2023 FIRST SEMESTER FINAL EXAMINATION

Faculty: **Engineering and the Environment**

Department: **Metallurgical Engineering**

Paper Code/Title: **EMG 5101 ADVANCED MINERALS ENGINEERING**

Duration: **3 Hours**

Examiner: **Eng S. Hobwana**

INSTRUCTIONS TO CANDIDATES

1. Answer **ANY 4** questions.
2. Start the answer to each question on a fresh page.
3. Show all your working.
4. Each question carries **25 marks**.
5. Attach the graph on page 5 if you choose to answer **Question 5**.
6. This question paper comprises 7 printed pages including cover page.

Question 1

Explain the similarities and differences between the following terms as they are related to mineral processing. Use sketches in your answers.

a) Separation/Economic efficiency (6)
b) Coagulation/Flocculation (6)
c) Cataracting/cascading medium (6)
d) Merrill-Crowe/Carbon-in-pulp process (6)
e) List any mineral commodity mined in Zimbabwe which is not beneficiated using froth flotation. (1)

Question 2

a) What is the purpose of steelmaking and how is it achieved? (7)
b) Give a detailed description of one pyrometallurgical method of the extraction of zinc from a ZnS concentrate, include any pre-treatment processes. (10)
c) The presence of impurities during electrolytic processing of zinc causes a number of operational problems. With the aid of a flow diagram describe and explain the different purification steps that are employed in order to reduce the levels of impurities in the electrolyte. (8)

Question 3

a) A rougher bank has 4 cells in it. The feed to the bank has a solids mass flowrate of 1000 t/hr and a grade of 1.5% copper. In order to assess the performance the flowrate and grade of the concentrate streams from each of the cells was measured:

	Cell 1	Cell 2	Cell 3	Cell 4
Concentrate Grade	30	25	20	15
Solids flow rate to concentrate (t/hr)	8	6	5	4

Calculate the cumulative down the bank grade recovery curve. (8)

b) Flotation circuits typically consist of banks of cells, with a rougher, cleaner, scavenger arrangement being a commonly used one.

Sketch a standard rougher, cleaner, scavenger circuit labelling the banks and streams. (3)

c) A circuit with such a configuration achieves an 80% recovery over the rougher bank, a 50% recovery over the scavenger bank and a 60% recovery from the cleaner bank.

What is the overall recovery of the circuit? (6)

d) Assuming that we keep the operating conditions of the other banks constant, but increase the froth depth in the cleaner circuit.

What would happen to the circuit recovery and concentrate grade? (1)

e) What would happen to the feed rates and grades for each of the banks and why? (3)

f) Typically, for a given feed rate and grade, the circuit recovery can only be increased at the expense of grade and vice versa.

Assume that you have a typical smelter contract in which you are paid for a portion of the metal value and charged based on the mass of concentrate to be treated, and that the circuit is operating at the optimum trade-off between grade and recovery at the current metal price. How would you adjust your circuit's operation in response to an increase in the metal price and why? (4)

Question 4

a) A milling circuit consists of a SAG mill in open circuit. The product from the SAG mill feeds a set of cyclones, with the underflow from the cyclones passing into a ball mill and the overflow into a flotation circuit. The product from the ball mill is then recycled.

Draw this circuit with appropriate labels. (3)

b) SAG mills will typically have a larger diameter relative to their length than ball mills.

How do ball and SAG mills differ in terms of grinding media and why would this impact the shape of the mills? (3)

c) In order to analyse the performance of this circuit we will be considering two size fractions, namely that above and below 100 microns in size. The total solids feed into this milling circuit is 2000 tph of which 10% is already below 100 microns in size. The SAG mill will reduce 30% of the material above 100 microns in its feed to below this size, while the ball mill will reduce 40% of the feed material above 100 microns to below this size. In the cyclones the material above 100 microns has a partition number of 0.9, while the partition number for the material below 100 microns is 0.3.

Carry out a mass balance over the circuit calculating the mass flowrates of each of the components in each of the streams. What is the % passing 100 microns in the feed to the flotation circuit? (10)

d) The 80% passing size for the mill circuit feed is 0.8cm and for the product it is 95 µm.

