Examination: TA3210 Extractive metallurgy

Date: 2 April 2007
Time: 9:00 AM – 12:00 AM
Location: Zaal L, 3mE building, Mekelweg 2, Delft

This examination contains 6 questions with a total mark of 80, among which 10 marks are bonus points. This accounts for 70% of the total evaluation of the course. The rest 30% is accounted for by 2 reports for 2 case studies. The deadline for submission of the 2 reports is 10th April 2007.

Question 1: General questions in metallurgical processes *(20 marks)*

(1) Please name the essential pyrometallurgical and hydrometallurgical unit operations.

(2) Please describe what factors could affect the production cost and market price of metals.

(3) What are the Kellogg and Ellingham diagrams? How they are used in metallurgical operations?

(4) Please write down the different components of the cell voltage and their relative importance in electrowinning of metals.

(5) What are the purposes of roasting of sulphide concentrates? What products you could expect from the sulphide roasting?

Question 2: Ironmaking *(10 marks)*

(1) Please describe the raw materials used in blast furnace ironmaking process and how they are prepared before feeding to the blast furnace. What are the roles of metallurgical coke in ironmaking blast furnace process?

(2) What are the various zones of the blast furnace, and the main physical – chemical changes in these zones?

Question 3: Refining of metals *(10 marks)*

(1) Please explain how blister copper is refined? What are the steps and main chemical reactions in the operation?

(2) What are the objectives of steelmaking? What are the main differences between BOF and EAF steelmaking processes?

Question 4: Hydrometallurgical processes *(10 marks)*

(1) What are the functions of leaching operation in hydrometallurgical processes? What types of leaching processes can be identified, and what are their main characteristics?

(2) How the leaching solutions are purified, and how the targeted metals are precipitated as metal products in hydrometallurgical processes (explain with examples)?

Question 5: Metallurgical thermodynamic calculations ***(20 marks)***

(1) During copper converting, the FeS in the copper matte is firstly removed in the slag-making stage. After that copper is converted from the white metal (almost pure Cu_2S) into metallic copper by blowing air or oxygen into the converter. Please use the following thermodynamic data to calculate the equilibrium partial pressure of oxygen for conversion of pure Cu_2S to pure Cu at 1300°C, if p_{SO2}=0.1 atm.

$$\frac{2}{3}Cu_2S_{(l)} + O_2 = \frac{2}{3}Cu_2O_{(l)} + \frac{2}{3}SO_2 \qquad (1)$$

$$\Delta G^o_{(1)} = -256898 + 81.17T \qquad (J/mole\ O_2)$$

$$Cu_2O_{(l)} + \frac{1}{2}Cu_2S_{(l)} = 3Cu_{(l)} + \frac{1}{2}SO_2 \qquad (2)$$

$$\Delta G^o_{(4)} = 17991 - 29.44T \qquad (J/mole\ Cu_2O)$$

(2) Sulphide smelting of nickel is similar to sulphide smelting of copper. However, during nickel converting in practice, only high grade nickel matte (Ni_3S_2) is produced instead of metallic nickel. *Please use the thermodynamic data below and proper thermodynamic calculations to explain why it is not appropriate and advisable to convert nickel matte directly to metallic nickel.*
Melting point of nickel, nickel oxide, and nickel sulphide are: 1455°C, 1955°C and 789°C, respectively.

$$\frac{1}{2}Ni_3S_{2(l)} + 2NiO_{(s)} = \frac{7}{2}Ni_{(l)} + SO_2$$

$$\Delta G^o = 293842 - 166.52T \qquad (J)$$

Question 6: Electrometallurgy ***(10 marks)***

(1) Please write down the electrochemical reactions of: (a) electrowinning of zinc, (b) electrorefining of copper, and (c) molten salt electrolysis of aluminium. Explain briefly how these 3 types of operations work.

(2) How current efficiency and energy efficiency are linked together in the electrowinning or electrorefinning of metals? What are your ideas to increase current efficiency and reduce the energy consumption for electrowinning of metals.

(End)