

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

ROYAL SCHOOL OF MINES

EMEC 2004/5

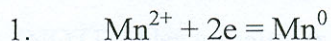
HYDROMETALLURGY

Thursday 2 December 2004

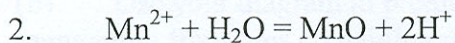
Time allowed: 3 hours

ANSWER FIVE QUESTIONS ONLY

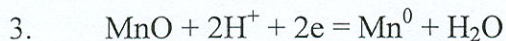
1. (a) Draw an accurate E-pH diagram for the Mn-H₂O system for an activity of manganese ions of 0.1M, using the following data:



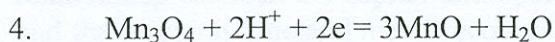
$$E = -1.179 + 0.0295 \log\{ \text{Mn}^{2+} \}$$



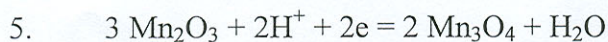
$$\log\{ \text{Mn}^{2+} \} = 17.82 - 2\text{pH}$$



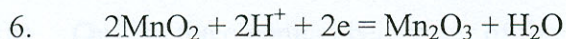
$$E = -0.652 - 0.0591\text{pH}$$



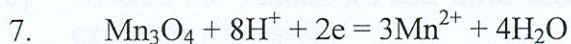
$$E = 0.240 - 0.0591\text{pH}$$



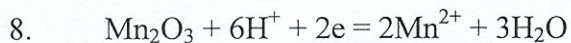
$$E = 0.689 - 0.0591\text{pH}$$



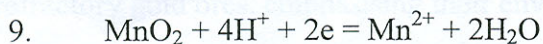
$$E = 1.014 - 0.0591\text{pH}$$



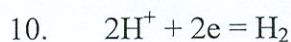
$$E = 1.824 - 0.2364\text{pH} - 0.0886 \log\{ \text{Mn}^{2+} \}$$



$$E = 1.443 - 0.1773\text{pH} - 0.0591 \log\{ \text{Mn}^{2+} \}$$



$$E = 1.228 - 0.1182\text{pH} - 0.0295 \log\{ \text{Mn}^{2+} \}$$



$$E = -0.0591\text{pH}$$

(CONTINUED)



$$E = 1.229 - 0.0591pH$$

(NOTE: Use a scale for E from -2 to +2 volts on your graph.)

(15 marks)

1. (b) Use your diagram to predict the conditions necessary for the leaching of manganese from ores containing pyrolusite, MnO_2 .

(5 marks)

ME/91/5

2. Write an essay on industrial leaching methods. Explain why there is an inverse relationship between the capital and operating costs of the leaching method used and the leaching time and metal recoveries achieved. Illustrate your answer with industrial examples.

(20 marks)

HYD/02/3

3. (a) Explain the principles of solvent extraction. (5 marks)
- (b) Outline the chemical behaviour of the three main classes of solvent extraction reagent. (6 marks)
- (c) Discuss the similarities and differences between solvent extraction and ion exchange processes. (9 marks)

HYD/04/4

4. What is meant by the term, 'refractory gold ore'? Give the mineralogical causes of refractoriness in gold ores. Describe three types of process currently used to treat refractory gold ores, emphasising their environmental impacts.

(20 marks)

HB/00/28

5. (a) A nickel refinery treats a mixed nickel-cobalt sulphide precipitate produced as a by-product from nickel laterite leaching. The refining process involves oxygen pressure leaching of the mixed sulphides, followed by purification of the leach liquor, separation of nickel and cobalt by solvent extraction and electrowinning of the metals.

The leach liquor leaving the autoclave contains a mixture of metal sulphates, with the following metal ion concentrations: Ni^{2+} , 100 g/l; Co^{2+} , 10 g/l; Zn^{2+} , 1 g/l. Prior to solvent extraction, zinc is removed by treating the solution at 25°C with hydrogen sulphide gas to precipitate zinc sulphide. Using the solubility product data given below, estimate the minimum concentration of zinc in the purified leach liquor that can be achieved without loss of either nickel or cobalt to the zinc sulphide. Clearly state and comment upon any assumptions that you make in your calculations.

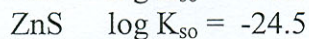
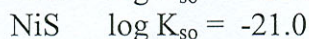
(10 marks)

- (b) Compare and contrast two solvent extraction processes used industrially to separate cobalt and nickel in solutions similar in composition to that described above. The solution purification stages prior to solvent extraction and the metal recovery stages following solvent extraction need not be considered.

(10 marks)

DATA

Solubility products at 25°C:-



Relative atomic masses:-



HB/J97/6

6. Discuss the application of solvent extraction and electrowinning for the recovery of copper from oxidised copper ores. Show how the process is closed cycle and virtually zero-discharge, in principle requiring only the input of electrical power to produce high grade copper metal.

(20 marks)

HYD/02/7

7. (a) Describe the basic Roast-Leach-Electrowin (RLE) process for the production of zinc from zinc sulphide concentrates.

(8 marks)

(b) Compare and contrast the Jarosite and Goethite processes for the removal of iron from zinc leach liquors.

(12 marks)

HYD/04/7

8. (a) Outline the Bayer process for the production of pure alumina from bauxite ores. Discuss the influence of the mineralogy of bauxites on the conditions used to dissolve them and on the consumption of leaching reagent. Show where the main energy inputs to the process occur and discuss how these can be minimized.

(14 marks)

(b) Describe, with the help of a diagram, the essential features of the Hall-Heroult electrolytic cell for the production of aluminium.

(6 marks)

HYD/03/9