



UNIVERSITY
OF
JOHANNESBURG

PROGRAM : NATIONAL DIPLOMA
EXTRACTION METALLURGY

SUBJECT : HYDROMETALLURGY 3

CODE : MHD 3111

DATE : SUMMER EXAMINATION 2013
23 NOVEMBER 2016

DURATION : (SESSION 1) 08:30 - 11:30

WEIGHT : 40: 60

TOTAL MARKS : 100

EXAMINER : PROF A.F. MULABA-BAFUBIANDI

MODERATOR : Dr. W. BOLHA-WELO

NUMBER OF PAGES : 6 PAGES

INSTRUCTIONS : ANSWER ALL QUESTIONS.
CALCULATORS PERMITTED (ONE PER STUDENT).

REQUIREMENTS : 2 SCRIPTS PER STUDENT

QUESTION 1:

Base metals like Ni, Co and Cu are found as by-products in the extraction of platinum group metals from South African ores. During the processing of such a feed, dissolution in an aqueous solution of sulfuric acid is conducted. Solid liquid separation, clarification and purification are among the subsequent steps following the leaching process. Iron is one of the important impurities to take into account. As the solubility is temperature and concentration dependant

1.1. Using the graph 1 here below, discuss the operating conditions favourable to keep nickel into solution so that the purified pregnant solution is pumped into the nickel electrowinning plant for nickel extraction. [6]

1.2. As iron is one of the impurities to absolutely remove, using the graph 1 here below discuss the conditions to keep the plant at so that iron is removed from the pregnant solution (before purification) while nickel still remains in solution [10]

1.3. In such a metallurgical plant where nickel, cobalt and copper metals are to be produced, calculate the molarity of saturated CoSO_4 and saturated CuSO_4 as well as concentration of Cu metal and that of Co metal.

[Given: atomic weights: Cu= 63.5, S=32; O=16; Co=58.9

Solubility of copper sulphate: 16.8 g/100g of solution; solubility of cobalt sulphate: 25.6g/100g of solution [10]

[26]

QUESTION 2

Reduction and oxidation potential table of element (here below) may be used to predict the dissolution behaviour of minerals. It may also be used to predict the extraction of metals from their aqueous solutions. Gold from the Witwatersrand reef in South Africa is extracted using cyanide dissolution through either carbon in leach (CIL) or carbon in pulp (CIP) process. Depending on the mineralogy of the deposit, impurities like silver, copper and iron accompany gold into the leachate. Using the redox potential table mentioned above

2.1. Explain why Fe and Cu have to be removed from such a leachate before Au extraction. (6)

2.2. Give a detailed block diagram/flowsheet of the recovery of Au starting from the Run of Mine (ROM). (10)

2.3. Based on your proposed flowsheet, elaborate on how to deal with the possible environmental issues regarding the handling and disposal of liquid and solid effluents. (8)

[24]

