Bachelor´s Degree in Chemistry

Subject Guide

1. Information about the subject

SUBJECT	General Chemistry		**CODE**	GQUIMI01-1-001
EDUCATIONAL OFFER	Bachelor´s Degree in Chemistry	**CENTER**	Facultad de Química	
TYPE	Core	**N° TOTAL CREDITS**	12.0	
PERIOD	Annual	**LANGUAGE**	Spanish English	
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2. Context

“General Chemistry” completes, along with the “*Basic operations of laboratory and computer tools”* course, the chemistry contents included in

the Basic Module, which is addressed in the **first year** of the Degree in Chemistry. It is an annual course of 12 ECTS (6 ECTS each semester). Like other courses in the Basic Module, *General Chemistry* allows the students to complete their knowledge acquired during high school, required to address successfully the Fundamental Module materials. **Therefore, it is mandatory to pass this subject in order to register in the courses of the Fundamental Module.** Moreover, given its fundamental nature, General Chemistry is the proper background in the pursuit of the objectives of the course "*Basic operations of laboratory and computer tools"* that is scheduled in the second semester of the first year.

There are no prerequisites for this course, although it is strongly recommended for the students to have completed all high school courses of Chemistry, Physics and Mathematics. As it is the first course of chemistry in the Chemistry Degree, its objectives include: (i) to standardize the chemical knowledge of students entering this Degree, (ii) to allow the students to clearly identify the facts, concepts and principles of Chemistry and to know how to use them appropriately in different situations, and (iii) to provide students with the skills and abilities needed for further study of related subjects.

In this course, basic concepts will be presented, that will allow the students to understand, from a microscopic perspective, the nature of matter, from atoms to molecules and from these, following the introduction of intermolecular forces, the states of aggregation (gases, liquids, and solids). The necessary fundamentals of chemical kinetics and thermodynamics will be introduced in order to understand the chemical equilibrium and phase transitions. An important general objective is to promote in the students an interest in learning chemistry, and to present the role of chemistry in nature and in today's society.

This course will be taught by professors from the four areas of knowledge within the School of Chemistry. Particularly:

1. Prof. Mª Elena Lastra Bengochea, from the area of Inorganic Chemistry (Department of Organic and Inorganic Chemistry) and Prof José Manuel Recio Muñiz, from the area of Physical Chemistry (Department of Physical and Analytical Chemistry), will teach expositive lessons (CE), classroom practices (PA) and group mentoring sessions (TG) during the first semester.

2. Prof. Vicente del Amo Sánchez, from the area of Organic Chemistry (Department of Organic and Inorganic Chemistry) and a professor, yet to be determined, from the area of Analytical Chemistry (Department of Physical and Analytical Chemistry) will teach expositive lessons (CE), classroom practices (PA) and group mentoring sessions (TG) along the second semester.

3. Requirements

As mentioned in the previous section, as *General Chemistry* is a first year course, there aren't administrative or academic pre-requirements, although it is highly recommended that students have completed courses on Mathematics, Physics and Chemistry that are offered in the pre-university education. As an orientation, a set of chemical concepts that students should be able to use at the beginning of this course should be:

(i) Chemical nomenclature.

(ii) Determination of chemical formulas.

(iii) Solutions. Ways to express their concentration.

(iv) Chemical equations. Stoichiometric calculations. Limiting reagent. Reaction yields.

(v) Chemical equilibrium.

(vi) Acids and bases. Neutralization.

(vii) Oxidation-reduction reactions.

4. Competencies and learning results

Competences (knowledge):

1. To consolidate the knowledge about fundamentals of chemical terminology, nomenclature, and units. (CE-1)

2. To correlate the macroscopic properties with those of the atoms and molecules constituents of matter. (CE-2)
3. Recognize the variation of the periodic properties of the chemical elements. (CE-3)
4. Identify the characteristics of the different states of aggregation and theories used to describe them. (CE-4)
5. Describe the types of chemical reactions and their associated characteristics. (CE-5)

Skills (know-how):

1. Solve quantitative and qualitative problems according to previously developed models. (CE-20)
2. To apply the principles of thermodynamics and their applications in chemistry. (CE-7)
3. Process and compute data in relation to the information and chemical data. (CE-24, CG-3)
4. To use correctly inductive and deductive methods in the field of chemistry. (CE-32)
5. Recognize and evaluate the chemical processes in everyday life. (CE-33)
6. Elaborate, present and defend scientific reports, both in written and oral form. (CG-8, CG-20, CE-36)
7. To correlate chemistry with other disciplines. (CE-34)

