



UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

SCHOOL OF ENGINEERING

EXAMINATIONS: NOVEMBER 2019

COURSE AND CODE: EXTRACTIVE METALLURGY

ENCH4EM

DURATION: 2 HOURS

TOTAL MARKS: 100

INTERNAL EXAMINERS:

DR J POCOCK

INTERNAL MODERATOR:

PROF BK LOVEDAY

EXTERNAL MODERATOR:

DR L MAHARAJ

INSTRUCTIONS:

1. **ALL** questions should be attempted.
2. 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.
3. Calculations must be shown in sufficient detail to illustrate your understanding of the procedure.

As the entire module has been conducted as a self-study module, this examination covers all aspects of the module based upon self-study. It is divided into two sections covering the researched case studies (assignments), and the general background to pyrometallurgy, hydrometallurgy and electrometallurgy.

SECTION A – CASE STUDIES (BASED UPON THE ASSIGNMENTS)**QUESTION 1**

Briefly describe the production of a metal detailed in the case studies from a concentrate by pyrometallurgical (high temperature) processing. Use a block diagram to show the process and include details of the raw materials, reactions involved and process temperature(s).

TOTAL /20/**QUESTION 2**

Briefly describe the production of a metal or concentrate detailed in the case studies from a concentrate or an ore by hydrometallurgical (aqueous dissolution) processing with or without the use of bacteria. Use a block diagram to show the process and include details of the raw materials, reactions involved and process conditions.

TOTAL /20/

SECTION B – GENERAL EXTRACTIVE METALLURGY**QUESTION 3**

In a pyrometallurgical process, what are the main functions of a slag layer? What properties must a slag have to fulfill these functions?

TOTAL /10/

QUESTION 4

An alloy of Copper and Nickel is being prepared by adding Copper Oxide rich slag to pure Nickel in a crucible at 1600 degrees Centigrade. For every mole of slag, there are five moles of pure Nickel metal. The slag contains 50 mol % CuO with the balance made up of CaO and SiO₂. The replacement reaction occurs as:



Assuming ideal behavior, determine the conversion of the CuO, and composition of the metal alloy formed?

TOTAL /15/

QUESTION 5

Discuss the advantages of hydrometallurgical processing of an ore over pyrometallurgical processing?

TOTAL /10/

QUESTION 6

Using a diagram, describe what is meant by in-situ leaching of an ore, and how it is achieved. Under what circumstances would in-situ leaching of an ore be used in practice?

TOTAL /10/

QUESTION 7

In an electrowinning circuit, copper is being precipitated onto cathode starter plates from an acidic sulphate solution at a pH of 3. The copper ion concentration can be taken as 1M. The anodes are standard lead oxide anodes at which water is being dissociated.

- a) Using the Pourbaix diagram attached on page 4, determine the equilibrium potential difference across the cells for the deposition of copper at the cathode. Indicate the anode and cathode potentials on the Pourbaix diagram and submit this with your answer booklet.

(5)

- b) Given the table of electrodes and associated Tafel slopes, determine the overall potential difference required for successful deposition of copper to the cathodes with a current density of 400 A/m².

(10)

Tafel Slope data

Oxygen Generation at a Lead Oxide Anode:

Log i_0 = -12.0, Tafel Slope = 0.12V

Copper deposition at a Copper Cathode:

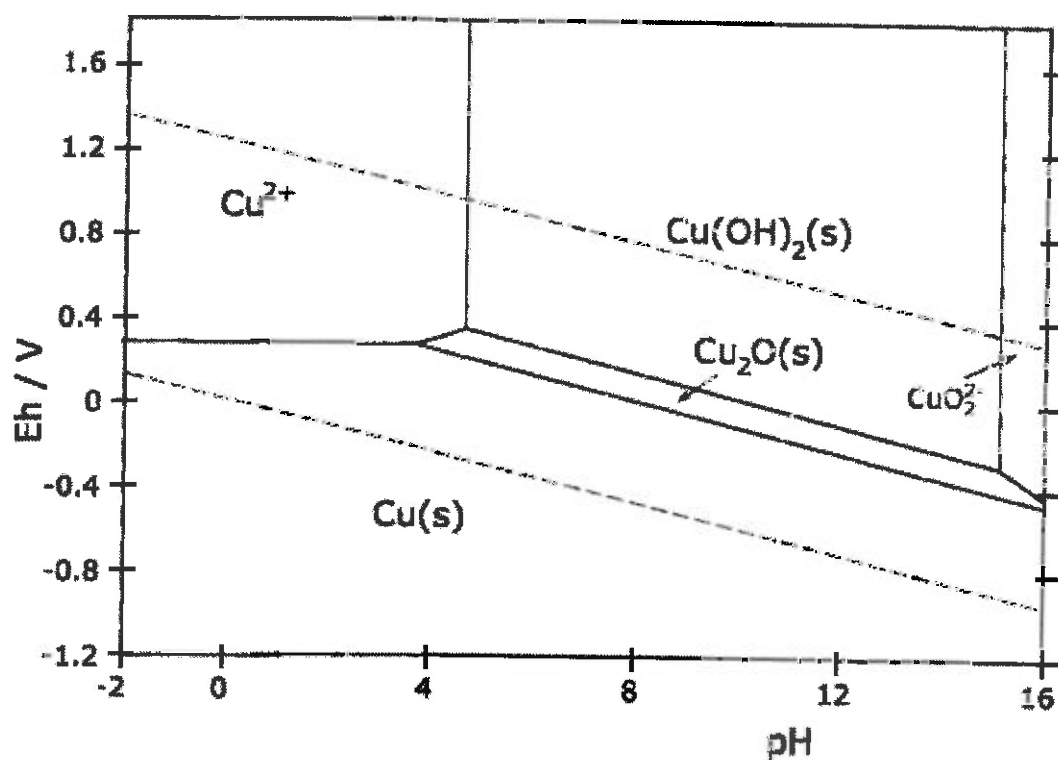
Log i_0 = -0.7, Tafel Slope = 0.12V

TOTAL /15/

DETACH THIS PAGE AND SUBMIT WITH YOUR ANSWER BOOK

STUDENT NUMBER: _____

COPPER POURBAIX DIAGRAM



Note that the upper dotted line indicates electrode potential for the reaction:

