FACULTAD DE
CIENCIAS QUÍMICAS

INORGANIC CHEMISTRY I

COURSE GUIDE

BSc Chemistry

Academic Year 2025-2026

UNIVERSIDAD
COMPLUTENSE
MADRID

I.- IDENTIFICATION

COURSE NAME:	**Inorganic Chemistry I**
CREDITS (ECTS):	**12**
CHARACTER:	**Formation Obligatory**
SUBJECT:	**Inorganic Chemistry**
MODULE:	**Basic**
DEGREE:	**Bachelor in Chemistry**
SEMESTER/TERM:	**Annual (second year)**
DEPARTMENT/S:	**Inorganic Chemistry**

PROFESSORS:

Course coordinator	**Profesora:** MARINA PARRAS VÁZQUEZ **Departamento:** Química Inorgánica **Despacho:** QA-205 **e-mail:** mparras@ucm.es
Laboratory coordinator	**Lecturer:** MARIA LUISA RUIZ GONZÁLEZ **Department:** Inorganic Chemistry **Office:** QA-133 **e-mail:** luisarg@ucm.es

Theory Group E	
1st Semester	**Professor: ANA QUEREJETA FERNÁNDEZ** **Department:** Inorganic Chemistry **Office: QA-134** **e-mail: anaque02@ucm.es**
2nd Semester	**Professor: ELIZABETH DEL CASTILLO** **Department:** Inorganic Chemistry **Office: QA-226** **e-mail: ecastill@ucm.es**

Laboratory

Group	Semester	Professor/a	e-mail	Office	Depar.
E1 **E2**	1º	Almudena Torres Pardo Paula Kayser González	atorresp@ucm.es pakayser@ucm.es	QA-135 QA-118	QI
	2º	Miguel Cortijo Montes Cristian Cuerva de Alaiz	miguelcortijomontes@ucm.es c.cuerva@ucm.es	QA-216 QA-229B	QI

II.- OBJECTIVES

GENERAL OBJECTIVE

The main aim is to initiate the student in the study of the chemical elements of the Periodic Table. It is intended that the student acquires the appropriate knowledge that allows him to learn and correlate the structure, properties, reactivity, isolation methods and applications of the elements and their compounds.

Acquisition of both manual and intellectual skills in the synthesis of inorganic compounds and their subsequent separation and purification. Students must become familiar with the handling and use of common materials and processes in an inorganic chemistry laboratory, as well as learn to correlate the structure, bonding, and reactivity of inorganic compounds with the way they are prepared.

SPECIFIC OBJECTIVES:

o To carry out a systematic study of the chemical elements and the main types of compounds.
o To relate the physical and chemical properties of inorganic substances with their chemical bond.
o To relate the properties of the elements and their compounds with their structure.
o To start the study of compounds with fundamentally ionic bond and coordination compounds.
o To recognize the importance of Inorganic Chemistry within Science, and its impact on industrial and technological society.
o To carry out the synthesis of different inorganic compounds that require basic and specific experimental procedures.
o To acquire experimental work routines and appropriate knowledge concerning to the work and safety standards in the laboratory.

III.- PREVIOUS KNOWLEDGE AND RECOMMENDATIONS

PREVIOUS KNOWLEDGE:

Nomenclature and chemical formulation. Periodic system. Reaction adjustment. Atomic structure. Periodic properties. Chemical bond. Basic laboratory operations.

RECOMMENDATIONS:

It is recommended to have passed the basic subjects of General Chemistry, Basic Laboratory Operations and Computer Science Applied to Chemistry.

IV.- SUBJECT CONTENTS

BRIEF DESCRIPTION OF THE CONTENTS:

Theoretical contents

Non-metallic elements. Trends in structure and reactivity; physicochemical properties. Hydrogenated and oxygenated combinations of non-metals. Metallic elements: bond, structures, physicochemical properties, stability of the different oxidation states, extraction

methods and applications. Basic aspects of coordination compounds. Introduction to the study of solids with fundamentally ionic bond.

