University of Miskolc

Faculty of Materials Science and Engineering
Antal Kerpely Doctoral School of Materials Science & Technology

Chemical Metallurgy-II (Theoretical fundamentals of processes for metal production)

Prof. Tamás Kékesi, DSc

COURSE DESCRIPTION

2016.

Chemical Metallurgy-II (Theoretical fundamentals of processes for metal production)

Prof. Tamás Kékesi, DSc

Lecturer

Dr. Tamás Kékesi Tamás, professor, Institute of Metallurgy.

Room: B1 3rd Floor, 310b. mail: kekesi@uni-miskolc.hu, tel: ext.1545, +36306556371, http://www.metont.uni-miskolc.hu.

Target group

The course is offered for all students of the Kerpely Doctoral School, especially in the field of chemical metallurgy and foundry engineering.

Language

English or Hungarian.

Scope

The objective of the course is to interpret the physical-chemical conditions and the characteristics influencing the efficiency of extractive metallurgical processes.

Learning outcomes

The content of the course offers the deeper understanding of the equilibrium conditions and kinetic characteristics of chemical reactions capable of purposefully transforming metalliferous or metallic materials. The students acquire the fundamental theoretical knowledge for controlling, developing or interpreting the processes. The resulting knowledge primarily serves the success of doctoral students pursuing research in the field of chemical metallurgy.

Methodology

The course is held in weekly 2 hour lectures for larger groups, but it is offered on a personal basis for 1-2 students, by defining the actual curriculum and providing test questions. The main blocks are terminated by personal consultations, when the learning outcomes are promoted by interactive communication and controlled instruction.

Constituent topics

The equilibrium conditions and the possible reactions of classical metallurgical processes are assessed by the methods of classic thermodynamic methods. The students learn the way of determining the equilibrium constants of simple and complex processes as functions of physical-chemical parameters. Thermodynamic functions are determined by manual and computer aided methods. The kinetic conditions of the processes are

interpreted. The kinetic characteristics of heterogeneous processes are determined by experimental methods.

The equilibria of solubility and solution stability, giving the basis for hydrometallurgical processes, as well as the separation and neutralisation reactions of metal ions are examined. By the interpretation of the equilibria in redox reactions and the related electrode potentials, the students learn the principles and practical characteristics of electrolytic processes suited to the extraction and purification of metals.

- Metallurgical thermochemistry, the thermodynamic examination of reactions of metals.
- Determination of the thermodynamic functions of metal – non-metallic reagents according to the temperature, and the relationship of standard and real systems.
- Determination of the changes in the standard Gibbs free energies of typical pyrometallurgical reactions as functions of the temperature.
- The types and characteristics of the thermodynamic software used in chemical metallurgy.
- Determining the expected course of reactions, the compositions of equilibrium systems and the degrees of conversion.
- The formation and reduction of metal oxides and other compounds of metals. Application of oxygen potentials in assessing the possibility of charbothermic reduction.
- Thermodynamic determination of the selectivity and efficiency boundaries of molten metal refining.
- Kinetics of metallurgical reactions. Rate equations and the rate constant.
- The temperature dependence of the reaction rate.
- Determination and interpretation of the activation energy of processes.
- Dissolution and precipitation in aqueous media. Solubility equilibria.
- The role of the pH and the redox potential.
- Reactions and characteristics of dissolved ions.
- Methods of ion separation suitable for the purification of solutions.
- The formation and the equilibria of complex ions.
- The types of organic ion-exchange materials and liquid extraction agents.
- The reactions of solution purification and concentration based on ion-exchange.
- The concept and the significance of electrode potentials.
- The principal reactions of electro-refining and electrowinning.
- The role of electrode-kinetic phenomena. The concept and the determination of the polarization and overpotentials.
- The methods of enhancing electrorefining efficiency.
- Electro-deposition of reactive metals.

