VNIVERSITAT DE VALÈNCIA

Course Guide
34196 Physical Chemistry Laboratory I

COURSE DATA

Data Subject	
Code	34196
Name	Physical Chemistry Laboratory I
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1110 - Degree in Chemistry	Faculty of Chemistry	2	First term

Subject-matter

Degree	Subject-matter	Character
1110 - Degree in Chemistry	7 - Physical Chemistry	Obligatory

Coordination

Name	Department
PORCAR I BOIX, IOLANDA	315 - Physical Chemistry

SUMMARY

The “Physical Chemistry Laboratory” is a compulsory subject taught in the third semester (2nd year) of the Degree in Chemistry.

The course will consist of conducting a series of experimental practices with which it is intended that students acquire skills in the use of some of the most common techniques used in a laboratory of Physical Chemistry. The experiments will be quantitatively carried out and persecute the determination of magnitudes that bring into play concepts related to chemical kinetics and thermodynamics of chemical equilibrium and phase equilibrium. Practices are held so that students have to: a) pre resolve issues related to its approach and realization using the acquired theoretical knowledge, and b) make a graphic and numerical treatment, and critical analysis of the results obtained in the laboratory.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

To address successfully the subject, it is essential that the student possesses a number of previous theoretical and practical knowledge. The course is designed so that the knowledge needed to address the proposed experiences have obtained previously in the introductory session.

OUTCOMES

1108 - Degree in Chemistry

- Develop capacity for analysis, synthesis and critical thinking.
- Show inductive and deductive reasoning ability.
- Demonstrate leadership and management skills, entrepreneurship, initiative, creativity, organization, planning, control, leadership, decision making and negotiation.
- Solve problems effectively.
- Demonstrate ability to work in teams both in interdisciplinary teams and in an international context.
- Demonstrate ability to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences and using information technology, as appropriate.
- Demonstrate a commitment to ethics, equality values and social responsibility as a citizen and as a professional.
- Learn autonomously.
- Demonstrate the ability to adapt to new situations.
- Acquire a permanent sensitivity to quality, the environment, sustainable development and the prevention of occupational hazards.
- Demonstrate knowledge of the main aspects of chemical terminology, nomenclature, conventions and units.
- Demonstrate knowledge of the characteristics and behaviour of the different states of matter and the theories used to describe them.
- Demonstrate knowledge of the main types of chemical reaction and their main characteristics.
- Demonstrate knowledge of the principles of quantum mechanics and their application to the description of the structure and properties of atoms and molecules.
- Demonstrate knowledge of the principles of thermodynamics and kinetics and their applications in chemistry.

- Evaluate, interpret and synthesise chemical data and information.
- Handle chemicals safely.
- Handle the instrumentation used in the different areas of chemistry.
- Interpret data from observations and measurements in the laboratory in terms of their significance and the theories that underpin them.
- Relate theory and experimentation.
- Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.
- Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.
- Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.
- Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.
- Express oneself correctly, both orally and in writing, in any of the official languages of the Valencian Community.
- Have basic skills in the use of information and communication technology and properly manage the information obtained.

LEARNING OUTCOMES

The previous section includes the competences contained in the document VERIFICA.This subject addresses part of the learning results of the matter Physical chemistry laboratory II that allow to acquire specific knowledge of chemistry, cognitive skills and general skills recommended by the EUROPEAN CHEMISTRY THEMATIC NETWORK (ECTN) for the Chemistry Eurobachelor® Label. The following table lists the learning outcomes acquired in the subject Physical chemistry laboratory I related to the competences of the degree in Chemistry.

SPECIFIC KNOWLEDGE OF CHEMISTRY	
The learning process should allow the degree graduates to demonstrate:	
The principal techniques of structural investigations, including spectroscopy	Ability to recognise chemical elements and their compounds: preparation, structure, reactivity, properties and applications..(CE7). Show knowledge of the structure and reactivity of the main classes of biomolecules and the chemistry of the main biological processes..(CE12).

	Show knowledge of the structure and reactivity of the main classes of biomolecules and the chemistry of the main biological processes..(CE12). Demonstrate knowledge of the principles, procedures and techniques for the determination, separation, identification and characterisation of chemical compounds.(CE8)
The principles of thermodynamics and their applications to chemistry	Demonstrate knowledge of the principles of thermodynamics and kinetics and their applications in chemistry..(CE6).
The kinetics of chemical change, including catalysis; the mechanistic interpretation of chemical reactions	Demonstrate knowledge of the principles of thermodynamics and kinetics and their applications in chemistry..(CE6).

