UAB
Universitat Autònoma de Barcelona

Inorganic and Equilibrium Chemistry

Code: 106045
ECTS Credits: 9

2024/2025

Degree	Type	Year
2500897 Chemical Engineering	FB	1

Contact

Name: Francisco Cespedes Mulero

Email: francisco.cespedes@uab.cat

Teachers

Fernando Novio Vazquez

Teaching groups languages

You can view this information at the end of this document.

Prerequisites

Basic knowledge of general chemistry. General knowledge of the elements of the Periodic Table and their reactivities. Formulation and nomenclature of inorganic chemicals.

Objectives and Contextualisation

Context

The subject Inorganic and Equilibrium Chemistry is taught in the Degree in Chemical Engineering as a basic subject in the first academic year. It is an introductory and finalist subject, since it has no continuity in the Syllabus.

Objectives

To acquire the basic knowledge to understand and solve problems related to heterogeneous and homogeneous ionic equilibria in aqueous media (acid-base, complexes, precipitation and redox). Understand and apply successive approximations in the simplified resolution of systems in equilibrium. Know acid-base titrations and how to choose a suitable indicator. The objective of the second part of the course is to provide the student with a basic knowledge of the different elements of the periodic table and their compounds, with special emphasis on those of greatest industrial interest. For this reason, in each group of the periodic table, one or two products have been selected from among those obtained in large-scale industry, in order to explain their synthesis and applications in some detail.

Competences

- Apply relevant knowledge of the basic sciences, such as mathematics, chemistry, physics and biology, and the principles of economics, biochemistry, statistics and material science, to comprehend, describe and resolve typical chemical engineering problems.
- Develop personal work habits.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.

Learning Outcomes

1. Apply knowledge of abundance, natural state and reactivity of chemical elements to the method or methods of obtainment and/or purification.
2. Apply standards when naming chemical compounds and recognise the different ways of expressing concentrations in dissolution.
3. Apply the different bonding and structure theories of inorganic chemistry to the prediction of physical and chemical properties and the behaviour (reactivity) of elements and their compounds.
4. Evaluate the implication of inorganic chemistry for the preparation of new materials, pollution, decontamination, new sources of energy, etc.
5. Explain the origin of the order of the chemical elements in the periodic table and how different periodic properties vary via the periodic table.
6. Identify and predict the reactivity, trends and behaviour of elements in accordance with the group, period and block to which they belong.
7. Identify the main inorganic compounds of industrial interest and their large-scale synthesis.
8. Identify the reactions in which changes in oxidation states are produced and understand the principles governing the spontaneity of these reactions as well as the main applications and consequences of electrochemical processes.
9. Recognise the different processes for acid-base evaluation by means of their curves and be able to choose the suitable indicator.
10. Recognise the main utensils of the chemical laboratory and use them adequately to carry out basic laboratory operations.
11. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
12. Understand the importance of regulatory dissolutions and apply them to the generation of controlled acidic mediums.
13. Understand the natural state in which elements are found from their physical and chemical properties.
14. Understand the nature of acid-based equilibriums and analyse them by means of balances of matter and load, both in the case of monoprotic and polyprotic species.
15. Understand the principles governing the processes of extraction and precipitation and apply them to the interpretation of heterogeneous phase equilibriums.
16. Work autonomously.

Content

Theoretical content

First part

I.- Introduction

Lesson 1: Free energy: spontaneity criterion. Relationship between ΔG0 and the steady state. Equilibrium constant of a reaction. Dependence of the equilibrium constant with temperature. Expressions of the equilibrium constant. Le Chatelier Principle.

Lesson 2: Introduction to the study of ionic balance. Electrolytes. Arrhenius theory. Characteristics of water as a solvent.

II.- Acid-base balance

Lesson 3: Acids and bases. Historical definitions and theories. Autoionization of water. Definition of pH. Relative strength of an acid-base pair, pKa.

Lesson 4: Balance of matter in strong and weak electrolytes. Electroneutrality rule. Electrical balance. Rigorous calculation of the pH of an aqueous solution of an acid-base pair. General Formula.

Lesson 5: Calculation of the pH of a solution of an acid or a base. Calculation of pH in mixtures of conjugated acids and bases. Delphi buffers: preparation and properties. Calculation of the pH of mixtures of acid-base pairs. Polyprotic acids.

Lesson 6: Acid-base volumetries. Buffer solution. Damping capacity. Neutralization curves. Strong and weak protoliths, monoprotic and polyprotic. Acidimetry and alkalimetry. Valuing solutions. Primary patterns. Acid-base indicators.