What will the power requirement of the milling circuit be given that the Bond work index of the material is 18kWh/t? (2)

e) The circulating load passing through the ball mill is quite large. We wish to reduce the circulating load, but we have already optimised the performance of the ball mill itself and can't improve it further. We can, though, replace the hydro-cyclones:

   Should the new cyclones be larger or smaller than the current ones and why? (2)

f) What impact would this have on the flotation feed? (1)

g) After the new hydro-cyclones have been installed we wish to measure their impact on performance, but it is hard to directly measure solid flowrates. Instead we measure the solids contents in the streams around the cyclone. Its feed has a solids content of 50%, its overflow a solids content of 40% and the underflow a solids content of 60% (all solids contents by mass):

   Assuming that the feed rate to the circuit is unchanged, what is the new circulating load passing through the ball mill? (4)

Question 5

a) In the processing of free milling gold one of the commonly used process routes is to mill the ore, subject it to cyanide leaching in a series of tanks followed by CIP to extract the gold from solution.
   We will assume that the gold exhibit first order leach kinetics and that 10% of the ore is refractory.

   If 25% of the total gold is extracted in the first tank, how many tanks will be required to extract at least 80% of the gold? (5)

b) The leaching circuit is fed at the rate of 1000t/hr of solids and the solids content is 50% by weight, with a solids density of 2.5. Each tank in the leaching circuit has a volume of 1500 m^3.

   What is the residence time within each tank in the leaching circuit? (3)

c) If we assume that the head grade of the ore was 8g/t and that the 80% gold recovery over the leach circuit was achieved

   What will be the gold concentration in solution following the leaching given the flowrates and solids contents given above? (2)

d) In the CIP circuit which follows the leaching circuit carbon is contacted with the solution in a counter-current fashion. 98% of the gold in solution is recovered, resulting in a change in the amount of gold loaded onto the carbon from 100 g/t in the carbon returning from the elution and reactivation to 1000g/t as it leaves the CIP circuit.

   What is the mass flow rate of carbon through the circuit? (2)

e) For the purpose of these calculations it can be assumed that each of the CIP stages are in equilibrium and that at equilibrium the relationship between the gold in solution and that loaded on the carbon follows the relationship on the attached graph.

How many equilibrium stages are required to achieve this extraction? Show all calculation as well as the constructions on the graph **(hand graph in)**. (7)

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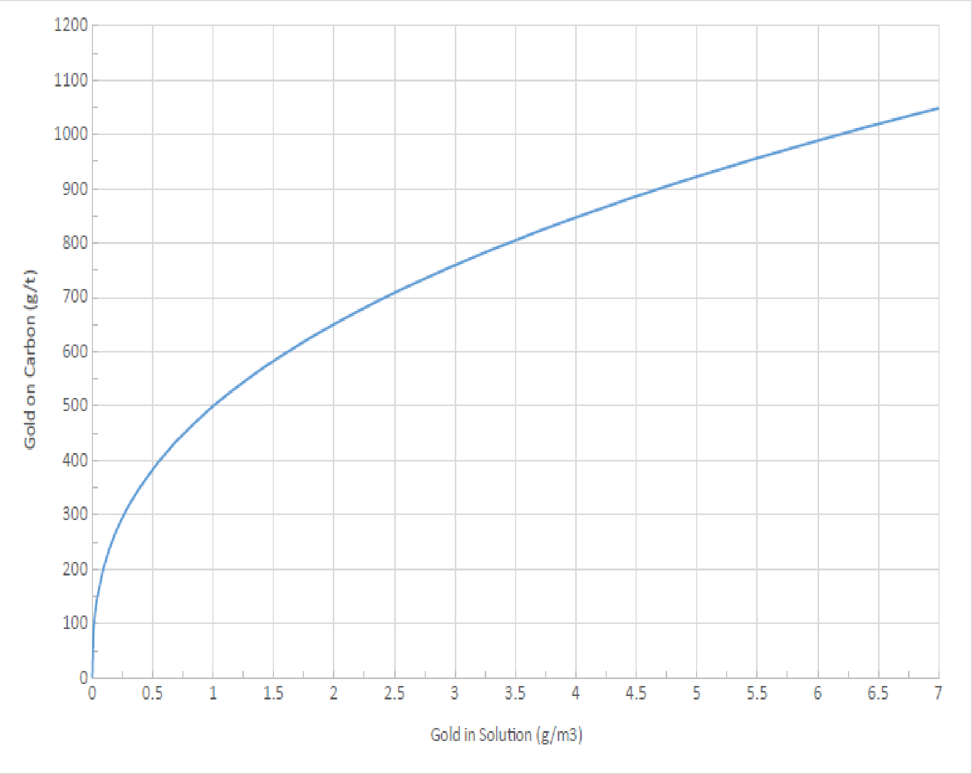
f) If there is a much higher proportion of refractory gold and, as is commonly the case, it is associated with sulphide minerals, these can be floated to produce a concentrate.

Name and briefly describe 3 different processing options for treating this material? (6)

Student Number: ______________________



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