



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

DEPARTMENT OF MINING AND PROCESS ENGINEERING

QUALIFICATION : BACHELOR OF ENGINEERING IN METALLURGY	
QUALIFICATION CODE: 08BEMT	LEVEL: 7
COURSE CODE: HMT 710S	COURSE NAME: HYDROMETALLURGY 314
SESSION: JUNE 2022	PAPER: THEORY
DURATION: 2 HOURS	MARKS: 60

SECOND OPPORTUNITY QUESTION PAPER	
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MODERATOR:	Dr. Theresa Coetsee

INSTRUCTIONS
<ol style="list-style-type: none">1. Answer all questions.2. Read all the questions carefully before answering.3. Marks for each question are indicated at the end of each question.4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.

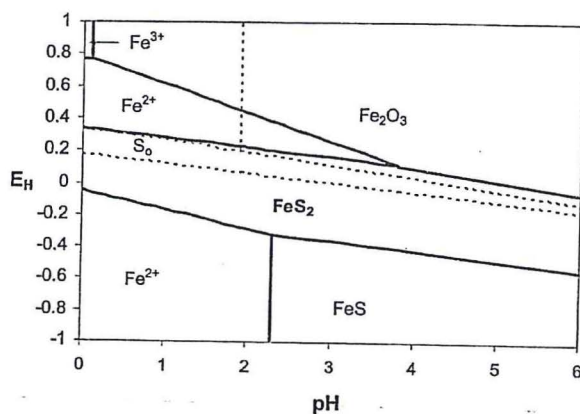
THIS QUESTION PAPER CONSISTS OF 4 PAGES (Including this front page)

Question 1**[12]**

- 1.1 Differentiate between electrowinning and electrorefining. (4)
- 1.2 The efficiency of the hydrogen reduction reaction can have a major influence on the viability and efficiency of electrowinning. (4)
- a) Use zinc electrowinning to explain that statement. (4)
- b) Discuss how the substrate and other process conditions like pH may influence the hydrogen reduction reaction. (4)

Question 2**[12]**

Using the Eh – pH diagram in the appendix for the Fe – S – H₂O system at unit activity soluble species at 298K, answer the following questions.



Fe – S – H₂O system at unit activity soluble species at 298K

- 2.1 What are the products of oxidation of pyrite at pH 8? (2)
- 2.2 Write a balanced equation for the leaching of pyrite using ferric ions at a pH 1. (3)
- 2.3 Estimate the ΔG^0 for the reaction at 298K. (2)
- 2.4 Suggest an alternative for leaching of pyrite and give a balanced chemical reaction for it. (2)
- 2.5 A sample of pyrrhotite is exposed to a moist environment at a pH of about 6 for several months. What would you expect to see if the sample were sectioned and examined microscopically? (3)

Question 3**[14]**

- 3.1 In electrowinning cells, a voltage higher than E_{cell} has to be applied. In other words, more energy than what is dictated by thermodynamics has to be supplied. This is termed overpotential. Discuss the overpotential in terms of three components. (3)
- a) Activation over-potential: (3)
- b) The ohmic polarization: (3)

c) Concentration overpotential: (3)

3.2 Discuss how and when mass transfer of metal ions to an electrode may become the rate limiting process in the electrowinning of that metal at the electrode. Also indicate how you would define the maximum rate of metal deposition in terms of the relevant parameters. (5)

Question 4 [7]

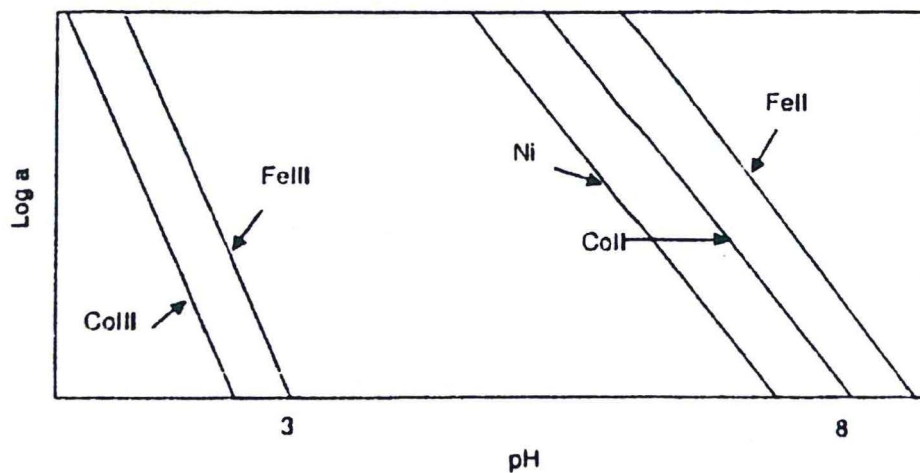
Blister copper that is produced is normally treated using the copper electrorefining process.

4.1 Explain why this is the case. (2)

4.2 Discuss the factors that determine the operating current density in copper electrorefining. (5)

Question 5 (5)

The pregnant leach solution from the cementation leach process contains nickel, cobalt and iron. Nickel is to be recovered through an electrowinning process. From the given log a – pH diagram, explain the steps required to precipitate iron and cobalt from this solution so that they do not report to the electrowinning circuit. (5)



Question 6 [10]

Consider a gold ore with a grade of 4 g/t containing 3% FeS (pyrrhotite), 5% calcite (CaCO_3) and other minor components being processed at a rate of 197 tons per hour.

Atomic mass: Au 197.0; Fe 55.85; Na 23.0; O 16.0; S 32.07; C 12.0; N 14.0 g/mol

6.1 Calculate the expected minimum cyanide mass flowrate for gold dissolution only if cyanide is added as NaCN. (3)

6.2 Calculate the minimum oxygen mass flowrate if it is added as pure oxygen. (5)

6.3 Would you expect the actual required flowrates to be what you calculated? Defend your answer. (2)