III.- Complex formation equilibria

Lesson 7: Introduction. Agreements. Lewis acids. Stability constants and complex formation constants. Complex and acidic.

IV.- Precipitation balances

Lesson 8: Solubility and solubility product of a solid slightly soluble in water. Effect of other solutes on the solubility of a substance. Effect of temperature on the solubility of a solid.

Lesson 9: Solubility and acidity. Solubility and complexation. Fractional precipitation.

V.- Oxidation-reduction equilibria

Lesson 10: Degree of oxidation. Definitions. Electrochemical batteries. Agreements. Measure of the f.e.m. of a stack. Nernst equation.

Lesson 11: Electrode potential. Normal potential. Reduction potential at 25oC. Factors that influence the electrode potential: acidity of the medium, precipitation of some of the redox couple species. Applications. PH measurement. Glass and reference electrodes.

Second part

Lesson 1: Introduction and General Aspects. Abundance of the elements in the universe and in the earth's crust. Oxidation states and electron configurations in the s and p elements. The size of the atoms and ions. The importance of the bond energy and electronegativity. Polarizability and polarizing capacity: Rules of Fajans. Inorganic products for the chemical industry

Lesson 2: Hydrogen. Synthesis, properties and reactions of elemental hydrogen. Hydride types and reactivity. The hydrogen economy.

Lesson 3: The other elements of block s: alkaline and alkaline earth elements. Group overview. Simple compounds: halides, oxides, hydroxides and carbonates. Basic compounds for the chemical industry: calcium carbonate, sodium carbonate (Solvay process) and sodium hydroxide (chlor-alkali process).

Lesson 4: The elements of group 13. Group overview. Important boron compounds. The extraction of metals for their minerals. The process of obtaining aluminum.

Lesson 5: The elements of group 14. Group overview. The carbon and its oxides. The greenhouse effect. Silicon compounds: silicon dioxide, silicates and aluminosilicates. The cement and glass industry.

Lesson 6:The elements of group 15. Groupoverview. The industrial synthesis of ammonia and nitric acid and their applications. The phosphate industry.

Lesson 7: The elements of group 16. Group overview. Oxygen and the products of fractional distillation of air. The ozone and the problem of the ozone layer. Hydrogen peroxide. Industrial synthesis and applications of sulfuric acid.

Lesson 8: The elements of group 17 and 18: halogens and noble gases. General aspects of each group. Chlorine applications. Hydrochloric acid.

Lesson 9: The elements of block d. Some important industrial products of the compounds of the block d elements.

Practical sessions

Practice 1. Scales. volumetric material

Theory: Mass measurements. Volumetric measurements. Units of concentration. Dilutions Density.

Laboratory: Weighing technique. Determination of the density of standard solutions. Calculation of the concentration of a sodium chloride solution from the determination of its density.

Practice 2. Determination of the degree of acidity of a commercial vinegar

Theory: Acid-base volumetry.

Laboratory: Evaluation of the degree of acidity of a commercial vinegar.

Practice 3. pH measurement. Relative strength of acids and bases

Theory: Acids and bases. PH scale. The pH meter.

Laboratory: Relative strength of acids and bases. Hydrolysis of salts. Buffer and non-buffer solutions.

Practice 4. Simple extraction

Theory: Simple extraction concept. Theoretical foundation. Extraction equipment. Emulsions

Laboratory: Separation of a mixture of benzoic acid, 1,3-dinitrobenzene and aniline. Extraction with a basic and acidic aqueous phase.

Practice 5. Separation and purification of solids

Theory: The Bunsen burner. Suctionand gravity filtration.

Laboratory: Separation of the components of a mixture. Filtration and sublimation. Identification of compounds

Practice 6. Extraction of copper from a mineral

Theory: Reactions redox and precipitarion.

Laboratory: Extraction of copper from a mineral of copper. Solubility/precipitation equilibria of metal compounds.

Practice 7. Reactivity of bloc p elements (sulfur compounds)

Theory: Sulfur oxoacids and oxosalts. Redox reaccions.

