



FACULTY OF ENGINEERING AND ENVIRONMENT



DEPARTMENT OF METALLURGICAL ENGINEERING

INTRODUCTION TO HYDROMETALLURGY

EMR 3201

Final Examination Paper

AUGUST 2022

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner's Name: Mr. O D Chikati

Instructions

1. Answer any 4 questions
2. Each question carries 25 marks.
3. Use of calculators is permissible.

Additional Requirements

Calculator

Periodic Table of Elements

Mark Allocation

Question 1-5	25 Marks
Part Questions	As shown in each part question.
Total Attainable	100

QUESTION 1

- a) Define the term leaching as applied in hydrometallurgy. [2]
- b) With the aid of a clearly labelled diagram, discuss the mechanism of a heterogeneous leaching system involving three phases. [7]
- c) Outline the extraction of nickel from Laterites. [8]
- d) You are a process engineer at a mine and have been tasked to select the leaching reagents for a process. What are the characteristics constitute an effective leaching reagent. [4]
- e) Distinguish between the following;
- i) Cementation and precipitation [2]
- ii) Carbon in leach and carbon in pulp [2]

QUESTION 2

- a) A sulphate leach solution contains 50g/l copper and 30 g/l ferric iron. Given that $\log K_s(\text{Cu}(\text{OH})_2) = -19.32$ and $\log K_s(\text{Fe}(\text{OH})_3) = -38.8$; $M_{\text{Cu}} = 63.546$; $M_{\text{Fe}} = 55.847$, estimate the;
- i) pH at which copper and iron begin to precipitate as hydroxides at 25°C [4]
- ii) pH when 99.9 % of iron is precipitated and determine the copper concentration at this pH [2]
- b) Instead of precipitation, it is proposed that solvent extraction be used in the purification of the solution. Given the general formula of the extractant as RH;
- i) Write down the copper-RH reaction. [2]

- ii) Explain the importance of pH in the solvent extraction process [4]
- iii) Give any two solvent extractants used in copper extraction [2]
- iv) Explain why solvent extraction has an advantage over precipitation in this process. [6]
- c) Explain channelling and sorption and their effects in relation to heap leaching [5]

QUESTION 3

- a) Gold is commonly extracted by alkaline cyanide leaching in oxygenated aqueous solutions.
 - i) Write down Elsener's equation in gold cyanidation. [2]
 - ii) What are the key factors that affect the gold dissolution kinetics [4]
 - iii) How would you set to optimize the factors in a plant environment [4]
- b) A complex sulphide ore constituting ZnS, CuFeS₂, FeS₂, can only be separated by flotation. The concentrates from the flotation process are to be leached using biological means. Describe in detail the 'indirect' biological leaching using any of the metal sulphides concentrates as an example.[10]
- c) A 4cm³ waste acidic water containing 0.05M H₂SO₄ needs to be neutralized with 0.2M NaOH to produce an alkaline solution of pH 10. How much base (0.2M NaOH) solution must be added? [5]

QUESTION 4

- a) You have been appointed in a team of hydrometallurgists to advise on processing of a large deposit of low grade gold ore. Discuss the choice of cyanidation leach method between heap or agitation. What factors are important in the choice between the two methods? [6]

b) Give a detailed account of the Merrill-Crowe precipitation and carbon adsorption as methods of recovering gold from pregnant solution explaining each step carefully.

[13]

c) Briefly explain how biological insitu leaching is carried out in the extraction of minerals. **[6]**

QUESTION 5

a) Differentiate between electrowinning and electro refining. [5]

b) Outline and explain the electrorefining of copper. [10]

c) Define and illustrate the characteristics of ion exchange resins below;

I. Selectivity coefficient

II. Break through capacity

III. Separation factor

IV. Total ion exchange capacity. **[10]**