Experimental contents

Synthesis of inorganic compounds: halides, binary oxides, acids, salts, and coordination compounds

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■ PROGRAMME:

THEORETICAL:

Unit 1: Introduction
- Atomic orbitals in many-electron atoms.
- Energy and symmetry of the s and p orbitals.
- Characteristics of the elements based on their position in the periodic table.

Unit 2: Non-metallic elements
- Specific characteristics of hydrogen and the head group elements. Hydrogen. Comparative study of nitrogen, oxygen, and fluorine. Carbon and boron.
- Study of groups 14, 15 and 16. Allotropy. Properties variation within each group. Non-metal-metal transition.
- Halogens.
- Types of compounds and reactivity of non-metallic elements.
- Noble gases. Xenon compounds.

Unit 3: Hydrides of nonmetals
- General characteristics. Classification of the hydrogenated combinations of all the elements of the periodic table. Bonding, structures, physical and chemical properties of the hydrogenated combinations of the elements of groups 14-17.
- Study of some hydrogenated compounds of groups 14-17: H_2O, H_2O_2, NH_3, hydrogenated combinations of halogens.
- Boron hydrides s. Classification and nomenclature. Structure and bond. Physicochemical properties, reactivity, synthesis, and applications.

Unit 4: Oxides, oxoacids, and oxysalts of nonmetals
- Oxyanions, oxyacids and oxysalts: General characteristics. Oxyanions of chlorine, sulfur and nitrogen and their corresponding oxyacids.

Unit 5: Metallic elements
- Metallic elements in nature.
- Crystalline structure. Introduction to the band model in the study of metallic bond.
- Physical and chemical properties.
- Extraction methods.

Unit 6: Coordination compounds
- General concepts.
- Crystal Field Theory (CFT) applied to bonding: geometry and properties. Jahn-Teller effect. Limitations of CFT.

***Unit 7*: Non molecular compounds of metallic elements**
Crystal field theory applied to the ionic bond model. Limitations of the ionic bond model. Introduction to the band model.

LABORATORY EXPERIMENTS:

First semester experiments
1. Synthesis, crystallization and purification of oxosalts.
2. Synthesis of SO_2. Application as reducer.
3. Oxidizing properties of nitric acid. Comparison with H_2SO_4 and HCl.

Second semester experiments
1. Obtaining volatile halides. Hydrolysis of the halide obtained.
2. Preparation of coordination compounds. Isomerism in compounds of coordination.

V.- COMPETENCES

■ GENERAL:

- **CG1-MF1**: To recognize chemical processes in daily life.
- **CG2-MF1:** To relate Chemistry with other disciplines.
- **CG3-MF1:** To expand the studies in multidisciplinary areas.
- **CG5-MF1:** To demonstrate knowledge and understanding of the essential facts, concepts, principles, and related theories to the Chemistry areas.
- **CG6-MF1:** To analyse and solve qualitative and quantitative problems.
- **CG7-MF1:** To recognize and analyse new problems planning strategies to solve them.
- **CG8-MF1**: To consult and use scientific and technical information effectively.
- **CG9-MF1:** To demonstrate knowledge regarding laboratory materials and practical skills.
- **CG10-MF1**: To handle chemical products safely.
- **CG10-MF2:** To recognize and assess the risks in the use of chemical substances and laboratory procedures.
- **CG11-MF1:** To handle standard chemical instrumentation.
- **CG12-MF1:** To interpret data from observations and measurements in the laboratory.
- **CG13-MF1:** To recognize and implement good scientific practices of measurement and experimentation.

■ SPECIFIC:

- **CE8-MFQI1:** To describe and relate the bond, structure and properties of chemical elements and their compounds.
- **CE10-MFQI1**: To use experimental methods of synthesis of inorganic compounds.

■ TRANVERSAL:

- **CT1-MF1:** To prepare and write scientific and technical reports.
- **CT2-MF1:** To cooperate with other students through teamwork.
- **CT3-MF1:** To apply critical and self-critical thinking.
- **CT5-MF1:** To use chemical information, bibliography, and specialized databases.
- **CT6-MF1**: To identify the importance of chemistry in the industrial, environmental, and social context.
- **CT7-MF1:** To use tools and computer programs for the treatment of experimental results.
- **CT11-MF1:** To develop autonomous learning.
- **CT12-MF1:** To recognize the current energy problem and its relevance.
- **CT12-MF2:** To develop sensitivity to environmental issues.

