Universitat Autònoma de Barcelona

2022/2023

Inorganic and Equilibrium Chemistry

Code: 106045
ECTS Credits: 9

Degree	Type	Year	Semester
2500897 Chemical Engineering	FB	1	2

Contact

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Use of Languages

Principal working language: spanish (spa)
Some groups entirely in English: No
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

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 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.
3. Evaluate the implication of inorganic chemistry for the preparation of new materials, pollution, decontamination, new sources of energy, etc.
4. Explain the origin of the order of the chemical elements in the periodic table and how different periodic properties vary via the periodic table.
5. Identify and predict the reactivity, trends and behaviour of elements in accordance with the group, period and block to which they belong.
6. Identify the main inorganic compounds of industrial interest and their large-scale synthesis.
7. 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.
8. Recognise the different processes for acid-base evaluation by means of their curves and be able to choose the suitable indicator.
9. Recognise the main utensils of the chemical laboratory and use them adequately to carry out basic laboratory operations.
10. 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.
11. Understand the importance of regulatory dissolutions and apply them to the generation of controlled acidic mediums.
12. Understand the natural state in which elements are found from their physical and chemical properties.
13. 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.
14. Understand the principles governing the processes of extraction and precipitation and apply them to the interpretation of heterogeneous phase equilibriums.
15. 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. Synthesis of copper compounds

Theory: Redox reactions and precipitation.

Laboratory: Synthesis of copper compounds from a copper mineral.

Practice 7. Reactivity of elements of the p block

Methodology

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.

COVID-19: Methodology may change depending on how the pandemic evolves

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.

Activities

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

Assessment

Assessment

The assessment will be individual and will be carried out continuously in the different training activities that have been programmed.

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: 6 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 ACCEPTABLE 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 (2 theory + 6 practicals). If there is any lack of attendance, it will have to be duly justified.

- Have a mark equal to or higher than 4.5 out of 10 in the average mark of the individual written tests (partial exams).

The right to the make-up 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 of the ENTIRE COURSE. 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 (ex. retake) will have to be ≥ 5.0.

FINAL mark (for partial marks)= PARTIAL MARKS (≥ 4,5) *0,75 + PRACTICAL MARKS (≥ 5)*0,20 + (EXERCISES + ATTITUDE) * 0,05

FINAL mark (ex. recuperació)= RECOVERY EXAM mark (tota la matèria) (5,0 if the RECOVERY EXAM mark ≥ 5,0)*0,75 + PRACTICES mark (≥5) * 0,20 + (EXERCICIS + ACTITUD) * 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 t
Students will have to act honestly throughout the course. Participation in

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Carrying out work and solving problems. Attitude.	5%	2	0.08	1, 2, 3, 14, 12, 11, 13, 6, 5, 7, 8, 9, 15
Completion of three written mid-term tests	75%	5	0.2	1, 2, 3, 14, 12, 11, 13, 4, 6, 5, 7, 10, 8, 9, 15
Laboratory reporting	20%	2	0.08	1, 2, 3, 12, 6, 5, 10, 15

Bibliography

Part 1

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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

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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