MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SESSION EXAMINATION FOR

MASTER OF SCIENCE (CHEMISTRY)

SCH 815: MINERAL PROCESSING AND RECYCLING PROCESSES

DATE: 27/8/2021 **TIME: 2.00-5.00 PM**

INSTRUCTIONS:

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 15 marks).

SECTION A

QUESTION ONE (30 MARKS)

a) Before mineral ores are subjected to chemical treatment, they are pre-treated by a series of processes, mainly physical rather than chemical in nature. These processes constitute what is known as ore dressing. State any 3 ore dressing processes. (3 marks)

b) Position of the Ellingham lines of the oxide of the metal considered and reducing agent is important. Using a graphical sketch describe how relevant Ellingham lines are in mineral processing. (4 marks)

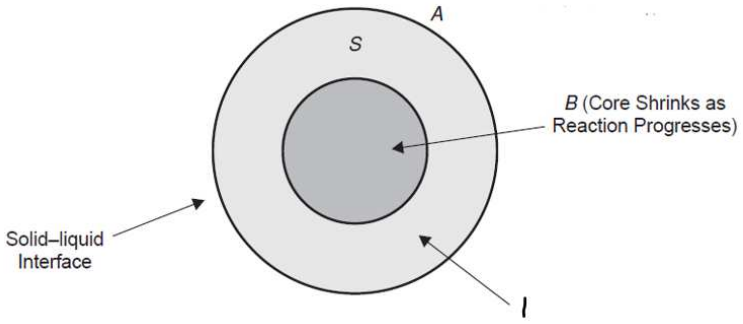
c) Distinguish with relevant examples, between calcination and smelting, in the context of pyrometallurgy (4 marks)

d) Titanium cannot be obtained from rutile or ilmenite by reduction with C because it forms an intractable titanium carbide. Describe the Kroll process as an alternative method used to extract titanium from its ores at red heat. (4 marks)

e) Pure vanadium is obtained via the Jantesh process. Describe the process in detail and give one significant use of Vanadium. (4 marks)

f) Owing to the ionic nature of the oxides and slags and to the electronic nature of the metallic phases, the overall reaction involves the transfer of electrons between the reacting species. Using a diagram show the location of elementary reactions between carbon (or silicon) dissolved in a liquid metal and the oxide dissolved in a slag (slag-metal reaction) with formation of CO bubbles at the interface. (5 marks)

g) Study the diagram below and answer the questions that follow:



i. State what A, S and I represent (3 marks)

ii. List any Three resistances/limiting steps are identifiable in such a reacting system (3 marks)

SECTION B (ANSWER TWO QUESTIONS)

QUESTION TWO (15 MARKS)

Discuss the following methods used to recover metals from leach liquor (15 marks)

a) Solvent extraction

b) Ion exchange

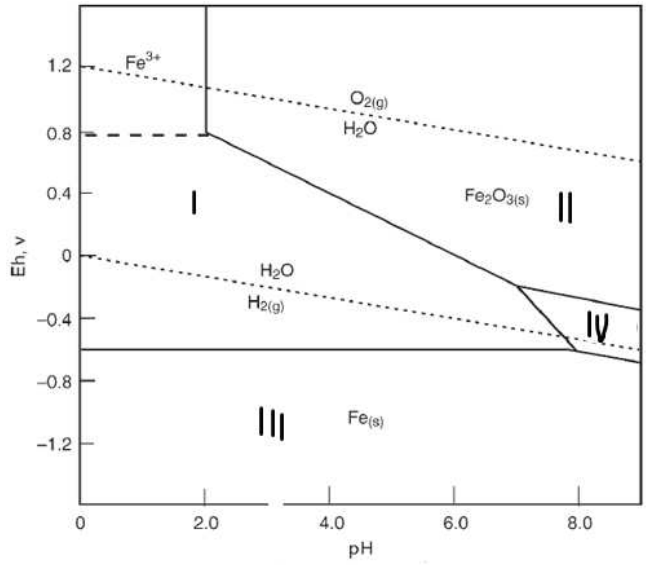
c) Electrowinning

d) Cementation

e) Chemical precipitation

QUESTION THREE (15 MARKS)

a) Consider the fate of an iron bar immersed in water under various oxidation/reduction potentials and pH values of the solution. Eh–pH Diagram (Pourbaix diagram) for the Fe–H_2O System is shown below. Describe the lower and upper phase boundaries of water in relation to the oxidation/reduction potential. Use relevant equations appropriately. (9 marks)



b) Write down the various equations representing the phase boundary lines for the following Fe-bearing species. (6 marks)

i. I and II

ii. II and IV

iii. Fe^{3+} and II

QUESTION FOUR (15 MARKS)

a) Describe the MacInnes method (mean salt method) and the Debye–Huckel method for estimation of activity coefficients for ions (6 marks)

b) Operations and waste products associated with metal extraction and processing are the principal causes of environmental concerns about metal mining. Concerns include:

i. Physical disturbances to the landscape

ii. Soil, air, and water contamination

iii. Public safety

Discuss these environmental impacts (9 marks)

QUESTION FIVE (15 MARKS)

a) Solvent extraction operations are often run continuously in a counter current mode as shown in Figure below. Draw a McCabe–Thiele diagram and show the distribution isotherm line for an ion between the aqueous phase and organic phase together with the operating line of a solvent extraction system (7 marks)

b) Derive the Gibbs–Helmholtz equation. (4 marks)

c) Consider a galena mineral, PbS (Radius = 1 mm; molar density = 5 mol/cm^3) that is subjected to leaching. If the diffusion of O_2 through the diffusion boundary layer is limiting, how long would it take to complete the reaction? Assume k_m = 0.1 cm/s; $\{O_2\} = 2.7 \times 10^{-7}$ mol/cm^3. Pb =270.2; S = 32.06. (4 marks)

<PbS> + 2 {H^+} + 1/2 {O2} = {Pb^{2+}} + <S> + {H_2O}