Attitudes (to be able to):

1. Develop the ability for analysis and synthesis. (CG-1)
2. Solve problems effectively (CG-2)
3. Develop critical reasoning. Based on their expertise and on the information obtained from the literature, students will be able to judge their results and the procedures used to reach them. (CG-17)
4. Learn autonomously. (CG-9)
5. Sensitizing with the subjects related to the environment. Develop an environmental awareness(CG-12)
6. Acquire skills to evaluate, interpret, and summarize chemical information. (CE-22)
7. Work as a team. (CG-18)

These skills must be translated into the following learning outcomes:

1. Development and proper presentation of a report both in oral and written form. In one of the proposed cross-curricular activities students must read a popular science text related to chemistry, or to environmental issues, and elaborate a summary report that must be presented orally to the classmates and the teaching staff. Also students should work, in a group team, on a topic proposed by the teaching staff. The summary of the work will be collected in a poster that students should explain and defend in a public session.
2. Outline and solve problems in the field of chemistry. Different group mentoring sessions will be planned, in which students should explain how to address the resolution of some different questions or problems. The questions/problems will be proposed in advance to the students, that should be addressed independently or in groups outside the classroom and before the corresponding group mentoring session. Such activities will allow assessing the adequacy of the learning outcome to the proposed competencies.
3. To demonstrate environmental consciousness and respect. Within cross-curricular activities, students will visit industries of the region and shall draw up a report in

accordance with the guidelines set by the teaching staff. These guidelines will emphasize the environmental implications of the concerned industrial activity.

4. Demonstrate and use basic scientific knowledge acquired in this course. This learning outcome will be evaluated by different written exams and the participation of students in classroom practices and group mentoring sessions.
5. Use correct basic chemical terminology, expressing ideas with the accuracy required in the scientific world, being able to establish relationships between the various concepts. This outcome will be assessed through appropriate examinations.
6. Predict the chemical behaviour of elements and compounds on the basis of its composition and the structure of its atoms and molecules. This competence will be evaluated by examinations and by the work done by the students on the resolution of the proposed exercises and issues to be presented in classroom practices and group mentoring sessions.
7. Explain the changes of state of matter and its thermodynamic basis. It will be evaluated by examinations and by the work done on the resolution of the proposed exercises and issues to be presented in classroom practices and group mentoring sessions.
8. Apply the concepts relating to composition of matter and the basic thermodynamic and kinetic principles to chemical reactions. It will be evaluated by examinations and by the work done on the resolution of the proposed exercises and issues to be presented in classroom practices and group mentoring sessions.
9. Use the concepts of chemical equilibrium with special emphasis on the balances in solution. It will be evaluated by examinations and by the work done on the resolution of the proposed exercises and issues to be presented in classroom practices and group mentoring sessions.

5. Contents

1. INTRODUCTION TO THE CHEMISTRY. ATOMIC STRUCTURE OF THE MATTER.

1.1. Science and Scientific method.

1.2. Purpose of chemistry and its relation to Physics and other sciences.

1.3. Macro- and microscopic conceptions of the matter.

1.4. Matter, radiation and energy. Fundamental interactions in nature.

1.5. States and properties of matter. Elements and compounds.

BLOCK OF CONTENTS I: MICROSCOPIC STRUCTURE OF THE MATTER

2. ATOM: NUCLEAR STRUCTURE AND NUCLEAR CHEMISTRY

2.1. Experimental evidences of the nature and structure of the atom.

2.2. Thomson experiment: electron discovery.

2.3. Rutherford experiment: Discovery of the atomic nucleus.

2.4. Introduction to the microscopic description of matter: electrons, protons and neutrons.

2.5. Chemical elements: concept, atomic number and atomic mass. Isotopes.

2.6. Radioactivity. Naturally occurring radioactive isotopes. Radioactive series.

2.7. Rate of radioactive decay.

2.8. Nuclear stability and nuclear binding energy.

2.9. Nuclear reactions and artificially induced radioactivity. Preparation of radioelements.

2.10. Nuclear fission and fusion. The origin of the chemical elements.

2.11. Applications of isotopes and radioisotopes

3. ATOM: ELECTRONIC STRUCTURE

3.1. Bohr atomic model.

3.2. Experimental evidences of the quantum nature of matter and radiation.

3.3. Electromagnetic radiation. Interaction of the radiation with matter: Atomic spectra.

3.4. Black body radiation. Photoelectric effect.

3.5. Waves and particles: dual behaviour. Uncertainty Principle.

3.6. The Schrödinger equation. The particle in a box.

3.7. Solution of the Schrödinger equation for the hydrogen atom. Atomic orbitals.

3.8. Energy levels. Quantum numbers. Wave function and electron probability density in orbitals.

3.9. Polyelectronic atoms. The exclusion principle. Electronic configuration.

3.10. Aufbau principle and Hund rule.

3.11. Electronic structure and periodic table. Periodic properties: size of atoms and ions, ionisation energy and electronic affinities.