VI.- LEARNING OUTCOMES

At the end of the course the student should be able to:

- To recognize the Periodic Table as the way to organize and correlate the information related to chemical elements.
- To use the Periodic Table as the tool to obtain rationalized information of the properties of any group of elements.
- To compare the characteristics of nitrogen, oxygen, fluorine and hydrogen, and of the carbon and boron.
- To identify and relate the allotropic forms of the elements of groups 13 to 16, analysing the structure-properties relationship.
- To analyse the influence of the different parameters that determine the chemical reactivity of the elements.
- To identify the different types of compounds of non-metallic elements.
- To explain the specific characteristics of the noble gases and their main compounds.
- To identify the hydrogenated combinations of the elements of the periodic system.
- To explain the bonding and the properties of the hydrogenated combinations of non-metallic elements.
- To describe the bond and the main properties of the most representative hydrogenated compounds, such as water, hydrogen peroxide, ammonia.
- To classify the hydrogenated boron compounds explaining their characteristics.
- To classify the binary oxides of the elements of the periodic system according to the bonding nature and its acid-base properties.
- To describe the general characteristics of the oxides of non-metallic elements.
- To explain the bond and properties of the main oxides of non-elements metallic.
- To explain the bond and main properties of oxoacids and oxysalts of the non-metallic elements.
- To describe the factors that affect the acidity of oxoacids.
- To describe the bond, properties, synthesis, and applications of representative acids, like sulfuric and nitric acids.
- To describe the structure of metals from close-packings.
- To explain the metallic bond.
- To explain the variation of the physical properties of metals.
- To evaluate the relative stability of the different oxidation states of metals.

o To propose methods for obtaining metals.
o To formulate and name coordination compounds.
o To classify the different types of isomerism.
o To explain the observed geometries according to the valence bond theory (VBT)
o To apply the crystal field theory (CFT) to different coordination geometries.
o To identify and describe high and low spin compounds according to CFT.
o To explain the factors that affect the splitting doubling energy of the crystal field.
o To explain the most favourable electronic distribution in compounds of octahedral, tetrahedral, and square plane geometry as a function of crystal field stabilization energy (CFSE).
o To evaluate the distortions of the geometries using the CFT.
o To apply the CFT to justify colour, magnetism, and other properties.
o To recognize the limitations of VBT and CFT.
o To describe the structural types from the occupation of holes in close-packing of ions.
o To analyse the energetic aspects of ionic solids.
o To analyse the influence of covalence in the structure and energy of an ionic solid.
o To recognize the limitations of ideal models.
o To adequately design the synthetic stages of some inorganic compounds as a function of its nature.
o To use the most appropriate methods to isolate and purify these compounds.

VII.- WORKING HOURS DISTRIBUTED BY ACTIVITY

Activity	Attendance (hours)	Self-study (hours)	Credits/ hours
Lectures	56	54	4.4/110
Seminars / Problem classes	18	40	2,32/58
Tutorials / Guided work	10	22	1,28/32
Laboratories (including seminars)	40	33	2,92/73
Works and exams preparation	6	21	1,08/27
Total	**130**	**170**	**12/300**

VIII.- METHODOLOGY

The teaching strategy will follow a mixed methodology based on cooperative learning, collaborative learning, and self-learning. The classroom activities are scheduled **in lectures, seminars, tutorials and suggested activities and practical classes.**

The theoretical classes (2 hours / week throughout the course) will be lecture-based and the professor will present, in an orderly way, the theoretical concepts and experimental facts that allow the student to obtain a global and comprehensive vision of the subject. At the beginning of each lesson the main contents and objectives will be exposed. At the end of the unit, new proposals can be made allowing the interrelation of previously studied contents

with those of the rest of the subject or with other subjects. To support the theoretical explanations, appropriate teaching material, either in photocopies or through the **Virtual Campus**, will be provided to the students.

The seminar (9 hours / semester) will aim to apply the knowledge acquired to a set of questions/exercises. Previously, a list of questions will be provided to the students so that they can try to resolve them prior to the seminar. Part of the exercises will be solved in class by the teacher while others will be performed by students. Some of the questions will be related to inorganic species not described in the theoretical development of the subject. Therefore, the students can use the acquired knowledge to justify the facts raised in them.

