COURSE OUTLINE

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES		
DEPARTMENT	DEPARTMENT OF CHEMISTRY		
LEVEL OF STUDIES	ISCED level 6 - Bachelor's or equivalent level		
COURSE CODE	YN501	**SEMESTER**	5th
COURSE TITLE	Inorganic Chemistry II		

TEACHING ACTIVITIES *If the ECTS Credits are distributed in distinct parts of the course e.g. lectures, labs etc. If the ECTS Credits are awarded to the whole course, then please indicate the teaching hours per week and the corresponding ECTS Credits.*	**TEACHING HOURS PER WEEK**	**ECTS CREDITS**
THEORY	4	7
LABORATORY	3	
Please, add lines if necessary. Teaching methods and organization of the course are described in section 4.		

COURSE TYPE *Background, General Knowledge, Scientific Area, Skill Development*	Specialization & Skills Development
PREREQUISITES:	According to the Undergraduate study program, there are no prerequisite courses. However, it is recommended that students have successfully completed the courses principles of General Chemistry and Inorganic Chemistry I.
TEACHING & EXAMINATION LANGUAGE:	Greek
COURSE OFFERED TO ERASMUS STUDENTS:	NO
COURSE URL:	https://eclass2.emt.duth.gr/courses/CHEM_E102/

(2) LEARNING OUTCOMES

Learning Outcomes

Please describe the learning outcomes of the course: Knowledge, skills and abilities acquired after the successful completion of the course.

After successfully completing the course, students will be able to:

- Identify the transition elements (d-block) of the Periodic Table and write their ground-state electronic configurations.
- Write the electronic configuration of transition metals in all their oxidation states.
- Know and understand the periodic properties of the transition elements (atomic and ionic radius, melting/boiling points, ionization energy, electron affinity, metallic character).
- Understand coordination compounds and the fundamental interpretations of A. Werner's theory.
- Know the concepts of coordination compounds, ligands, coordination numbers, stereochemistry of complexes, as well as their colors and magnetic properties.
- Name coordination compounds and identify the structural isomers and stereoisomers of coordination complexes, as well as their thermodynamic stability.
- Know chelating compounds and the applications of metal complexes.
- Understand and apply bonding theories in coordination compounds: valence bond theory, crystal field theory, and molecular orbital theory.
- Interpret the electronic spectra of transition-metal complexes.
- Understand the magnetic properties of coordination compounds.
- Know the methods of preparing coordination compounds and the basic concepts of reaction kinetics in coordination chemistry.

- Describe the origin, chemical properties, and uses of representative transition metals.
- Have knowledge of organometallic compounds (carbonyls, metal alkyls, carbenes, carbynes, carbides, cyclopentadienyl complexes, metal clusters).
- Synthesize, purify, crystallize, and characterize coordination compounds of transition-metal ions.

General Skills

Name the desirable general skills upon successful completion of the module

Search, analysis and synthesis of data and information,	*Project design and management*
ICT Use	*Equity and Inclusion*
Adaptation to new situations	*Respect for the natural environment*
Decision making	*Sustainability*
Autonomous work	*Demonstration of social, professional and moral responsibility and sensitivity to gender issues*
Teamwork	*Critical thinking*
Working in an international environment	*Promoting free, creative and inductive reasoning*
Working in an interdisciplinary environment	
Production of new research ideas	

By the end of this course, students will have developed the following general competencies:

- Ability to understand the concepts and principles related to the chemistry of transition elements (d-block).
- Ability to comprehend the concepts and properties of coordination compounds and to recognize their applications.
- Ability to apply theoretical knowledge to the synthesis, analysis, and solution of related chemical problems.
- Ability to search and evaluate information in order to address questions concerning current and emerging applications of coordination compounds.
- Ability to collaborate effectively with others on chemical and interdisciplinary problems.
- Ability to synthesize and characterize coordination compounds in the laboratory.
- Ability to adopt and apply appropriate methodologies for solving unfamiliar problems.
- Study skills required for continuous professional development.
- Additionally, upon completion of the course, students will have acquired the following transferable skills:
    - Adaptation to new situations
    - Decision-making
    - Independent work
    - Critical thinking and self-evaluation
    - Creative and inductive reasoning

(3) COURSE CONTENT

1. Transition metals of the d-block of the Periodic Table
    - Definitions
    - Electronic structures of atoms and ions
    - Oxidation states
    - Periodic properties of the metals
    - Physical properties
    - Chemical properties
    - Characteristic properties of the metals
2. Fundamentals of coordination chemistry
    - Historical overview
    - Coordination compounds
    - Werner’s theory
    - Ligands
    - Coordination numbers and geometries
    - Nomenclature of coordination compounds
    - Isomerism in coordination compounds (structural isomers, stereoisomers)

