NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF GEOLOGICAL, MINING AND METALLURGICAL ENGINEERING

METALLURGICAL ENGINEERING PROGRAM

GE311 – METALLURGIC PHYSICAL-CHEMISTRY

I. GENERAL INFORMATION

CODE	**:**	GE311 Metallurgic Physical-Chemistry
SEMESTER	**:**	5
CREDITS	**:**	4
HOURS PER WEEK	**:**	5 (Theory–Practice– Laboratory)
PREREQUISITES	**:**	ME211 Physical-Chemistry
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Metallurgical Engineering

II. COURSE DESCRIPTION

The course prepares students in the application of concepts, methods and technics of physical-chemistry into metallurgy. Also, students understand different contact systems, contact interface between phases liquid-gas, liquid-liquid, solid-liquid, solid-gas. Important variables such as surface tension, adsorption, wettability, contact angle and their application into different metallurgical processes as flotation lixiviation, among others.

III. COURSE OUTCOMES

At the end of the course, students:

1. Organize and apply physical-chemistry methods in laboratory tests and in industrial processes.
2. Explain the way how the interphase affects the different types of contacts, as well as the corresponding processes for understanding the surface physical-chemical properties.
3. Analyze the properties and behavior of different type of interphase: liquid-liquid, liquid-gas, liquid-solid, solid-gas.
4. Apply physical-chemical methods to minerals processing and metallurgical processes.
5. Understand the properties and behavior of colloidal solutions.

IV. LEARNING UNITS

1. PHYSICAL CHEMISTRY OF SURFACES

Definition / Surfaces, interfaces and interphases / Importance of interphases.

2. LIQUID-GAS INTERPHASE, SURFACE TENSION

Surface tension / Measurement methods. / Relation between surface tension and structure / Interface free energy / Young-Laplace equation / Manifestations of surface tension / Surface tension of aqueous solutions / Surfactants agents.

3. LIQUID-LIQUID INTERPHASE

Introduction / Cohesion and adhesion / Scattering coefficient. / Interphase thermodynamics / Gibbs equation / Relative interphase excess / Surface tension measurement.

4. LIQUID-SOLID INTERPHASE

Solid surfaces / Internal energy, interphase free energy and emersion heat / Solid-liquid adhesion work / Contact angle / Contact angle measurement / Solid-liquid interphase adsorption / Freundlich isothermal adsorption process.

5. SOLID-GAS INTERPHASE

Physical adsorption / Chemical adsorption / Adsorption isothermal line / Brunauer's classification of adsorption isothermal lines. / Lagmuir's isothermal line.

6. COLLOIDS

Introduction / Colloidal solutions characteristics / Types of colloids / Electric properties of colloidal systems / Colloids, double electric layer model / Stern's theory / Stern-Graham model / Colloids stability / Kinetic coagulation.

V. LABORATORY

Session 1: Physical-chemical properties of liquids.
Session 2: Purity of xanthates.
Session 3: Flotation of polymetallic minerals.
Session 4: Activated carbon adsorption
Session 5: Sedimentation, Stokes law.
Session 6: Final work presentation.

VI. METHODOLOGY

The course takes place in theory, practice and laboratory sessions. In theory, faculty presents and analyze concepts and methods. In practice sessions diverse problems related to extractive metallurgy are solved and analyzed. In laboratory sessions, students perform test and verify expected outcomes and results. After each laboratory experience, students submit a report describing procedures and summarizing results and conclusions. Student's active participation is promoted.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + EF + PL) / 3

EP: Mid-term Exam EF: Final Exam
PL: Average of practice and laboratory work

VIII. BIBLIOGRAPHY

1. MACKOVIAC, J.
   Physical-Chemistry for Metallurgists, Technos Ed., Madrid, Spain, 2002.
2. ADAMSON A. W.
   Chemical-Physics. Ed. Reverte Co., Barcelona, Spain, 1979.
3. ASTUCURI T. V.
   Introduction to Minerals Flotation.