COMPETENCES AND COGNITIVE SKILLS	
The learning process should allow the degree graduates to demonstrate:	
Ability to demonstrate knowledge and understanding of the facts, concepts, principles and fundamental theories related to the topics mentioned above.	Demonstrate knowledge and understanding of essential facts, concepts, principles and theories related to the areas of chemistry..(CE13).
Ability to apply this knowledge and understanding to the solution of common qualitative and quantitative problems.	Solve qualitative and quantitative problems following previously developed models..(CE14). Recognise and analyse new problems and plan strategies to solve them..(CE15). Understand the qualitative and quantitative aspects of chemical problems..(CE24).
Ability to calculate and process data, related to information and chemistry data.	Solve qualitative and quantitative problems following previously developed models..(CE14). Recognise and analyse new problems and plan strategies to solve them..(CE15).

COMPETENCES AND COGNITIVE SKILLS RELATED TO THE PRACTICE OF CHEMISTRY	
The learning process should allow the degree graduates to demonstrate	
Capacities to handle chemical products safely, taking into account their physical and chemical properties, including any risk associated with their use.	Handle chemicals safely..(CE17). Evaluate the risks in the use of chemicals and laboratory procedures..(CE21).
Capacities to monitor, observe and measure the chemical properties, facts or changes, and perform their registration (collection) and documentation in a systematic and reliable way.	Handle the instrumentation used in the different areas of chemistry.(CE19). Relate theory and experimentation..(CE22). Recognise and evaluate chemical processes in daily life..(CE23). Understand the qualitative and quantitative aspects of chemical problems..(CE24).
Ability to interpret data derived from observations and laboratory measurements in terms of their relevance, and relate them to the appropriate theory.	Interpret data from observations and measurements in the laboratory in terms of their significance and the theories that support it (CE20). Relate theory and experimentation (CE22). Recognize and assess the chemical processes in daily life (CE23). Understand the qualitative and quantitative aspects of chemical problems (CE24). Relate chemistry with other disciplines (CE26).

GENERAL COMPETENCES

The learning process should allow the degree graduates to demonstrate:	
Ability to apply practical knowledge to solve problems related to qualitative and quantitative information..	Solve problems effectively..(CG4). Solve qualitative and quantitative problems following previously developed models..(CE14). Relate theory and experimentation..(CE22). Recognise and evaluate chemical processes in daily life..(CE23). Understand the qualitative and quantitative aspects of chemical problems..(CE24).
Calculation and arithmetic capabilities, including aspects such as analysis error, estimates of orders of magnitude, and correct use of the units.	Develop capacity for analysis, synthesis and critical thinking.. (CG1). Show inductive and deductive reasoning ability..(CG2). Solve problems effectively..CG4).
Skills related to information technology such as word processing, spreadsheet, recording and storage of data, internet use related to the subjects.	Demonstrate ability to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences and using information technology, as appropriate..(CG6). Have basic skills in the use of information and communication technology and properly manage the information obtained.(CT2).
Planning and time management skills.	Develop capacity for analysis, synthesis and critical thinking. (CG1). Demonstrate leadership and management skills, entrepreneurship, initiative, creativity, organization, planning, control, leadership, decision making and negotiation..(CG3).
Study skills necessary for professional development. These will include the ability to work autonomously.	Demonstrate leadership and management skills, entrepreneurship, initiative, creativity, organization, planning, control, leadership, decision making and negotiation..(CG3).

	Demonstrate ability to work in teams both in interdisciplinary teams and in an international context..(CG5). Learn autonomously.(CG8). Demonstrate the ability to adapt to new situations..(CG9). Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.(CB5).

Regarding the Sustainable Development Goals (SDGs), it is expected that students will be able to know in this subject how to apply the knowledge learned to guarantee an inclusive, equitable, and quality education and promote learning opportunities for everyone (SDG 4).