4. MOLECULES: ELECTRONIC STRUCTURE AND BONDING

4.1. Introduction to chemical bonding. Types of chemical bonds.

4.2. Theory of Lewis. Resonance. Exceptions to the octet rule.

4.3. Valence-shell electron-pair repulsion theory.

4.4. Polar Covalent Bonds. Electronegativity.

4.5. Order, length and strength of chemical bonds.

4.6. Valence bond theory.

4.7. Molecular orbital theory.

5. INTERMOLECULAR FORCES

5.1. Nature and types of intermolecular forces.

5.2. Hydrogen bonding. Relevance of the hydrogen bond: water and life.

BOCK OF CONTENTS II: MACROSCOPIC STRUCTURE OF MATTER AND AGGREGATION STATES

6. GASES PROPERTIES

6.1. Kinetic-molecular theory of gases.

6.2. Macroscopic properties of gases: gas pressure, Boyle and Charles laws.

6.3. The ideal gas equation.

6.4. Mixtures of gases. Dalton law.

6.5. Diffusion and effusion. Graham law.

6.6. Real gases. Equation of van der Waals.

7. LIQUIDS AND SOLIDS

7.1. Properties of liquids: surface tension, capillarity and viscosity.

7.2. Solids: bonding and properties.

7.3. Vapour pressure of substances.

7.4. Phase diagram. Phase rule.

7.5. Change of State. Energy variations accompanying phase changes.

7.6. Liquefaction of gases. Critical temperature.

8. SOLUTIONS: BASIC CONCEPTS AND COLLIGATIVE PROPERTIES

8.1. Solutions and colloids.

8.2. Intermolecular forces and dissolution processes.

8.3. The equilibrium in the process of dissolution. Saturated solution. Solubility. Solubility curves.

8.4. Gas-liquid solutions. Henry's law.

8.5. Liquid-liquid solutions.

8.6. Distribution of a solute between two solvents. Partition coefficient.

8.7. Vapour pressure of solutions. Raoult's law.

8.8. Changes in the freezing point and boiling point.

8.9. Osmosis. Osmotic pressure.

8.10. Vapour pressure of binary liquid mixtures.

8.11. Fractional distillation. Azeotropes.

8.12. Solutions of electrolytes. Van´t Hoff factor.

SECOND SEMESTER

BLOCK OF CONTENTS III: THERMODYNAMICS, EQUILIBRIUM AND KINETICS FUNDAMENTALS

9. BASIC CONCEPTS AND FIRST LAW OF THE THERMODYNAMICS

9.1. Basic concepts in thermodynamics.

9.2. Energy, heat and work.

9.3. The first law of thermodynamics. Internal energy.

9.4. Calculation of magnitudes included in the first law.

9.5. Reaction enthalpy. Standard States.

9.6.Laws of Thermochemistry. Calorimetry.

