NATIONAL UNIVERSITY OF ENGINEERING

COLLEGE OF GEOLOGICAL, MINING AND METALLURGICAL ENGINEERING

MINING ENGINEERING PROGRAM

ME211 – PHYSICAL CHEMISTRY

I. GENERAL INFORMATION

CODE	**:**	ME211 Physical Chemistry
SEMESTER	**:**	4
CREDITS	**:**	4
HOURS PER WEEK	**:**	6 (Theory, Practice, Laboratory)
PREREQUISITES	**:**	ME212 Chemical Analysis
CONDITION	**:**	Compulsory

II. COURSE DESCRIPTION

The course prepares students in the application of concepts, methods and principles of physical-chemistry for describing and analyzing phase equilibrium surface phenomena, adsorption, electrochemistry in Galvan and electrolytic cells. Students use mathematical models to simulate and analyze process behavior and compare the results with those obtained experimentally.

III. COURSE OUTCOMES

At the end of the course, students:

1. Identify the variables of physical-chemical phenomena and use them in the formulation of mathematical models.
2. Solve problems related to phase equilibrium in binary systems, as well as surface phenomena applied to adsorption of metals and organic compounds.
3. Differentiate ideal and real solutions, as well as Galvan and electrolytic cells, understanding the importance of oxidation and reduction reactions.
4. Integrate mathematical models for obtaining phase-equilibrium curves, as well as the speed of chemical reactions of several orders.
5. Interpret and analyze simulation results and compare them with experimental results.

IV. LEARNING UNITS

1. CHEMICAL EQUILIBRIUM

Introduction / Direct and indirect reaction speed / Equilibrium constant / Chemical equilibrium of ideal gases / Equilibrium constant in concentration and pressure units / Chemical equilibrium in solution / Heterogeneous equilibrium / Dependence of equilibrium constant respect to temperature.

2. DISSOLUTIONS

Introduction / Phase recognition / Dissolution and composition / Partial molar magnitudes / Partial molar volume of a mono-phase system / Relationship between dissolution volume and partial molar volume / Measurement of partial molar volumes. Gradient method / Other partial molar magnitudes / Mixture magnitudes / Partial molar enthalpy, entropy and Gibbs energy / Dissolution integral and differential heats / Ideal dissolution and ideal mixture / Ideal dissolutions thermodynamic properties / Raoult law / Henry law / Real solutions and activity coefficient.

3. PHASE EQUILIBRIUM IN BINARY AND TERNARY SYSTEMS

Phase rules / Chemical potential / Gibbs energy / Phase and component / State and equilibrium changes / Phase equilibrium for a one-component system / Bi-dimensional diagram for pure water / Phase diagram of CO_2 / Phase change enthalpy and entropy / Clapeyron equation / Solid-liquid equilibrium / Cooling of solid mixtures / Eutectic point systems / Transitions points and congruent points / Leverage rule / Three-component systems and phase diagrams /

4. **CALCULATION OF PHYSICAL-CHEMICAL PROPERTIES OF ORGANIC AND INORGANIC COMPOUNDS**
   Critic pressure and volume / Compressibility factor / Acentric factor / Heat capacity / Gas heat capacity / Liquid heat capacity / Solid heat capacity / Vapor pressure / Surface tension / Water solubility / Viscosity of organic gases / Viscosity of liquids / Gas thermal conductivity / Liquid and solids thermal conductivity.

5. **SURFACE PROCESSES**
   Surface composition / Surface analysis / X-ray spectrometry / Light microscope / Electronic microscope / Electron diffraction / Surface adsorption / Solid surface types / Adsorption mechanism / Adsorption and desorption equilibrium / Adsorption isothermal /

6. **ELECTRO-CHEMISTRY**
   Electrochemical cells / Unique electrode potential / Galvan cells / Reduction potential table / Potential of hydrogen electrode / Nernst equation / Oxidation potential and corrosion / Cell temperature coefficients / Electrode types / Electric conduction in solutions / Kohlrausch equation / Ion-independent migration law / Ionic mobility / Electrolysis / First and Second Faraday laws / Batteries / Fuel cells.

7. **TRANSPORT PROPERTIES**
   Thermodynamic and configuration properties / Ideal gas properties / Diffusivity, viscosity and thermal conductivity / Potential energy / Electrostatic forces / Intermolecular forces / Lennard-Jones energy / Transport properties of real substances.

V. LABORATORY AND PRACTICAL EXPERIENCES

Laboratory 1. Dissolutions
Laboratory 2. Phase equilibrium in binary systems
Laboratory 3 Heat capacity
Laboratory 4. Electro-chemistry
Laboratory 5. Diffusivity, viscosity and thermal conductivity

VI. METHODOLOGY

The course takes place in theory, practice and laboratory sessions. In theory sessions, faculty presents concepts, laws and applications. In practice sessions, various problems are solved and their solution analyzed. In laboratory sessions students carry out experiments to verify physical-chemistry theory. At the end of each laboratory experience, students present report summarizing main findings, results and conclusions. Student’s active participation is promoted throughout the course.

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 Laboratory and Practice Works.

VIII. BIBLIOGRAPHY

1. **ADAMSON ARTHUR W.**
   Physical Chemistry, Reverte Editorial, Barcelona, Spain.
2. **CASTELLAN GILBERT W.**
   Physical Chemistry – Pearson Education, Spain.