QUESTION 3

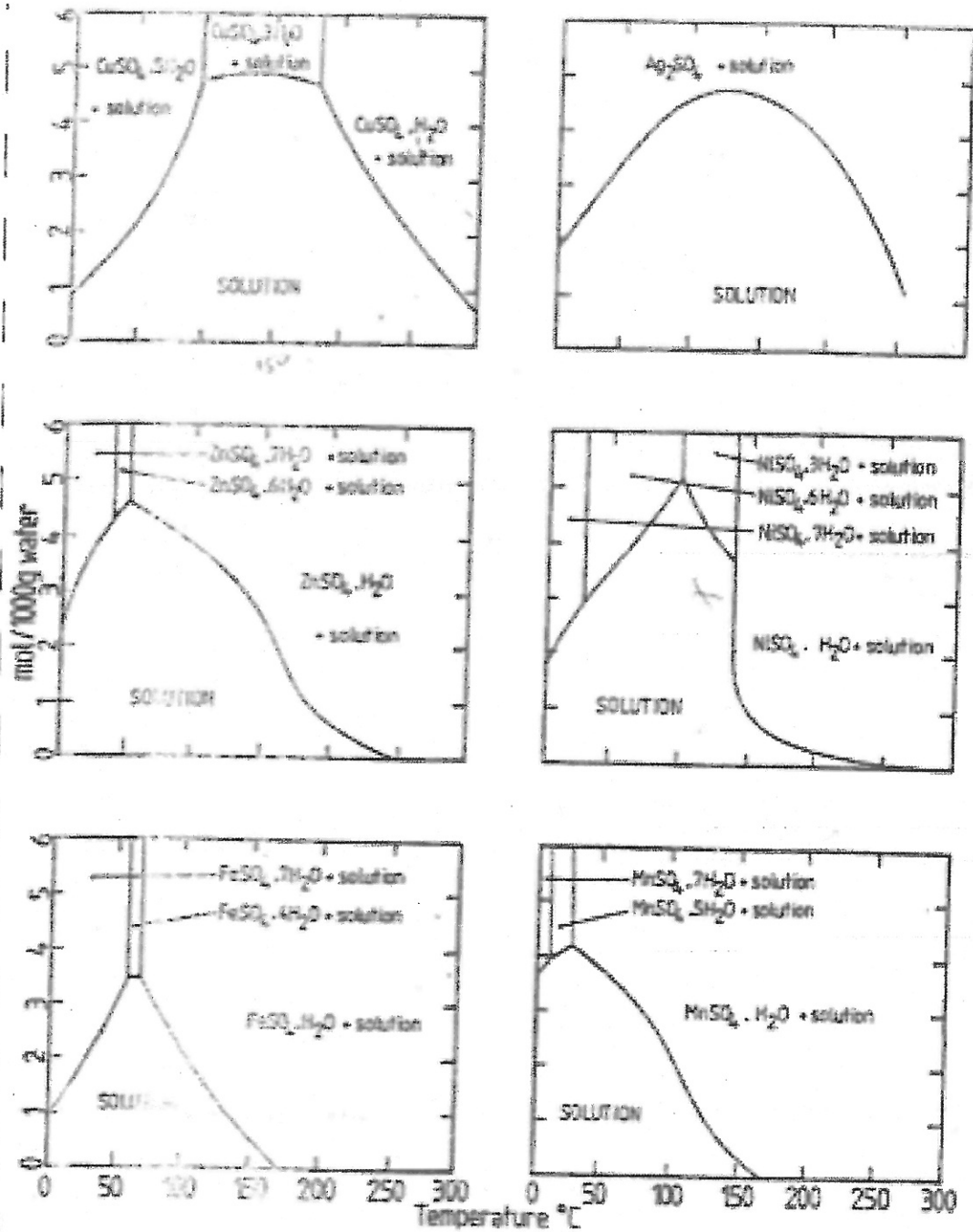
At the Fairview plant in Mpumalanga, Bacterial leaching process is performed for refractory gold ores. The mine needs to engage with the new neighbouring environment and stakeholders to explain them some of the activities at their metallurgical bio-plant and ensure them of its safe operation. You are appointed as a young metallurgist at the above mine. You are required to write a short explanation on

- 3.1 Heap leaching (3)
 - 3.2 In-situ Leaching (3)
 - 3.3 Discuss the advantages and disadvantages of bioleaching. (4)
 - 3.4 Discuss direct and indirect bacterial leaching. What are microbial media? State the name and composition of bacterial media used for bioleaching of sulphidic ores. (5)
 - 3.5. South Africa is known for their bioleaching operation. Discuss the bioleaching activities in South Africa (4)
 - 3.6. Due to the lack of good sulfide reefs, oxidized materials are processed. Elaborate on the recovery of Cu and Co from oxidized Cu-Co ore using bacterial leaching (process with reactions and mechanisms with mention of the strains used will be important). (6)
- [25]
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QUESTION 4

- 4.1. With the help of the standard reduction potential table below explain why for the electrolytic extraction of Zn from its hydrometallurgical solution one has first to remove Fe present. (4)
- 4.2. An hydrometallurgical solution contains Cu, Ni and Co in quantities enough to be recovered in an economical electrolytic route. Suggest a specific way for the extraction of each of the individual metals ie Cu, Ni and Co. Justify your opinion. (8)
- 4.3. As a S4 extraction metallurgy student, you are required to electrolytically extract 20 tons of Cu from its aqueous solution when a current of 700 A is used. Determine the time -duration (in hours) required. (5)
- 4.4. During the electrowinning of base metals the Nernst equation is used to set and fix the potential of the electrolytic cell for an optimised metal recovery. As the process proceeds, bleeding of the electrolyte is required.
- 4.4.1. Explain the electrolyte bleeding process (3)
- 4.4.2. Explain the electrodynamic of the cell as the electrowinning proceeds (5)

[25]



Graph 1: Solubility of sulphate salts in function of temperature.

Table 1: Standard electrode reduction potentials

Metal	Zn	Fe	Ni	Cu	H	Au
E^0 (V)	-0.76	-0.44	-0.25	+0.34	0.00	+1.42