MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR FIRST SEMESTER EXAMINATION FOR

MASTER SCIENCE (CHEMISTRY)

SCH 815: MINERAL PROCESSING AND RECYCLING PROCESSES

DATE: 16/4/2019 **TIME: 2.00-5.00 PM**

INSTRUCTIONS:

ANSWER YOUR QUESTIONS IN ANSWER BOOKLET PROVIDED.

ANSWER QUESTION ONE [COMPULSORY] AND ANY OTHER TWO QUESTIONS.

QUESTION ONE (30 MARKS)

a) Define the following terms (6 marks)

i. Pozzolana

ii. Hydration of cement

iii. Bassemerization

b) Separation of minerals by froth flotation techniques depends on the wettability of particles.

i. Draw a schematic diagram of the equilibrium contact between an air bubble and a solid immersed in a liquid (2 marks)

ii. In this context, write down the Young–Dupre equation expression and clearly show how contact angle is related to interfacial tension, γ. (2 marks)

c) A cementation reaction, $Zn + Cu^{2+} = Cu + Zn^{2+}$, is taking place at the surface of a zinc plate of 10 cm x 10 cm area. Feed flowing parallel to the plate at a velocity of 1 m/s contains copper at 1 mol/dm^3. Estimate the rate of deposition if the mass transfer of Cu^{2+} to the zinc plate is limiting. The diffusivity of Cu^{2+} is 7.2 x 10^{-6} cm^2/s, and the kinematic viscosity of water is 0.01 cm^2/s. (Note that the density of Zn is 7.14 g/cm^3.) (4 marks)

d) With equations only, outline how Zirconium is extracted commercially via the Kroll process. (4 marks)

e) Draw a schematic diagram of electrical double layer used in flotation processes. Clearly show *the "potential determining" ions* (3 marks)

f) State the importance of Calcium sulfate in cement production marks. (2 marks)

g) State what each of the following processes are all about

i. Mond process

ii. Jantesh process (4 marks)

h) Describe the sulfate-reducing microbial Processes for simultaneous removal of both heavy metal ions and sulfates (use relevant equations) (3 marks)

QUESTION TWO (20 MARKS)

a) Describe the following floatation processes

i. Electrostatic adsorption

ii. Galena flotation (8 marks)

b) Using copper-bearing species as an example, and useful mass balance equations; discuss the relevance of stability constants of coordination complexes in hydrometallurgy. (6 marks)

c) The activity coefficient of a cation or an anion can be estimated by using the Debye–Huckel method. State this equation and outline its relevance in hydrometallurgy (6 marks)

QUESTION THREE (20 MARKS)

a) Describe, with relevant equations, the reaction kinetics that occur during cement burning (8 marks)

b) Show how titanium is extracted from both rutile and ilmenite. Explain why it is not obtainable by reduction of its oxides with C. (4 marks)

c) Purification of $TiCl_4$ is a rigorous process. Account for this statement. (8 marks)

QUESTION FOUR (20 MARKS)

a) In hydrometallurgy, leaching of solids may produce a layer that is insoluble but permeable to ion diffusion, which can be well described by shrinking core models.

i. Provide a detailed description of pictorial representations showing three identifiable resistances in reacting systems *viz*: (1) film diffusion); (2) chemical reaction at the reactant–product interface and (3) product layer diffusion.

(5 marks)

ii. If film diffusion as the limiting step, show that;

$$\frac{t}{t_{comp}} = 1 - \left(\frac{r_c}{R}\right)^3$$

(5 marks)

b) Consider a metal sulfide MS (molecular weight = 100; diameter = 1 mm; density = 5 g/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; $\{O_2\}$ = 2.7×10^{-4} mol/dm^3.

$<MS> + 2\ \{H^+\} + 1/2\ \{O_2\} = \{M^{2+}\} + <S> + \{H_2O\}$ (4 marks)

c) In hydrometallurgical mineral processing, there exists potential risk associated with release of toxic metallic cations into the environment. From literature, technologies considered for metals separation from aqueous streams can be subdivided the technologies into three categories namely; 1. Conventional treatment, 2. Recognized recovery technologies and 3. Emerging recovery technologies. In this context, describe any 2 processes in each of the categories (6 marks)

QUESTION FIVE (20 MARKS)

a) Hydrocarbons of petroleum origin are known to be numerous and thus ubiquitous in soil systems. Both *in situ* and *ex situ* bioremediation of soils contaminated by petroleum and petroleum products have now been well studied. In situ methods include volatilization, biodegradation, soil flushing with chemicals, vitrification, passive remediation among others. In all these the successful design of each remediation depends on several subsurface parameters. In this soil remediation context, answer the following questions.

i. Discuss three various in situ soil remediation methods (6 marks)

ii. Name and give an account of any three subsurface parameters that each in situ remediation depends on (6 marks)

b) Platinum metals, Ag and Au are highly valuable metals that occur in rare deposits such as occur native sperrylite, $PtAs_2$, Argentine, Ag_2S and calaverite, $AuTe_2$ and are often alloyed with each other and with copper obtained by a composite process.

i. Describe how each of Pt and Ag are extracted from their ores (4 marks)

ii. Give detailed extractive-metallurgy advice you would give to geochemists responsible for Au exploration in Kenya. Assume rare Gold deposits have been discovered in Kakamega. (4 marks)