To carry out a more personalized monitoring of students and to promote autonomous or group work, a series of **specific activities** will be proposed. As a part of these activities, the teacher will schedule **short exams or questions** that will be collected to evaluate the evolution of the students and the degree of achievement of knowledge they are acquiring.

Furthermore, the teacher will schedule **supervised tutorials** (3 hours/semester) globally or in small groups of students, based on proposed issues, either by them or by the teacher, related to the subject matter. It is also possible to entrust the preparation of some theoretical aspects to small groups of students, prior to their teaching in class.

Laboratory practical teaching, addressing contents related to the lectures and conveniently scheduled to complement and support the lectures and seminars, will be developed. The experimental laboratory sessions will take place along five days (4 hours / day) in each semester. In these sessions, experiments selected from those proposed in the practical program of the subject, included in the practice guide, will be carried out.

The practical sessions will be reinforced with, seminars to explain required concepts to carry out the chemical experiments. Previously, students must search the bibliography for all the data and information necessary to carry them out. They will then carry out the practice and develop, in parallel, a laboratory notebook, which reflects in detail each of the performed operations and reactions. The teacher will supervise and discuss the work done with the student, solving any doubts that have arisen during its development. The laboratory notebook will be delivered to the teacher at the end of the practice period of five days in each semester.

IX.- BIBLIOGRAPHY

■ BASIC:

At the beginning of the course, the recommended bibliography will be discussed, indicating the most relevant aspects of each text and the degree of adaptation to the subject. The recommended texts of general nature are listed as follows.

- Housecroft, C.E.; Sharpe, A.G.: "*Inorganic Chemistry"*, 5th ed., Pearson Education Limited, 2018. (Print and electronic).
- Shriver, D.F.; Overton, T.; Rourke, J.; Weller, M.; Armstrong, F.: "*Inorganic Chemistry"*, 5th ed., Oxford University Press, 2009.
- Huheey, J.G.; Keiter, E.A.; Keiter, R.L.: "*Inorganic Chemistry. Principles of Structure and Reactivity"*, 4th ed., Prentice Hall, 1997.

The practical guides will be available to the student in the Virtual Campus of the subject.

■ COMPLEMENTARY:

- Greenwood, N.; Earnshaw, A.: "*Chemistry of the Elements",* 2nd ed., Pergamon Press, 1997.
- Mingos, D. M. P.: "*Essential Trends in Inorganic Chemistry",* Oxford University Press, 1998.
- Müller, H.: "*Inorganic Structural Chemistry"*, 2nd ed., Wiley, 2007.
- West, A. R.: *"Solid State Chemistry and its Applications"*, 2nd ed., Wiley, 2014.
- Cox, P.A. "The electronic Structure and Chemistry of Solids » Oxford University Press, 1987.

■ LABORATORY EXPERIMENTS:

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- Dann, S. E., "*Reactions and Characterization of Solids"*, The Royal Society of Chemistry, London, 2000.
- Woollins, J. D., *"Inorganic Experiments"*, Wiley, 2006.

All the recommended bibliography for each specific lesson will be shown in class or in the Virtual Campus. In addition, from time to time, more specific bibliography on a specific aspect dealt within the course program can be indicated to the students

X.- ASSESSMENT PROCEDURE

For the final evaluation, it is mandatory to participate in the different activities proposed and to attend all the laboratory sessions. It will also be necessary for the student to have participated in at least 70% of the classroom activities to access the final evaluation.

The student's academic performance and the final grade for the subject will be computed, weighted, according to the percentages shown in each of the aspects listed below. All grades will be based on the absolute score of 10 points, and in accordance with the scale established in RD 1125/2003. This criterion will be maintained in all calls.

The grades of the activities planned for the evaluation of the subject (partial exams, laboratories, tutorials, delivery of questions, ...) will be communicated to the students well in advance before the completion of the final exam, so that they can properly plan the study of this or other subjects.