Laboratory: Synthesis and reactivity of thiosulphate. Reflux, filtration, crystalization and purification.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Classes of problems	16	0.64	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
Laboratory Sessions	28	1.12	1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16
Seminars	7	0.28	1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
master classes	32	1.28	1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15
Type: Supervised			
Scheduled tutorials	9	0.36	1, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15
Type: Autonomous			
Self study	124	4.96	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16

Although the teacher will use the master class to transmit knowledge of the core aspects of each subject, the student will have to be an active part of the learning process (interactive master class). In this sense, initiatives on enquiry, motivation and the process of getting to know things will be promoted, with the student having to create and adapt them to their own learning process. Students will carry out laboratory practices with the aim of completing and reinforcing the knowledge acquired in the theoretical classes and seminars. The teacher will carry out tasks of orientation, guidance and reinforcement of those aspects that present greater difficulty. Abundant bibliographic material will be made available to students, including theoretical content as well as exercises. In order to encourage critical reasoning, discussion and reflection by students, working groups will be set up in problem classes and seminars in order to complete the learning process through group discussion.

Satisfaction surveys: Approximately 15 minutes of a class will be set aside, within the timetable established by the centre or by the degree, so that students can answer the surveys to evaluate the teaching performance of the teaching staff and the evaluation of the subject or module.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Carrying out work and solving problems. Attitude.	5%	2	0.08	1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16
Completion of three written mid-term tests	75%	5	0.2	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,

				15, 16
Laboratory reporting	20%	2	0.08	1, 2, 3, 4, 6, 7, 11, 13, 16

Assessment

The assessment will be individual and will be carried out continuously in the different training activities that have been programmed. This subject does not foresee the single evaluation system.

Individual written tests: There will be three partial exams that will include the contents covered in the different lessons, the weight of which will be 75% of the final mark. At the end of the course it will be possible to take a make-up exam for all students who have failed the course and who have a mark of more than 5.0 in the practical sessions.

Laboratory Reports: 7 practical sessions are scheduled. The practicals will be done in pairs. At the end of each practical, a report (per pair) must be filled in and submitted before the end of each session (45 minutes to complete the report). The grade of each report will be the grade obtained for each member of the pair of students. All practical sessions are compulsory. A practical not carried out (and not justified according to the teacher's criteria) will be an automatic failure of the course. The lecturer in charge of the course will evaluate the cases of absences justified by the student. The mark obtained for each practical report will be complemented with a mark for the laboratory notebook and attitude. The total weight of the final mark for practical work will be 20% of the final mark for the course.

Completion of exercises and work: Throughout the course, students will complete exercises that will be proposed by the teacher. Some exercises will have to be done in class, and others will have to be done as independent work by the student. In any case, the days on which the exercises will be done will be scheduled and there will be no prior notice. All exercises are compulsory.

Attitude in the training activities: Active participation, attendance in person, as well as the attitude in the different training activities such as master classes, problems, seminars and practical laboratory sessions, will besubjectively assessed by the lecturer.

Exams taken and attitude will have a weight in the final mark of 5%.

It will be considered NOT EVALUABLE as a final grade when any of these cases is completed:

- Missing all the laboratory practice sessions.

- Not taking any individual written test (midterm) and not taking the RECOVERY exam.

In order to pass the course, it is necessary to obtain a score equal to or higher than 5.0 out of 10 in the FINAL GRADE while completing the following conditions:

- To have completed the laboratory practicals with an average mark equal to or higher than 5.0 out of 10.

- To have attended all the sessions of laboratory practicals (3 theory + 7 practicals). If there is any lack of attendance, it will have to be duly justified.

- Have a mark equal to or greater than 4.5 out of 10 in the average grade of the first 2 individual written tests (2 partial) of the chemical equilibrium part.

- Have a mark equal to or greater than 4.5 out of 10 in the mark of the individual written test (1 partial) of the inorganic part.

The right to the recovery exam:

- In the case of not passing the course with all the requirements mentioned above, the student will have the right to a RECOVERY EXAM where ONLY the subject corresponding to the balance block and/or inorganic block that has not reached the minimum grade of 4.5 will be evaluated. In order to pass the course and take

the weighted average of this make-up exam together with other assessable activities, it is compulsory to obtain a RECOVERY EXAM mark equal to or higher than 5.0, but in this case, the weighted average will only be taken with a RECOVERY EXAM mark value equal to 5.0.

- Once the weighted average of all the assessable activities has been done, in order to pass the course, the FINAL mark (recovery exam) will have to be ≥5.0.

