UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

SCHOOL OF ENGINEERING

EXAMINATIONS: NOVEMBER 2018

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.

SECTION A – SELF STUDY

QUESTION 1

Bacteria have been used in hydrometallurgical processes to aid in removal of pyritic sulphur. Using an example from the case studies, describe with the aid of chemical reactions how the bacteria aid in the removal of pyritic sulphur, the general conditions in which they operate, and (for the case study chosen) what advantages and disadvantages the bacterial process has over the process it replaces.

TOTAL /20/

QUESTION 2

What are the differences between Blast Furnace iron making and Direct Reduction Ironmaking (DRI)? What are the advantages and disadvantages of using a DRI process over a Blast Furnace for the production of pig iron?

TOTAL /20/

QUESTION 3

Using a block diagram and giving general process conditions and reactions, briefly describe the Bayer Process for the production of alumina.

TOTAL /10/

SECTION B – LECTURED MATERIAL

QUESTION 4

a) What are the main functions of a slag layer in the pyrometallurgical processing of sulphide ores?

(7)

b) A converter slag containing 10 mole % copper oxide (CuO), 20 mole % iron oxide (FeO) and 5 mole % nickel oxide (NiO) with the balance silica is added to a smelting furnace with a matte containing 40 mole % copper sulphide (CuS), 45 mole % iron sulphide (FeS) and 15 mole % nickel sulphide (NiS). The slag flow is double the molar flow of the matte. Assuming ideal behavior and that all of the copper oxide is recovered to the matte as copper sulphide, what will be the conversion of nickel oxide to nickel sulphide?

(18)

Data:

Smelter temperature is 1200°C

$NiO + FeS \rightarrow FeO + NiS$ $\Delta G_{1473K} = -55$ kJ/mol

Universal Gas Constant R = 8.314 J/mol.K

TOTAL /25/

QUESTION 5

a) Using a block flow diagram, sketch a general flowsheet for the production of metal from low grade ore by hydrometallurgical means.

(8)

b) A copper Pourbaix diagram for standard conditions (1M, STP) is given on page 4. Using the diagram explain why copper ions can be easily plated from an acidic solution without significant generation of hydrogen.

(4)

c) Copper is being won from a solution at a pH 3 from a solution containing 1M Cu^{2+} ions. The anode is a lead oxide anode. What will be the overall cell potential necessary for plating the copper onto pure copper starter plates with a current density of 300 A/m^2?

(10)

d) Show by calculation whether there will be excessive hydrogen generation

(3)

Data:

Anode:

Tafel Slope = 120mV, $\log i_0 = -12.0$

Cathode:

For Copper deposition: Tafel Slope = 120mV, $\log i_0 = 2.0$
For Hydrogen generation: Tafel Slope = 120mV, $\log i_0 = -3.4$

TOTAL /25/

Copper Pourbaix Diagram (1M solution at standard T and P), dotted lines denote oxygen generation at an anode (top line), and hydrogen generation at a cathode (bottom line)