Within a maximum period of 20 days, the qualifications of the partial exams will be communicated, except in the case of the second partial, where the term may be shorter to adapt to the final exam. In any case, the minimum period of seven days between the publication of the grades and the date of the final exam for the subject will be respected.

■ WRITTEN EXAMS (THEORY): 60%

The evaluation of the competences acquired in the theoretical part of the subject (CG1-MF1, CG2-MF1, CG3-MF1, CG5-MF1, CG6-MF1, CG7-MF1, CG8-MF1, CE8 MFQI1, CT3-MF1, CT5-MF1, CT6-MF1, CT11-MF1, CT12-MF1 and CT12-MF2) will be carried out based on the evaluation of two partial exams, each one at the end of each

semester, and a final exam. Students who pass the two partial exams with a minimum score of 5.0 in each of them, will not be required to do the final exam (both in ordinary and extraordinary calls). However, students who have only passed one of the partial exams with a score equal to 6 or higher may do the **final exam** of only the partial exam they failed. In these cases, it will be necessary to obtain a minimum score of 4 to do an average with the approved part. Finally, students who must do the final exam must obtain a minimum score of 4.5 to get the final score of the subject. Students who have passed the two partial exams may also take the final exam if they wish to improve their grade. In these cases, they will be given half an hour to read the exam. If they choose not to submit it within that time, their final grade will be the average of the two midterms. However, if they decide to take the final exam, the grade obtained on that exam will be their final grade.

General competences CG1-MF1, CG2-MF1, CG5-MF1, CG6-MF1, CG7-MF1, CG8-MF1, the specific competence, CE8-MFQI1 and the transversal competences, CT3-MF1, CT5- MF1, CT6-MF1 will be assessed with the exams.

- **PERSONAL WORK/DIRECTED ACTIVITIES: 15%**

For the evaluation of the individual or group learning of the student, the following factors will be considered:

• Student skills in solving problems, proposed exercises and short exams.

• Assessment of the student's work in the seminars.

• Assessment of the work done by students during tutorials and other-directed activities.

The degree of achievement of the general competences CG1-MF1, CG2-MF1, CG5-MF1, CG6-MF1, CG7-MF1, CG8-MF1, of the specific competence CE8-MFQI1 and of the competence's transverse CT1-MF1, CT2-MF1, CT3-MF1, CT5-MF1, CT6-MF1, CT7-MF1, CT11-MF1, CT12-MF1, CT12-MF2 will allow the evaluation of all these aspects.

- **LABORATORY EXPERIMENTS: 25% (10% exam; 15% laboratory)**

Attendance at all experimental sessions and laboratory seminars is mandatory. Group changes will only be made for justified reasons.

The professor will assess the theoretical knowledge, the experimental procedures used, the aptitude and attitude of the student in the sessions and the progress observed in the student. The laboratory notebook prepared by each student during the practical period as well as any activity proposed by the lecturer will be also evaluated. All these aspects will account for 15% of the final grade.

After completion of all the experimental sessions (first and second semesters), a final exam will be carried out that will count a 10% of the final mark.

In order for this activity to contribute to the overall grade of the course, it will be necessary to achieve an average score of 5 with a minimum grade of 4.0 in the exam. There will be an extraordinary call in July for those students who have not passed the laboratory.

This activity will reinforce the knowledge acquired by the student, both in the theoretical classes and seminars, as well as in the rest of the activities of the course, which will result in the reinforcement of all general, specific, and transversal acquired competences.

General competences CG1-MF1, CG2-MF1, CG5- MF1, CG6-MF1, CG7-MF1, CG8-MF1, CG9-MF1, CG10-MF1, CG10-MF2, CG11- MF1, CG12- MF1, CG13-MF1 and the specific competences CE8-MFQI1 and CE10- MFQI1, and all the transversal ones will be assessed.