FINAL GRADE (by partial) = ((AVERAGE SCORE 2 PARTIALS EQUILIBRIUM (if ≥ 4.5)*2) + GRADE 1 INORGANIC PARTIAL (if ≥ 4.5))/3 * 0.75 + PRACTICAL GRADE (if ≥ 5) * 0.20 + (EXERCISES + ATTITUDE) * 0.05

FINAL GRADE (EQUILIBRIUM RECOVERY EXAM) = (5.0 (if EQUILIBRIUM RECOVERY EXAM GRADE ≥5.0) *2 + INORGANIC PARTIAL GRADE 1)/3* 0.75 + PRACTICAL GRADE (if ≥5) * 0.20 + (EXERCISES + ATTITUDE) * 0.05

FINAL GRADE (INORGANIC RECOVERY EXAM) = ((AVERAGE GRADE 2 EQUILIBRIUM PARTIALS (if ≥ 4.5))*2 + 5.0 (if INORGANIC RECOVERY EXAM GRADE ≥ 5.0))/3 * 0.75 + PRACTICAL GRADE (if ≥5) * 0.20 + (EXERCISES + ATTITUDE) * 0.05

FINAL GRADE (ALL SUBJECT RECOVERY EXAM) = 5.0 (if ALL SUBJECT RECOVERY GRADE ≥ 5.0) * 0.75 + PRACTICAL GRADE (if ≥5) * 0.20 + (EXERCISES + ATTITUDE) * 0. 05

If the PARTIALS mark is< 4.5 and/or the RECOVERY EXAM mark is < 5.0, a mark of 4.5 (fail) will appear on the academic transcript if the FINAL mark is equal to or higher than 5.0.

The final grades of the students who pass the subject may be distributed between 5 and 10, always maintaining the order of the students according to the grade FINAL NOTE obtained, to achieve the distribution between approved, notable, excel and MHs, which teachers consider suitable.

Students will have to act honestly throughout the course. Participation in dishonest attitudes (cheating, allowing copying or any action aimed at distorting an evaluation) in any follow-up test or exam will be reason for a grade of "Failed" with a final grade of 0 in the subject, regardless of the rest of the marks obtained by the students involved. During the written tests, mobile phones or any other telecommunication device must be disconnected and kept in the bags or backpacks that will have to be on the platform. If a student is found to be carrying an unauthorized device during the exam and/or follow-up test, the student will be expelled from the classroom and will have a "Failed" grade in the subject.

Bibliography

Part 1

J.A. LÓPEZ CANCIO. *Problemas de Química*. *Cuestiones y ejercicios*. Prentice Hall, 2000

SALES; VILARRASA. *Introducció a la nomenclatura química. Inorgànica i Orgànica.* 5 ed. Reverté SA, 2003

QUIÑOÁ; RIGUERA. *Nomenclatura y formulació de los compuestos inorgánicos*. McGraw Hill, 1997

ATKINS; JONES. *Principios de Química. Los caminos del descubrimiento*. 3ª ed. Editorial Medica panamericana, 2006

HARRIS. *Anàlisi Química Quantitativa (traducció al català de la 6ena edició en españyol)*. Reverté SA, 2006

MAHAN; MYERS. *Química. Curso universitario*. 4ª ed. Addison-Wesley Iberoamericana; 1990

CHANG. *Química.* McGraw Hill, 2010, 10ª ed.

SILVA; BARBOSA. *Equilibrios iónicos y sus aplicaciones analíticas*. Síntesis, 2002

PETRUCCI, HARWOOD, HERRING. *Química General.* 8ª ed. Prentice Hall, 2007

Part 2

Química Inorganica Descriptiva (2a edició), G.Rayner-Canham, Prentice-Hall, 2000

"Chemistry of the Elements" (2a edició), N.N. Greenwood & A. Earnshaw, Butterworth-Heinemann ,1997

Industrial Inorganic Chemistry (2nd Edition), K.H. Büchel, H.H Moretto, P. Woditsch, Wiley-VCH, 2000

E-books: The Essential Chemical Industry -online: http://essentialchemicalindustry.org/index.php

Virtual campus of the course

Software

Microsof 365, Teams

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	211	Catalan/Spanish	second semester	morning-mixed
(PAUL) Classroom practices	212	Catalan/Spanish	second semester	morning-mixed
(PLAB) Practical laboratories	211	Catalan/Spanish	second semester	morning-mixed
(PLAB) Practical laboratories	212	Catalan/Spanish	second semester	morning-mixed
(PLAB) Practical laboratories	213	Catalan/Spanish	second semester	morning-mixed
(SEM) Seminars	211	Catalan/Spanish	second semester	morning-mixed
(SEM) Seminars	212	Catalan/Spanish	second semester	morning-mixed
(TE) Theory	21	Catalan/Spanish	second semester	morning-mixed