distribution in Table 4.1, estimate the power required for comminution.

\(\text{(10)}\)

c) The product from the ball mill is classified by a hydrocyclone. Draw a process flow diagram representing the milling circuit.

\(\text{(2)}\)

d) Considering that the feed stream to the hydrocyclone is 30% of solids by volume and 30% of water is recycled in the underflow, calculate the flowrates of water in the underflow and overflow streams.

\(\text{(4)}\)

**DATA**

Product size distribution:

\[ P_i = \frac{f_i + \tau \sum B_{i,j} S_j P_j}{1 + \tau S_i} \]

Bond’s Law:

\[ W \ (kWh/t) = 10 \times W_i \times \left[ \frac{1}{\sqrt{P_{80}}} - \frac{1}{\sqrt{P_{80}'}} \right] \]

Power:

\[ F \ (kWh) = W \times F(t/h) \]

**TOTAL /25/**
SECTION B

QUESTION 5

a) Sketch a typical diagram of a crude oil atmospheric distillation tower and show the feed and typical products. (5)

b) Explain why a vacuum distillation tower must be used in addition to an atmospheric distillation tower. (2)

c) List three typical products of a vacuum distillation tower. (3)

TOTAL /10/

QUESTION 6

a) Explain in which units of a crude oil refinery hydrogen gas is produced and which one is the main unit for production of hydrogen gas. (3)

b) Explain in which units of a crude oil refinery hydrogen gas is consumed. (3)

c) List four important reactions for the production of hydrogen in a crude oil refinery. (4)

TOTAL /10/
QUESTION 7

a) Compare an amine unit and a Merex unit in a crude oil refinery in terms of their typical functions, typical feeds, typical products and typical solvent.  

(8)

b) Sulphur is a by-product of crude oil and natural gas refineries. In which unit sulphur is produced and explain in terms of the unit name, typical feeds and typical product.

(2)

TOTAL /10/

QUESTION 8

a) Compare an asphalt unit and a visbreaking unit in terms of their typical functions, typical feeds and typical products.

(4)

b) Explain in which unit heat is consumed and why.

(1)

TOTAL /5/
QUESTION 9

Determine the amount of methanol required to produce a gasoline blend with RVP = 15 psi from the gasolines listed in the following table. The RVP of methanol is 52 psi.

<table>
<thead>
<tr>
<th>Gasoline</th>
<th>Quantity/Volume (Barrel per day)</th>
<th>RVP (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphtha</td>
<td>5000</td>
<td>12.5</td>
</tr>
<tr>
<td>Reformate</td>
<td>5000</td>
<td>3.20</td>
</tr>
<tr>
<td>Isomerate</td>
<td>4000</td>
<td>6.33</td>
</tr>
<tr>
<td>FCC Gasoline</td>
<td>6000</td>
<td>6.21</td>
</tr>
</tbody>
</table>

Considering:

\[ B_{RVPI} = RVP_i^{0.25} \text{ and } B_{RVPI,Blend} = \sum X_{vi} \times B_{RVPIi} \]

\[ B_{RVPI} : \text{RVP blending index for gasoline } i \]

\[ RVP_i : \text{Reid vapour pressure (psi) for gasoline } i \]

\[ X_{vi} : \text{volume fraction of gasoline } i \]

TOTAL 15