

## Examination: TA3380 Extractive metallurgy

6 November 2009

Time: 9:00 AM – 12:00 AM

Location: Room CT2.02, Faculty CiTG

*about now*

*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.*

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### 1: General questions

(15 points)

- (1) Metals occur mostly in two types of ores: oxide and sulphide ores. To extract metals from these two types of ores, different processes are applied. Please state briefly typical processing routes for both types of ores. (5 points)
- (2) What are the purposes and main reactions of roasting of sulphide concentrates? What products you could expect from the sulphide roasting? Please explain how to the use of the Kellogg diagram in sulphide roasting process (see separate figures for reference). (5 points)
- (3) What is the Ellingham Diagram (see separate figure for reference)? How it is used in the evaluation of metallurgical processes, please give one example? (5 points)

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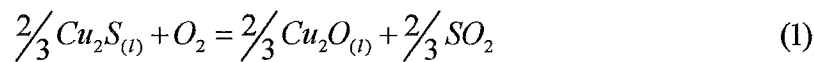
### 2: Ironmaking and steelmaking

(15 points)

- (1) Please describe how metallic iron (hot metal) is produced in Blast Furnace Process. Please also state: the raw materials, main chemical changes of feed along the movement in the furnace, various zones of the blast furnace, and different products of smelting operation. What are the roles of metallurgical coke in ironmaking blast furnace process? (7.5 points)
- (2) What are the main impurities in steelmaking process (brought by both hot metal and steel scrap)? How are they removed from the steel melt, and what are the main chemical reactions of these impurities removal? What are the benefits to use steel scrap, and what kind of consequences you could expect if you use only hot metal as the main feed (no use of scrap) in BOF converter process? (7.5 points)

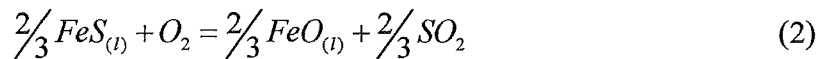
**3: Copper smelting and refining****(10 points)**

- (1) Copper occurs in majority as sulphide ores. Please describe the main extraction and refining steps and their functions of copper-making: from concentrates to refined copper as final metal product. (5 points)
- (2) Copper matte converting is carried out at about 1200°C. Please use Gibbs free energy functions below to indicate clearly: (a) the oxidation order of the 2 sulphide compounds of Cu<sub>2</sub>S and FeS in the matte (which is first); (b) Cu<sub>2</sub>O initially formed is unstable if there is substantial amount of FeS in the matte. The Gibbs free energy of the following 2 oxidation reactions as functions of temperature is given below:



$$\Delta G_{(1)}^\circ = -256898 + 81.17T \quad (\text{J/mole O}_2)$$

-150694



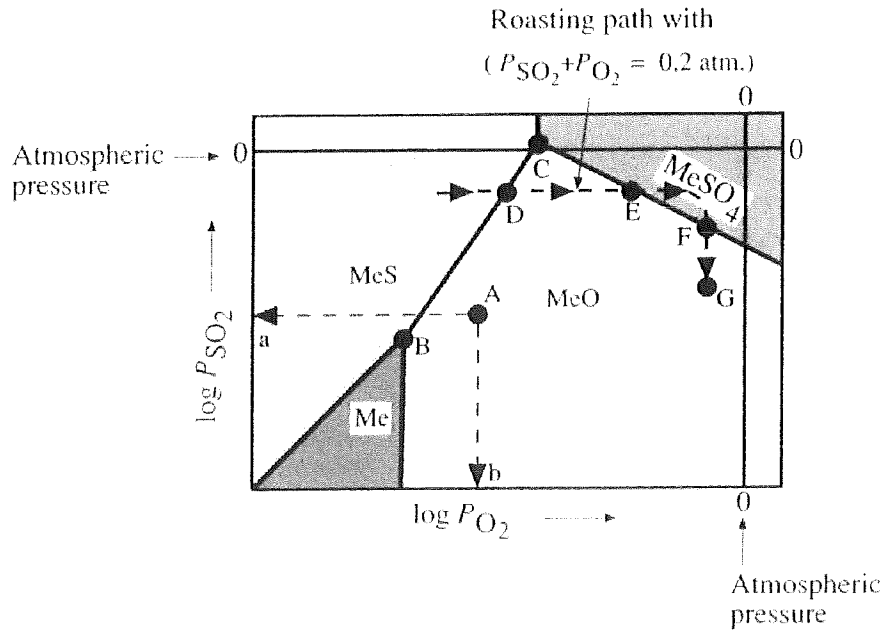
$$\Delta G_{(2)}^\circ = -303340 + 52.68T \quad (\text{J/mole O}_2)$$

