

Fall 1997

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ChE 221 - EXTRACTIVE PROCESSING

- Instructor: Eung Ha Cho, Professor, Chemical Engineering Department, College of Engineering and Mineral Resources
- Credit: 4
- Text Book: Class handout (approximately 200 pages)
- References: Principles of Extractive Metallurgy, Habashi, Gordon and Breach, New York, 1969.
Principles of Extractive Metallurgy, Rosenqvist, McGraw-Hill, New York, 1974.
- Objectives: This course covers unit processes for recovering metal values from mineral concentrates by hydrometallurgical and pyrometallurgical technologies. Particularly this course covers the basic mechanisms of leaching of minerals, solvent extraction, and electrowinning. This course also covers the basic mechanisms of roasting, smelting and refining processes.
- Topics:
- I. INTRODUCTION (1 lecture)
 - II. THERMODYNAMICS OF HYDROMETALLURGY (3 lectures)
 1. Electrochemical Reactions
 2. Eh- pH Diagram or Pourbaix Diagram
 - III. KINETICS OF HYDROMETALLURGY (3 lectures)
 1. Rate Controlling Steps
 2. Surface Reaction Control for Sphere
 3. Diffusion Control through Limiting Boundary Layer for Sphere
 4. Diffusion Control through Product Layer for Sphere
 5. Temperature Effect on Reaction Rate
 - IV. LEACHING THEORY AND METHODS (2 lectures)
 1. Theory of Leaching
 2. Leaching methods
 - V. SOLUTION PURIFICATION AND CONCENTRATION (3 lectures)
 1. Solvent Extraction
 2. Ion Exchange
 - VI. METAL RECOVERY (3 lectures)
 1. Cementation

2. Hydrogen Reduction
 3. Electrowinning
- VII. INDUSTRIAL HYDROMETALLURGICAL PROCESSES (5 lectures)
1. Cyanidation Process
 2. Bayer Process
 3. Uranium Oxides Leaching
 4. Sheritt-Gordon Process
 5. Jarosite Process
 6. Anaconda-Arbiter Process
- VIII. CALCINATION AND AGGLOMERATION (2 lectures)
1. Calcination
 2. Agglomeration
- IX. ROASTING OF SULFIDES (2 lectures)
1. Thermodynamics of Roasting
 2. Roasting Operations
 3. Heat Balance of Pyrite Roasting
- X. REDUCTION OF METAL OXIDES (4 lectures)
1. Thermodynamics of Oxide Reduction
 2. Reduction of Iron Ores
 3. Iron Blast Furnace
 4. Electric Iron Smelting
 5. Behavior of Impurity Elements during Iron-Making
 6. Reduction of Other Oxide Ores
- XI. VOLATILE METALS (2 lectures)
1. Production of Mercury Metal
 2. Theory of Zinc Oxide Reduction
 3. Industrial Zinc Processes
 4. Refining of Zinc by Distillation
- XII. SLAGS AND REFRACTORIES (3 lectures)
1. Blast Furnace Type Slags
 2. Non-Oxide Components in Slags
 3. Ferrous Slags
 4. Physical Properties of Slags
 5. Refractories
 6. Oxide Refractories
 7. Non-Oxide Refractories
- XIII. MATTE SMELTING (3 lectures)
1. Iron-Copper Mattes
 2. Copper Losses in Slag
 3. Iron-Copper-Nickel Matte
 4. Industrial Copper Smelting
 5. Nickel Smelting
 6. Lead Matte Smelting Processes
- XIV. REFINING PROCESSES (5 lectures)

1. Fire-Refining
2. Thermodynamics of Liquid Steel
3. Steelmaking Reactions
4. Desulfurization
5. Deoxidation
6. Refining by Metal-Metal Separation
7. Vacuum Refining

Laboratory Sessions:

- Lab 1 - Atomic Absorption Analysis
- Lab 2 - Leaching of Sulfide
- Lab 3 - Solvent Extraction
- Lab 4 - Oxidation of Galena

Grading Plan:

Homework	20%
Exams (3)	40%
Laboratory	20%
Final	20%