Test questions:

1. *What thermodynamic functions are characteristic of the metals and their compounds?*
2. *How does the temperature affect the values of the thermodynamic functions, and how can it be computed?*
3. *How can the change in the standard Gibbs free energy of a reaction be determined by manual or computer aided methods in function of the temperature?*
4. *How is the expected direction of a reaction be interpreted from the computed value of the equilibrium constant?*
5. *How can the relative stability of simple metal compounds (oxides, sulphides, chlorides, etc.) be determined?*
6. *What is the concept of oxygen potential, and for wat can it be used?*

7. *How can the thermodynamic conditions of carbothermic reduction of metal oxides be determined?*
8. *What is the role of the Boudouard-reaction in the mechanism of the carbothermic reduction?*
9. *What are the thermodynamic methods that can be used for the determination of the selectivity and extent of the oxidation reaction taking place in multicomponent metal melts?*
10. *How is the rate of reactions interpreted and what are the determining factors?*
11. *How does the rate relationship of reaction depend on the mechanism?*
12. *How can the metallurgical processes based on heterogeneous reactions be characterised?*
13. *How can one determine the rate constants?*
14. *How is the activation energy interpreted and determined, and what does it refer to?*
15. *How is it possible to increase the rates of metallurgical processes effectively?*
16. *What is the role of metal hydroxide stability in Hydrometallurgy?*
17. *How can the Pourbaix-type diagrams be constructed and interpreted?*
18. *How can the ions dissolved in various aqueous media be separated?*
19. *How do metal ions form complex ions in aqueous solutions?*
20. *How can the ion-exchange equilibria be interpreted and determined?*
21. *What is the basis of ion-chromatographic separation and how can its efficiency be determined?*
22. *How can the characteristics of redox equilibria be computed?*
23. *How does the electrode potential arise, and what does it depend on?*
24. *What are the conditions and characteristics of cathodic metal deposition from aqueous solutions?*
25. *What are the processes to result in the purification of metals during electrorefining?*
26. *What are the causes of overpotentials arising at the electrodes?*
27. *What are the electrode-kinetic relationships that determine the current density arising at an electrode?*
28. *What is the role of electrode polarization in the efficiency and quality aspects of electrolysis?*
29. *How can the characteristics of electrocrystallization be interpreted and influenced?*

Tantárgyhoz kapcsolódó irodalom

1. Tamás Kékesi: Foundamentals of Chemical Metallurgy, Digital textbook, 2013.
2. Kubaschewski, O., Alcock, C.B.: Metallurgical Thermochemistry, Vol. 24. International Series on Materials Science and Technology, , Ed. Raynor, G.V., Pergamon Press, 1979.
3. Fathi Habashi: Principles of Extractive of Extractive Metallurgy Volume 4 Amalgam and Electrometallurgy, Métallurgie Extractive Québec, 1998
4. Biswas, A.K., Reginald Bashforth, G.: The Physical Chemistry of Metallurgical Processes, Chapman & Hall, London, 1962.
5. Erdey-Grúz, T: Kinetics of electrode processes, Akadémiai kiadó, Budapest, 1972.
6. Pourbaix, M, Zoubov, N, Van Muylder, J.: Atlas d'Équilibres Électrochimiques, Gauthier-Villars, Paris, 1963.

+ If need be, the student may get literature directly relevant to his/her research.

Completion, examination

Oral examination, following the adequate answering of control questions.

Relevant topics for the complex examination

1. Determination of the thermodynamic functions of reactions.
2. Chemical processes of carbothermic reduction, the concept and the role of oxygen potential in the metal-oxide system.
3. The significance, thermodynamic conditions and limits of selective oxidation to be applied in chemical metallurgy.
4. The kinetics of metallurgical reactions, the determination of the rate constant and the activation energy.
5. Equilibria and possibilities of separation of metal ions in aqueous media.
6. The equilibria and kinetics of electrode processes, and the factors affecting the efficiency of electrolysis.