

Examination: TA3380 Extractive metallurgy

5 November 2010

Time: 9:00 AM – 12:00 AM

Location: Room CT2.99, Faculty CiTG

This examination contains 5 questions with total of 70 points. This accounts for 70% of the total evaluation of the course. The rest 30% is accounted for by one report from the case study.

*Note: Please answer **question 5** on separate papers for Dr. Jack Voncken.*

1: General questions

(10 points)

- (1) Please describe clearly what types of processing routes and unit operations are available to extract metals from (a) sulphide ores, and (b) oxide ores? Please also state the nature and objectives of these unit operations. (5 points)
- (2) Please describe briefly what the best knowledge you have learned in this course? What subject(s) you would like to know more in such as course? (5 points)

2. Roasting

(10 points)

- (1) What are the objectives of roasting for processing sulphide ores? What types of sulphide roasting processes are available in industrial practice? What are the main roasting reactions for each types of sulphide roasting? What kind of roasting furnace is normally used in industry? (5 points)
- (2) What is sintering and sintering roasting? What kinds of ores are suitable for sintering, and what kinds of ores are suitable for sintering-roasting? Please indicate the main difference between these two, using examples of ores. (5 points)

2: Ironmaking and steelmaking

(10 points)

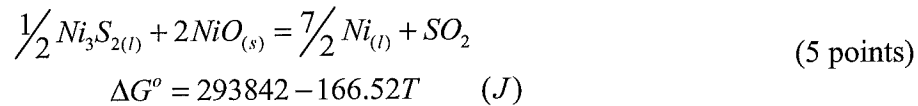
- (1) What are the functions of metallurgical coke in ironmaking blast furnace process? Please describe all possible reactions involved coke from top to the bottom of the furnace? Are all coke and pulverized coal fed into the blast furnace consumed in the blast furnace? If not, where the rest of them in the form of carbon go? (5 points)
 - (2) What are the two most important types of steelmaking processes? What are their general principles of operation (raw materials, heat supply, main reactions, products and by-products or wastes, furnace types etc.)? (5 points)
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3: Sulphide smelting and refining**(10 points)**

- (1) Copper occurs in majority as sulphide ores in nature. Please describe the main extraction and refining steps and their functions of copper-making process: from concentrates to refined copper as final metal product. Please also write down the main chemical reactions, the raw materials and products (Cu grade also) as well as wastes for each individual step. (5 points)
- (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. Metallic nickel is produced in the end through electrolysis of nickel sulphide.

Please use the thermodynamic data below and proper thermodynamic calculations to explain why it is neither appropriate nor advisable to convert nickel matte directly to metallic nickel in a conventional P-S converter? (please think about minimum operating temperature for the reaction)

Note that the melting point of nickel, nickel oxide, and nickel sulphide are: 1455°C, 1955°C and 789°C, respectively.

**4: Hydrometallurgical processes and electrometallurgy****(15 points)**

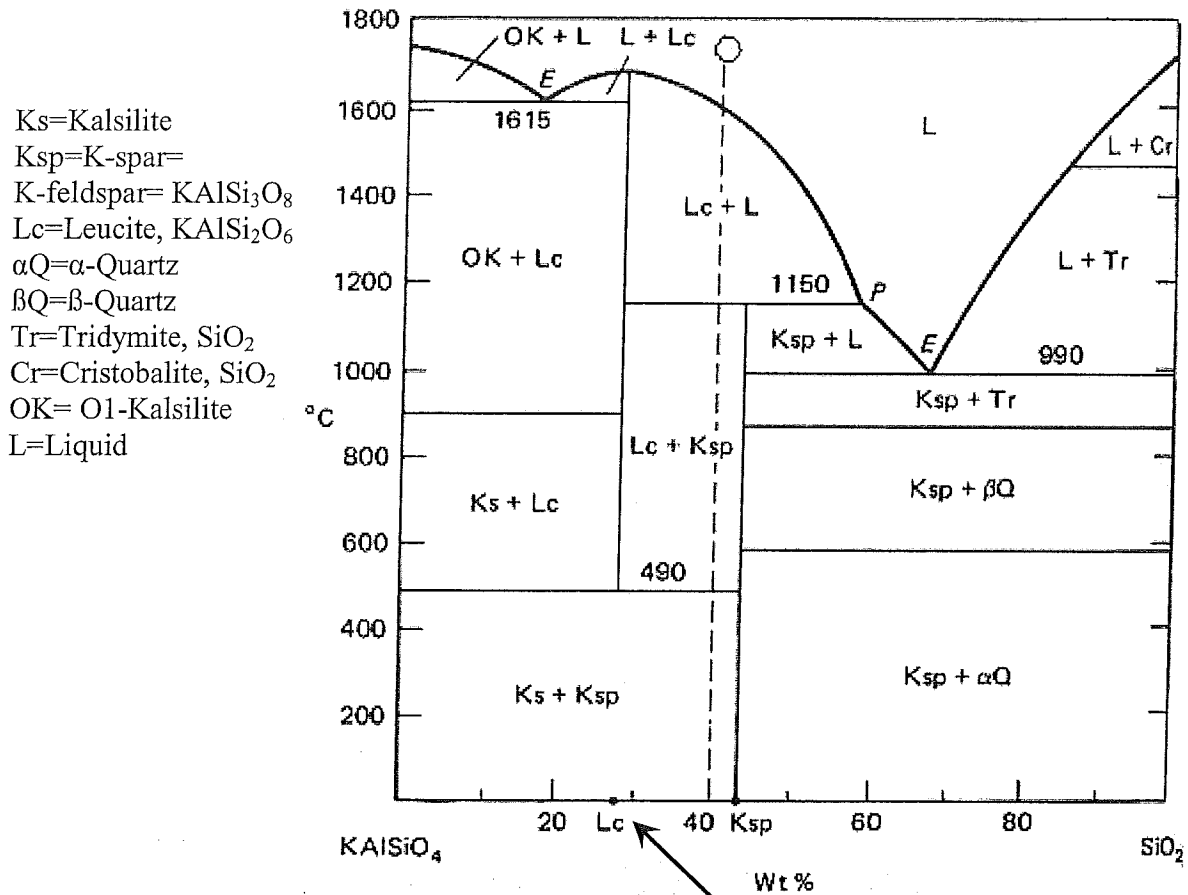
- (1) Please describe the unit operation for hydrometallurgical extraction of zinc metal from its sulphide concentrates (if it involves a non-hydrometallurgical operation, please describe it also). Please write down the main chemical reactions, major raw materials and products/by-products. (7.5 points)
- (2) What are the principles of electrolysis? What types of electrolytic processes are available for metals extraction and refining? Please give ONE example for each of the electrolytic process in extractive metallurgy.

Electrical power is the most important cost factor for electrolysis process. What physical law and operating parameters are determining the power consumption of the electrolysis for metals extraction or refining? (7.5 points)

5: Phase diagrams

(15 points)

Below the phase diagram for the system Kalsilite – Silica ($KAlSiO_4 - SiO_2$) is given.



- Indicate graphically the crystallization path of the melt composition indicated by the blue circle. Explain also in words what happens. You may use the separate sheet for graphically indicating the crystallization path. The diagram is printed larger on that sheet.
- Describe in words what happens when the composition (Lc) is heated from room temperature to its melting point.

Below the ternary diagram of the system $CaO - Al_2O_3 - SiO_2$ is given.

- Indicate in this diagram at least two eutectical points and two peritectical points.
- The straight lines in this ternary diagram are so called Alkemade Lines. What is the definition of an Alkemade Line ?