WORK TIME DISTRIBUTION AMONG ACTIVITY TYPES

THEMATIC UNIT	ACTIVITY	HOURS	GROUPS	START	END
1.Introduction	Theory	3	1	1st week	2th week
2. Non-metallic elements	Theory	11	1	1st week	7th week
	Seminar	5	1		
	Tutorships/Specific activity	2	1		
3. Hydrogenated combinations of nonmetals	Theory	6	1	8th week	10th week
	Seminar	2	1		
	Tutorships/specific activity	1	1		
4. Oxygenated combinations of nonmetals	Theory	9	1	10th week	14th week
	Seminar	2	1		
	Tutorships/Specific activity	2	1		
5. Metallic elements	Theory	12	1	15th week	18th week
	Seminar	5	1		
	Tutorships	2	1		
6. Coordination Compounds. Basics	Theory	8	1	19th week	24th week
	Seminar	2	1		
	Tutorships	2	1		
7. Compounds with fundamentally ionic bond	Theory	8	1	25th week	28th week
	Seminar	2	1		
	Tutorships	1	1		
Laboratory practices	5 Lab sessions	20	4	5 days of the first semester	
	5 Lab sessions	20	4	5 days of the second semester	
PLANNING BY THEORY GROUP					

SUMMARY OF ACTIVITIES

Teaching activity	Associated competences	Lecturer activity	Student activity	Assessment procedure	P	NP	Total	C
Theory classes	CG1-MF1, CG2-MF1, CG3-MF1, CG5-MF1, CG6-MF1, CG7-MF1, CG8-MF1, CE8-MFQI1, CT3-MF1, CT5-MF1, CT6-MF1, CT7-MF1, CT12-MF1, CT12-MF2	• Exhibition of theoretical concepts. • Raising questions and new proposals.	• Taking notes. Resolution of questions. • Development of new proposals. • Formulation of questions and doubts.	• Qualification of the answers made to questions related to theoretical concepts.	56	54	110	15 %
Seminars	CG1-MF1, CG2-MF1, CG5-MF1, CG6-MF1, CG7-MF1, CG8-MF1, CE8-MFQI1, CT1-MF1, CT2-MF1, CT3-MF1, CT5-MF1 CT6-MF1, CT7-MF1 CT11-MF1,CT12-MF1 CT12-MF2	• Application of theory to solving exercises and problems and developing experimental methods. • Raising of mew questions.	• Taking notes. • Resolution of exercises and questions. • Formulation of questions and doubts.	• Qualification of the answers (approach and result) made to solve practical exercises and numerical problems.	18	40	58	
Tutorials	CG1-MF1, CG2-MF1, CG5-MF1, CG6-MF1, CG7-MF1, CG8-MF1, CE8-MFQI1, CT1-MF1, CT2-MF1, CT3-MF1, CT5-MF1 CT6-MF1, CT7-MF1 CT11-MF1,CT12-MF1 CT12-MF2	• • Direction and supervision of the student's study and activities. • Raising questions.	• Consult the teacher about the difficulties encountered in the study and preparation of the subject. • Resolution of the questions raised. • Cooperation with colleagues and critical analysis of work	• Assessment of the work and the analyzes carried out.	10	22	32	
Exams (theory)	CG1-MF1, CG2-MF1 CG5-MF1, CG6-MF1 CG7-MF1, CG8-MF1 CE8-MFQI1 CT3-MF1, CT5-MF1, CT6-MF1	• • Proposal, monitoring and correction of the exam. • • Student's rating.	• • Preparation and performance of exams.	• • Correction and assessment of exams.	4	15	19	60 %

Teaching activity	Associated competences	Lecturer activity	Student activity	Assessment procedure	P	NP	Total	C
• Laboratories	All general, specific and transversal competences.	• Explanation and supervision of the experimental procedure. • Teaching of the interpretation and discussion of the experiences carried out.	• • Carrying out and analyzing the experiments. • • Preparation of the laboratory notebook.	• Continuous evaluation of the attitude and aptitude of the student in the laboratory. • Assessment of memory.	40	33	73	15 %
Exams (laboratory)	CG1-MF1, CG2-MF1, CG5-MF1, CG6-MF1, CG7-MF1, CG8-MF1, CG9-MF1, CG10-MF2, CG12-MF1 CE8-MFQI1 CT3-MF1, CT5-MF1 CT6-MF1	• • Proposal, monitoring and correction of the exam. • • Student's rating.	• • Preparation and performance of exams.	• Correction and assessment of exams.	2	8	10	10 %
P: face-to-face; NP: non-contact (autonomous work); C: qualification								