9.7. Standard enthalpy of formation.

10. THE SECOND AND THIRD LAWS OF THERMODYNAMICS. EQULIBRIUM AND SPONTANEITY CONDITIONS.

10.1. Spontaneous and non-spontaneous processes.

10.2. The concept of entropy. Second law of thermodynamics.

10.3. Third law of thermodynamics. Absolute entropies.

10.4. Gibbs free energy. Conditions of equilibrium and spontaneity.

10.5. Standard free energy of reaction. Standard free energy of formation.

11. CHEMICAL EQUILIBRIUM

11.1. Dynamic equilibrium and equilibrium constant.

11.2. Relationship between *K*C and the balanced chemical equation.

11.3. Equilibrium constant of reactions between gases.

11.4. Heterogeneous equilibrium.

11.5. The reaction quotient. Prediction of the evolution of the reaction.

11.6. Standard Gibbs free energy of reaction and equilibrium constant.

11.7. Modification of the conditions of equilibrium. Le Châtelier's Principle.

12. CHEMICAL KINETICS.

12.1. The rate of chemical reactions.

12.2. Rate law and reaction order.

12.3. Theoretical models for the kinetics of chemical reactions.

12.4. Influence of the temperature on the reaction rate.

12.5. Mechanisms of chemical reactions. Molecularity.

12.6. Catalysis.

13. PROTON-TRANSFER EQUILIBRIA

13.1. Brønsted-Lowry acid-base concept.

13.2. The self-ionization of water.

13.3. Strength of acids and bases it (according to the Brønsted-Lowry definition).

13.4. Concept of pH. Calculation of pH of strong and weak acids and bases.

13.5. The pH of saline solutions.

13.6. Buffered solutions

13.7. Lewis acids and bases.

14. SOLUBILITY AND COMPLEXATION EQUILIBRIA

14.1. Solubility. The solubility product constant.

14.2. Prediction of the degree of saturation of a solution.

14.3. Relationship between solubility and KPS.

14.4. The common ion effect.

14.5. Fractional precipitation.

14.6. Effect of pH on the solubility.

14.7. The equilibrium of complex formation. Solubility and complexation.

15. GALVANIC CELLS AND ELECTRON-TRANSFER EQUILIBRIA

15.1. The oxidation-reduction equilibrium: basic concepts.

15.2. Voltaic or galvanic cells. Diagram of a cell.

15.3. Cell potential.

15.4. Standard electrode potential. The electrochemical series.

15.5. Relationship between the equilibrium constant and the cell potential.

15.6. Nernst equation. Applications.

15.7. Batteries.

15.8. Corrosion. An undesired voltaic cell.

15.9. Electrolysis: Industrial processes.

6. Methodology and working plan

For the achievement of the objectives and competences proposed different methodologies will be used:

a) **Expositive lessons:** based primarily on lectures. In these sessions the teacher will present and discuss the subject matter of study, with special emphasis in the most innovative aspects and those of special complexity, integrating both theoretical aspects and examples that facilitate reasoning and analysing the matter under discussion. For this reason, regular attendance at such classes is highly recommended. It is also necessary for the student to complete the study of the matter with the reading of the recommended bibliography, to compare and expand the knowledge transmitted in the classroom.

b) **Classroom practices:** The specific application of the knowledge that students have acquired in the expositive lessons will take place in these sessions. Students shall be provided in advance with the questions or problems to be solved, and must work on them previously to proceed during the sessions to their analysis and discussion, individually and collectively.

c) **Group mentoring sessions:** These sessions will be held in small groups of students. In the group mentoring sessions students will clarify

doubts about the matter of study, stimulating a critical and reasoned analysis. For those means, a series of questions and exercises will be proposed in advance to the students. They must then try to solve these questions/problems previously and, later, they should discuss the proposed solutions in these sessions. Their contribution will be evaluated by the teaching responsible.

d) **Joint activities with other matters of studies**. Together with other courses of the year, students of the General Chemistry course will participate in the following common activities: visits and lectures, reading workshop, science week and interdisciplinary seminar.

All materials to be used during the planned activities (tables, graphs, series of exercises, etc.) will be available to the students in electronic format (through the e-Campus).

At the beginning of the course, it will be programmed an anonymous test (non-evaluable), in order to have an estimation of the previous chemistry knowledge of the students and, in addition, to detect those areas in which a revision is necessary.

The following table shows the dedication of a student to this course:

	Attendance	Non attendance	TOTAL
Expositive lessons	84	100	184
Classroom practices	14	24	38

Group mentoring sessions	8	16	24
Cross-curricular activities	8	10	18
Exams and evaluation activities	6	30	36
TOTAL	120	180	300

(Note): the methodology of the join cross-curricular activities can be read in the particular guides for each of these activities.

The timing for the planned activities of expositive lessons (CE), classroom practices (PA) and group mentoring sessions (TG) sessions is collected in the following table.

UNITS	**TOTAL HOURS**	**Attendance work**				**Non-attendance work**			
FIRST SEMESTER		**CE**	**PA**	**TG**	**TOTAL**	**CE**	**PA**	**TG**	**TOTAL**
1. INTRODUCTION TO CHEMISTRY. THE LANGUAGE OF CHEMISTRY.	3.4	1	0.25	0.25	1.5	1.3	0.3	0.3	1.9