- Chelating compounds
- Applications of coordination compounds

3. Chemical bonding in coordination compounds of transition elements
   - Valence Bond Theory (types of hybridization, applications)
   - Crystal Field Theory (octahedral crystal field, crystal field stabilization energy, tetrahedral and square planar fields, spectrochemical series of ligands, colors of metal complexes)
   - Molecular Orbital Theory (basic concepts, octahedral complexes, tetrahedral and square planar complexes, σ and π molecular orbitals)
4. Electronic spectra of coordination compounds of transition elements
   - Spectroscopic terms
   - UV-Vis electronic spectra of various octahedral and tetrahedral complexes
   - Spin-forbidden transitions
   - Jahn–Teller effect
   - Shape and intensity of absorption bands in electronic spectra
   - Charge-transfer spectra
5. Magnetic properties of coordination compounds
   - Diamagnetism and paramagnetism
   - Determination of magnetic susceptibility
6. Synthetic methods of coordination compounds
   - Addition reactions
   - Substitution reactions
   - Thermal decomposition reactions
   - Oxidation and reduction reactions
   - Trans effect
   - Reaction kinetics
7. Brief description of the physical and chemical properties of transition elements
   - Groups 3 to 10 of the Periodic Table (Copper, Silver, Gold, Zinc, Cadmium, Mercury, Scandium, Yttrium, Lanthanum, Actinium, Titanium, Zirconium, Hafnium, Rutherfordium, Vanadium, Niobium, Tantalum, Dubnium, Chromium, Molybdenum, Tungsten, Seaborgium, Manganese, Technetium, Rhenium, Bohrium, Iron, Ruthenium, Osmium, Hassium, Cobalt, Rhodium, Iridium, Meitnerium, Nickel, Palladium, Platinum)
   - Lanthanides, actinides, rare earths, applications
8. Organometallic compounds
   - Metal carbonyls, metal alkyls, carbenes, carbynes, carbides
   - Cyclopentadienyl complexes
   - Reactions of organometallic compounds
   - Metal clusters

LABORATORY

1. Synthesis, purification, and crystallization of complexes of transition metals.
   - Synthesis of copper complexes: $[Cu(NH_3)_4]SO_4 \cdot H_2O$, $[Cu(gly)_2] \cdot H_2O$, $K_2[Cu(C_2O_4)_2] \cdot 2H_2O$
   - Synthesis of chromium complexes: $Cr(acac)_3$
   - Synthesis of manganese complexes: $Mn(acac)_3$
   - Synthesis of cobalt complexes: trans-$[Co(en)_3]Cl_3$, cis-$[Co(en)_3]Cl_3$, $[Co(NH_3)_6]Cl_3$, $[Co(NH_3)_5Cl]Cl_2$, $[Co(NH_3)_5ONO]Cl_2$, $[Co(NH_3)_5NO_2]Cl_2$, CoTPP
   - Synthesis of nickel complexes: $[Ni(NH_3)_4]Cl_2$, $K_2[Ni(CN)_4]$, $K_4[Ni_2(CN)_6]$
   - Synthesis of iron complexes: $K_4Fe(CN)_6$, $K[FeFe(CN)_6]$, $Fe[FeFe(CN)_6]_2$, etc.
2. Characterization of complexes using spectroscopic techniques (IR, UV-Vis), conductivity measurements, and magnetic measurements.

(4) LEARNING & TEACHING METHODS - EVALUATION

TEACHING METHOD *Face to face, Distance learning, etc.*	In-person lectures and laboratory exercises
USE OF INFORMATION & COMMUNICATIONS TECHNOLOGY	Use of ICT (PowerPoint) and electronic notes for teaching both the Theory and Laboratory components. The lectures

<table>
<tr><td>(ICT)
Use of ICT in Teaching, in Laboratory Education, in Communication with students</td><td>include sample solved problems in each chapter to facilitate understanding of the theoretical material.
Face-to-face communication with students, as well as communication via email and the e-class platform.</td></tr>
<tr><td>TEACHING ORGANIZATION
The ways and methods of teaching are described in detail.
Lectures, Seminars, Laboratory Exercise, Field Exercise, Bibliographic research & analysis, Tutoring, Internship (Placement), Clinical Exercise, Art Workshop, Interactive learning, Study visits, Study / creation, project, creation, project. Etc.