To acquire a special sensitivity for sustainable management of water (SDG 6), raw materials and energy sources (SDG 7), as well as for an environmentally friendly and sustainable development (SDGs 11 , 12, 13, 14 and 15)

At the end of the course, students must be able to:

- Work in groups.
- Argue a problem from rational criteria.
- Make an oral presentation in a clear and coherent manner.
- Build a comprehensive and well-organised written text.
- Critically discuss the quality of the results.
- Apply an appropriate experimental methodology to the problem proposed.
- Express the variables measured and calculated using appropriate units and accurately.
- Present results appropriately in tables and figures.
- Have a logical criterion to choose the appropriate procedure and experimental technique for solving a problem.
- Distinguish what quantities or measures are key in the study to avoid possible sources of error.
- Understand in depth the procedures used and not simply follow the "recipes" presented in the scripts of practices.
- Analyse the values of the measurements so that they can be re-measured if an error is detected
- Deal with the measurements made properly for determining the parameters of interest in every experience.
- Analyse and discuss the results.
- Keep proper records in a laboratory notebook.
- Prepare laboratory reports.
- Prepare solutions.
- Use a primary standard.
- Determine the concentration of a solution by titration.
- Calibrate and manage a conductimeter.
- Determine the degree of dissociation of a weak acid by conductimetric measurements.
- Determine the average ionic activity coefficient by conductimetric measurements.
- Determine the dissociation constant of a weak acid by conductimetry.

- Handle a spectrophotometer, use the blank solution and perform absorbance measurements.
- Conduct a kinetic study through the measurement of the solution absorbance with time.
- Obtain the absorption spectrum of a substance.
- Determine the equilibrium constant of an acid-base indicator.
- Handle a refractometer.
- Build the boiling temperature-liquid composition phase diagram for a binary mixture.
- Characterise the azeotropic point of a binary mixture.
- Determine the activity coefficients of the components of a binary mixture.
- Determine the rate law (orders of reaction and rate constant) of a reaction by chemical titration.
- Analyse the effect of temperature on the reaction rate.
- Determine fractional lifetimes of a reaction.
- Calculate the activation energy of a reaction from fractional lifetimes.
- Critically evaluate the quality of the results obtained.

DESCRIPTION OF CONTENTS

1. CONDUCTIMETRIC DETERMINATION OF THE IONIZATION CONSTANT OF A WEAK ELECTROLYTE (acetic acid)

By using the conductivity of different acetic acid solutions, the degree of dissociation of the acid is determined as a function of the concentration. Also, the dissociation constant of the acetic acid is obtained by using different approaches

2. SPECTROPHOTOMETRIC DETERMINATION OF THE pK OF AN INDICATOR

The absorption spectrum of a series of solutions of the methyl orange indicator is registered at different pH, and from the absorbance measured and the pH of the solution, the equilibrium constant is determined.

3. KINETIC STUDY OF THE PHENOLPHTHALEIN DISCOLORATION IN BASIC MEDIUM

The rate law for the reaction of phenolphthalein discoloration in basic medium is determined. The absorbance of phenolphthalein in NaOH solutions of different concentration is measured as a function of time. The study is performed by applying an irreversible treatment at the beginning of the reaction and a reversible treatment at longer times.

4. STUDY OF THE EFFECT OF TEMPERATURE ON THE REACTION RATE

The kinetics of oxidation of the iodide ion by hydrogen peroxide in sulfuric acid medium is studied at two temperatures. The reaction occurs in the presence of a known amount of thiosulfate, which progressively reduces the iodine produced so that the iodide concentration remains approximately constant. This procedure allows us to follow the evolution of the hydrogen peroxide concentration with time and to determine the reaction order with respect to hydrogen peroxide. The experimental procedure design also provides the fractional reaction times at two different temperatures and, based on them, to determine the activation energy of the reaction.

5. KINETIC STUDY OF THE REACTION BETWEEN IODINE AND ACETONE

The rate law for the reaction between iodine and acetone catalyzed by acid is determined. The kinetic is followed by determining the samples concentration by thiosulfate titration. Reaction orders with respect to acetone and to acid are determined by changing concentrations of acid and acetone in different assays.

6. PHASE DIAGRAM BOILING POINT-COMPOSITION OF BINARY LIQUID MIXTURES

The phase diagram of the liquid-vapor mixture of methanol-chloroform is constructed and the azeotropic mixture composition is determined. The composition of the gas-phase is determined by measuring its refractive index and using the previously built calibration curve.