-240024

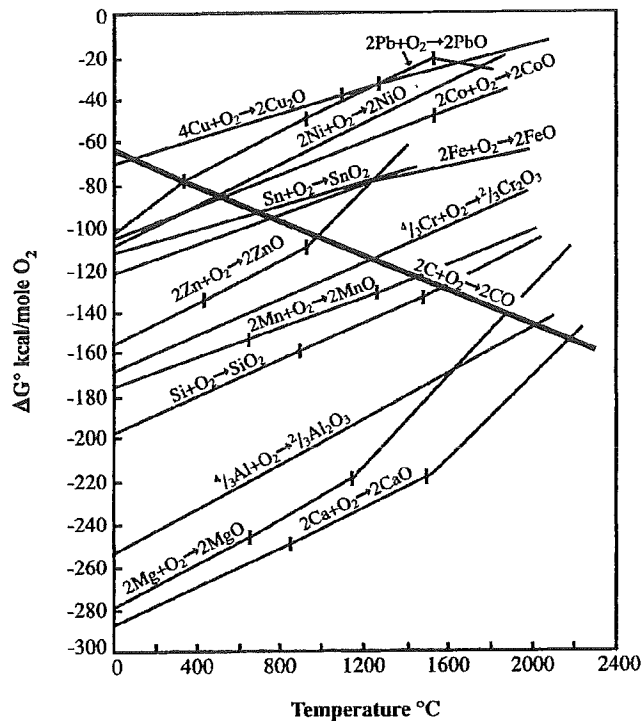
(5 points)

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

- (1) Leaching is one of the most important unit operations in hydrometallurgical processes. Please describe what types of leaching processes can be identified? What are their main characteristics and chemical reactions? (5 points)
- (2) Where precipitation processes are used in hydrometallurgical processes? What are their basic principles and main chemical reactions? (5 points)
- (3) What are electro-winning and electro-refining operations? Please use copper to explain the electrowinning and electro-refining processes in sulphate solution systems. (5 points)



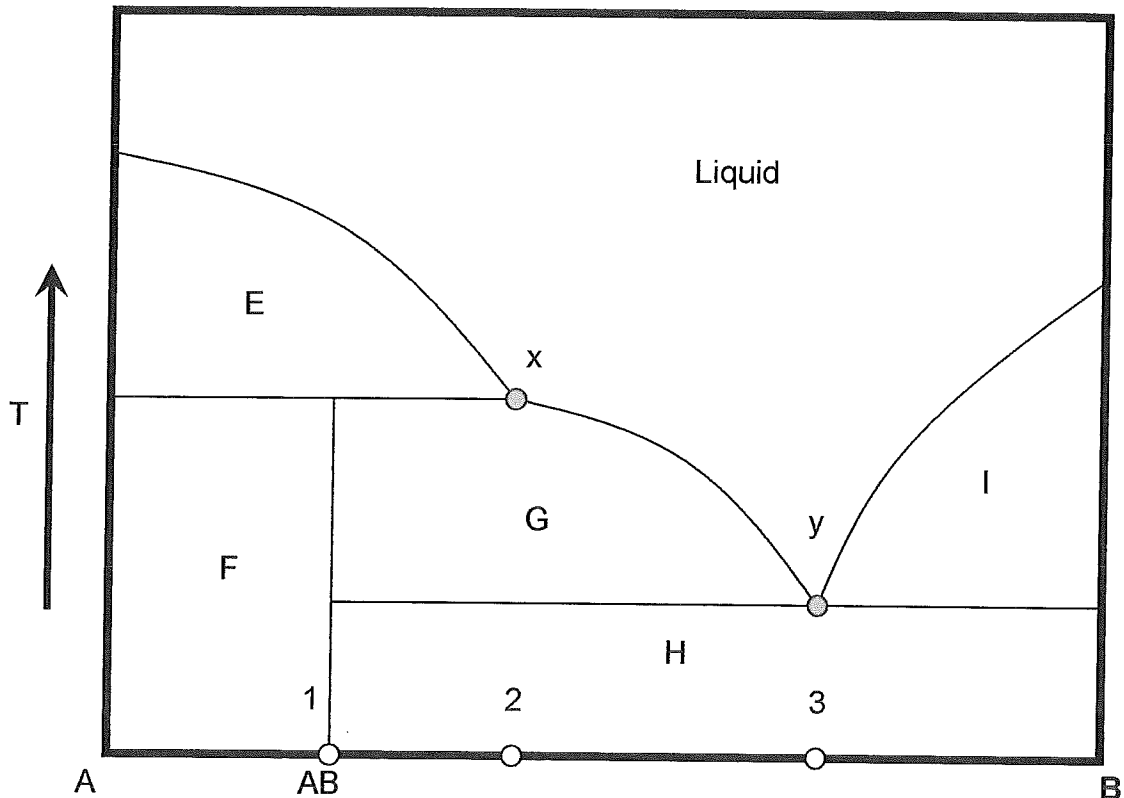
**Kellogg diagram of Me-S-O systems**



**Ellingham diagram of metal oxides systems.**

## 5: Phase diagrams

(15 points)



Gegeven is het bovenstaande binaire fasendiagram A-AB-B. De temperatuur (T) is verticaal uitgezet. De druk (P) wordt constant verondersteld. Het diagram bevat de primaire fasenvelden E, F, G, H en I, en het liquid-veld.

De totale waarde van de vraag is 15 punten. Bij elke deelvraag is de waarde daarvan in punten vermeld. Gebruik losse vellen bij vraag c. Voorzie elk los vel van naam en studienummer.

Beantwoord de volgende deelvragen:

- Benoem de punten X en Y. (1 p)
- Welke fasen zijn stabiel in de velden E, F, G, H en I? (4 p)
- Beschrijf het smeltgedrag van de samenstellingen 1, 2, en 3. Geef hierbij op een los vel de evolutie van vaste fase(n) en smelt aan. (10 p)