The supervised and unsupervised workload per activity is indicated here, so that total workload per semester complies to ECTS standards.</td><td>
<table>
<tr><th>Activity</th><th>Workload/semester</th></tr>
<tr><td>Lectures (4 hours of in-person teaching × 13 weeks)</td><td>52</td></tr>
<tr><td>Laboratory (3 hours of in-person teaching × 13 weeks)</td><td>39</td></tr>
<tr><td>Study hours for writing laboratory reports</td><td>18</td></tr>
<tr><td>Study hours for preparing for the laboratory final examinations</td><td>25</td></tr>
<tr><td>Study hours for preparing for the final theory examinations</td><td>35</td></tr>
<tr><td>Final laboratory examination (3 hours, in person)</td><td>3</td></tr>
<tr><td>Final theory examination (3 hours, in person)</td><td>3</td></tr>
<tr><td>Course Total
(25 hours of workload per credit unit)</td><td>175 hours (total student workload)</td></tr>
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<tr><td>STUDENT EVALUATION
Description of the evaluation process

Assessment Language, Assessment Methods, Formative or Concluding, Multiple Choice Test, Short Answer Questions, Essay Development Questions, Problem Solving, Written Assignment, Essay / Report, Oral Exam, Presentation in audience, Laboratory Report, Clinical examination of a patient, Artistic interpretation, Other/Others

Please indicate all relevant information about the course assessment and how students are informed</td><td>The grading distribution for the mixed course Inorganic Chemistry II (Y501) is: Theory 60 percent – Laboratory 40 percent.
Theory assessment is carried out through a written examination covering the entire syllabus. The written exam includes short-answer questions, extended-response questions, multiple-choice questions, and problem-solving exercises.
Laboratory assessment is calculated as follows:

Hardworking and successful performance of the laboratory experiments (Grade A).
This includes preparation, laboratory technique, behavior and consistency in the laboratory.
In addition, during certain laboratory sessions, unannounced short written quizzes and/or electronic tests may be administered.

The average grade of the laboratory reports (Grade B).
Students must submit their laboratory reports within a strict deadline of 7 days to the Instructor of the Laboratory Session.
All reports must be typed on a computer.
The grade reflects the quality of presentation and evaluation of experimental results, the interpretation</td></tr>
</table>

	of those results, and the correct responses to the questions included in each laboratory report. Students are required to submit at least 80% of all laboratory reports. Otherwise, they are not permitted to take the final written examination and must repeat all Laboratory Sessions in a subsequent academic year. The final written examination covering the content of the Laboratory Sessions (Grade C). The examination includes topics related to laboratory practice, the theoretical background of the laboratory exercises, and the associated calculations. Final course grade (scale 0-10) = (0.2 × A) + (0.3 × B) + (0.5 × C). i. 20 percent from Grade A ii. 30 percent from Grade B (average grade of laboratory reports) iii. 50 percent from Grade C (grade of the final written laboratory examination) To be considered as having successfully completed the laboratory component, a student must obtain a grade equal to or greater than 5 in each part, that is: (A + B) ≥ 5 and C ≥ 5. The above assessment criteria are announced during the first academic week of classes. They are also posted on e-class and accessible to all students. The final examination is conducted in the Greek language.

(5) SUGGESTED BIBLIOGRAPHY

1. Ανόργανη Χημεία, Τόμος Β, M. Weller, T. Overton, J. Rourke, F. Armstrong, Broken Hill Publishers LTD, 2022, ΚΩΔΙΚΟΣ ΕΥΔΟΞΟΥ: 102070044.
2. Χημεία ενώσεων συναρμογής, Τοσσίδης Ιωάννης Α., Εκδόσεις Ζήτη, 2001, ΚΩΔΙΚΟΣ ΕΥΔΟΞΟΥ: 11406.
3. Ειδική Ανόργανη Χημεία, Τα χημικά στοιχεία και οι ενώσεις τους, Π.Π. Καραγιαννίδης, 4η έκδοση/2009, Εκδόσεις ΖΗΤΗ, ΚΩΔΙΚΟΣ ΕΥΔΟΞΟΥ: 11420.
4. Προχωρημένη Ανόργανη Χημεία, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, ΚΩΔΙΚΟΣ ΕΥΔΟΞΟΥ: 86200125.
5. Ανόργανη Χημεία, Catherine E. Housecroft, Alan G. Sharpe (Επιμέλεια απόδοσης στα Ελληνικά: Ν. Χχατζλιάδης, Θ.Καμπανός, Α. Κεραμιδάς, Σ. Περλεπές), ΚΩΔΙΚΟΣ ΕΥΔΟΞΟΥ: 68407318.
6. Εργαστηριακές Ασκήσεις Ανόργανης Χημείας, Szafran Zvi, Pike M. Ronald, Singh M. Mono, ΚΩΔΙΚΟΣ ΕΥΔΟΞΟΥ: 77118124.

Relevant scientific journals:
- Inorganic Chemistry
- Coordination Chemistry Reviews
- Bioinorganic Chemistry
- All other relevant scientific journals