WORKLOAD

ACTIVITY	Hours	% To be attended
Laboratory practices	48,00	100
Tutorials	12,00	100
Development of group work	10,00	0
Development of individual work	20,00	0
Study and independent work	40,00	0
Preparation of evaluation activities	20,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

The course will run through the following teaching methods:

- Resolution of pre-laboratory questions and issues

- Lectures

- Practical classes

- Data processing and calculations

- Resolution of post-laboratory issues and questions

Before the beginning of the lab sessions there will be one introductory session in order to explain:

- The general rules of the physical chemistry laboratory

- How the course will develop

- Those concepts and skills that the student has not previously been taught but necessary to address the subject

The development of the course is structured around the following topics:

i) Preparation of the experience to be performed

The student will have the script for each of the experiences to be performed as well as a number of questions related to the theoretical concepts and experimental procedure used in each of the experiences. These questions will be answered before starting the lab session, submitted on-line or on paper, and then reviewed by the lecturer. The student must prepare each experiment with the help of all the material provided by the lecturer: script, issues, questions, tests and information.

ii) Work in the laboratory

The experiments are carried out in pairs and, in some cases, the results are shared among various partners in order to enhance teamwork.

iii) Laboratory notebook

An important part of laboratory work is the laboratory notebook. In that book, students must keep record of the observations made and data obtained during the experiences, together with the data processing and calculations required. In no case loose sheets may be used. It is **compulsory** to use the notebook, which must be available anytime for the lecturer to review it. Also, it has to be handed in at the end of the course within the deadline set in the general course instructions.

iv) Calculations and results

Treatment of the data and calculations obtained will be started in a specific lab session so that the lecturer can guide and direct what to do to achieve the final results. If data processing cannot be finished in class, the student will complete the task at home. One aspect to be considered in the presentation of results is the proper use of the units and of the corresponding significant figures. It is also important that students learn how to create tables and figures in which the data are collected.

v) Report of one of the experiments carried out

One goal of this course is that students become familiar with the presentation of a scientific work. To achieve this skill, each student will present a report of one experiment selected by the lecturer. This work will be prepared individually and submitted by the deadline set.

vi) Seminar

Orally and in pairs, students must present one of the practices carried out in the laboratory.

EVALUATION

Attendance at all sessions is compulsory in order to pass the course.

The assessment of learning will be made in two distinct blocks:

1) Continuous assessment throughout the learning phase. This assessment is not re-assessable.

2) Evaluation of specific activities. This assessment is re-assessable in a second evaluation sitting.

1) Continuous assessment involves:

i) Preparation of the experiment. (15% of the overall mark)

The lecturer will evaluate a number of issues/questions and previous activities that will be available on the virtual platform. These may be submitted online or handed in to the lecturer.

ii) Experimental work at the lab. (20% of the overall mark)

It takes into account the students'abilities in laboratory work and in the processing of results, as well as their interest and attitude.

iii) Laboratory notebook. (20% of the overall mark)

The lecturer will evaluate the collection and clarity of the data and results presented in the notebook, as well as its usefulness for working in the lab. It has to be written according to some specific instructions that should be given at the beginning of the course.

iv) Oral presentation. (10% of the overall mark)

The capacity for analysis and synthesis, communication skills, ability to transmit and relate physicochemical knowledge through an oral presentation made in pairs, will be evaluated.

2) Specific assessment involves:

v) Final report. (15% of the overall mark)

An individual report of one of the experiments has to be delivered by the deadline set by the lecturer. The report has to be written according to some specific instructions that should be given at the beginning of the course.

vi) Exam. (20% of the overall mark)

Students will undertake a written examination on the date indicated.

Each item (i-vi) must have a mark equal to or greater than 4 points to count towards the final mark.

FIRST EXAMINATION SITTING

The overall mark obtained by the student is the weighted average indicated above, regarding both the continuous and specific assessments (items i to vi).

SECOND EXAMINATION SITTING

In the second call the scores and final grade are obtained by applying the same criteria as in the first call. In a second examination sitting, only the mark achieved for specific activities (i.e., the final report and the exam) will be carried forward. However, if the student does not approved any of the items, the teacher may, it is feasible and considers it appropriate, propose additionals activities to recover it.

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