GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

INTRODUCTION TO HYDROMETALLURGY

EMR 3201

SECOND SEMESTER SECOND SEGMENT EXAMINATION (2024)

This examination consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Graph paper and a scientific calculator

Examiner's Name: Ms K.L Mahamba

INSTRUCTIONS

Answer any 4 questions

Each question carries 25 marks

QUESTION 1

You are given the following important information to be used in a nickel processing facility at standard conditions.

(1) $Ni^{2+}+2e^{-}= Ni$ E^{0}=-0.26V

(2) $Ni^{2+}+2H_2O=Ni(OH)_2+2H^{+}$ logK=-12.74V

(3) $Ni(OH)_2+2H^{+}+2e^{-}=Ni+2H_2O$ E^{0}=0.14V

(4) $Ni(OH)_3+H^{+}+e^{-}= Ni(OH)_2+2H_2O$ E^{0}=1.48V

(5) $Ni(OH)_3+3H^{+}+e^{-}=Ni^{2+}+3H_2O$ E^{0}=2.23V

a. Using the information above, construct the Eh-pH diagram of the Ni-H_20 system. Show all calculations.**[15]**

b. Indicate the regions of corrosion, anodic passivation and cathodic passivation on the diagram. **[3]**

c. Write down a simple reaction for Ni cathodic protection and determine the potential range where nickel can be cathodically protected at pH of 3. **[2]**

d. Write down a simple reaction for Ni anodic protection and determine the potential range where nickel can be anodically protected at pH of 3. **[2]**

e. Identify any important applications of the Pourbaix diagrams in hydrometallurgy. **[3]**

QUESTION 2

Write short explanatory notes on the following leaching methods:

a. Heap leaching. **[4]**

b. In situ leaching. **[4]**

c. Dump leaching. **[4]**

d. Biological leaching. **[4]**

e. Agitation leaching. **[4]**

f. Distinguish between the following processes:

i. Cementation and precipitation. **[2]**

ii. Carbon in leach and carbon in pulp. **[3]**

QUESTION 3

a. State the factors that affect cyanidation and explain how each factor contributes to the cyanidation process. **[10]**

b. Explain the mechanism of cyanidation. **[5]**

c. Electrowinning and solvent extraction are normally applied in metal extraction. Review the application of the two hydrometallurgical processes in the extraction of copper from its ores. **[10]**

QUESTION 4

a. Describe the extraction process of nickel from laterites with the aid of a flowsheet. **[10]**

b. Carbon consumption is one of the major challenges in the Hall-Heroult process, the use of permanent anodes is possible by using fused chloride electrolytes. Describe any method of electrowinning aluminum in fused electrodes. **[10]**

c. Assume a piece of gold is purely flat with an area on $1cm^3$ on each side. Given that maximum rate of dissolution of gold is $3.25mg/cm^2/hr$. What is the reduction in thickness on each side and the actual total reduction in thickness of this gold piece in microns per hour. If the gold piece is of 34microns thickness, what is the total time expected to dissolve this piece of gold. **[5]**

QUESTION 5

a. Carbon reactivation is a crucial step in gold processing, describe the 2 commonly used technologies for carbon regeneration. **[8]**

b. List and explain the three main unit processes involved in hydrometallurgy? **[3]**

c. With aid of clearly labelled diagrams, discuss the mechanism of a heterogenous leaching system involving three phases. **[6]**

d. Describe the following elution processes

i. The atmospheric Zadra process. **[4]**

ii. The Alcohol stripping process. **[4]**

QUESTION 6

a. Zimbabwe is losing a lot of capital by selling unprocessed minerals e.g. Pgms to other nations.

i. How can Ion exchange assist in value addition of these minerals? **[5]**

ii. Propose a design to process the minerals using IER which would lead to value addition. **[10]**

b. The Kwekwe roasting plant tailings are still rich in gold but conventional leaching has failed to recover the gold, however panners have through some unconventional means been able to recover some gold.

i. Could bacteria leaching be used to recover the gold? Explain your answer. **[5]**

ii. What challenges could be encountered in recovering this value? **[5]**

END OF QUESTION PAPER!!!