2. THE ATOM: THE STRUCTURE OF THE NUCLEUS AND NUCLEAR CHEMISTRY	9.4	3	0.5	0.5	4	4	0.7	0.7	5.4
3. THE ATOM: ELECTRONIC STRUCTURE	30	8	1	0.5	9.5	10.5	1.3	0.7	12.5
4. MOLECULES: ELECTRONIC STRUCTURE AND BONDING	34.7	13	1.25	0.75	15	17	1.7	1	19.7
5. INTERMOLECULAR FORCES	10.5	3	1	0.5	4.5	4	1.3	0.7	6
6. THE PROPERTIES OF GASES	10.5	3	1	0.5	4.5	4	1.3	0.7	6
7. LIQUIDS AND SOLIDS.	12.8	4	1	0.5	5.5	5.3	1.3	0.7	7.3
8. SOLUTIONS: BASIC CONCEPTS AND COLLIGATIVE PROPERTIES	19.7	7	1	0.5	8.5	9.2	1.3	0.7	11.2
TOTAL	131	**42**	**7**	**4**	**53**	**55.3**	**9.2**	**5.5**	**70**

UNITS	TOTAL HOURS	Attendance work				Non-attendance work			
SECOND SEMESTER		**CE**	**PA**	**TG**	**TOTAL**	**CE**	**PA**	**TG**	**TOTAL**
9. BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS	18	6	1	0.75	7.8	7.9	1.3	1	10.2
10. THE SECOND AND THIRD LAWS OF THERMODYNAMICS. EQUILIBRIUM AND SPONTANEITY CONDITIONS.	19.3	7	1	0.75	7.8	9.2	1.3	1	11.5
11. CHEMICAL EQUILIBRIUM	15.1	5	1	0.5	6.5	6.6	1.3	0.7	8.6
12. CHEMICAL KINETICS	15.1	5	1	0.5	6.5	6.6	1.3	0.7	8.6
13. PROTON-TRANSFER EQUILIBRIA	15.1	5	1	0.5	6.5	6.6	1.3	0.7	8.6
14. SOLUBILITY AND COMPLEXATION EQUILIBRIA	17.5	6	1	0.5	7.5	8	1.3	0.7	10
15. GALVANIC CELLS AND ELECTRON-TRANSFER EQUILIBRIA	22	8	1	0.5	9.5	10.5	1.3	0.7	12.5

TOTAL	122.1	**42**	**7**	**4**	**52.1**	**55.4**	**9.1**	**5.5**	**70**

Note: in the above table hours related to examinations and assessment (6 attendance hours and 30 non-attendance hours), and cross-curricular activities (8 hours of attendance work and 10 non-attendance hours) are not included.

7. Evaluation of the student's learning results

Aspect	**Criteria**	**Instrument**	**Weight**
Contents of units 1 to 8	Solving numerical problems and answering questions related to the above-mentioned contents. These criteria must be adjusted to the level of achievement of the planned objectives.	Written test (first part)	35%
Contents of units 9 to 15	Solving numerical problems and answering questions related to the above-mentioned contents. These criteria must be adjusted to the level of achievement of the objectives planned.	Written test (second part)	35%
Group mentoring sessions	The active participation of the students in the group mentoring sessions, the preparation of material to be presented/discussed in the sessions,	Participation of the student in these sessions, and the presentation (oral or written) of some of the	20%

	and the resolution of problems/exercises put forward by the teachers.	exercises/problems suggested by the teachers	
Transversal activities	See joint activities Guide	See joint activities Guide	10%
Contents of all units	Solving numerical problems and explain issues related to the contents of the syllabus of the course. These criteria must be adjusted to the level of achievement of the General objectives established for the subject.	Written test (Regular call final exam)	70%
Global contents of the subject	Solving numerical problems and explain issues related to the contents of the syllabus of the course. These criteria must be adjusted to the level of achievement of the General objectives established for the subject.	Written test (final examination of extraordinary calls)	100%

The group mentoring sessions will be based on series of exercises for each unit that the professor/s will propose in advance to the students, which should resolve them prior to the corresponding session. Some of the exercises will be proposed for group work. Doubts and difficulties encountered in its resolution must be stated during the group mentoring sessions. Written solved exercises will be handed in to the professor at the end of the session.

To pass the subject in the regular call it is necessary to obtain a minimum score of 5 out of 10 in each of the evaluated aspects, except in joint activities with other subjects:

- In each partial test, students must obtain a numerical qualification equal to or greater than 4 out of 10, and the arithmetic mean between the qualifications obtained in the two partial tests should be equal to or greater than 5. In the final exam in June, the numerical qualification shall be equal to or greater than 5 out of 10.
- In the group mentoring sessions students must obtain a numerical qualification equal to or greater than 5 out of 10.
- The weighted sum of the three evaluable aspects must be equal to or greater that 5 out of 10.

To pass the subject in an extraordinary call it is necessary to obtain a numerical qualification equal to or greater than 5 out of 10 in the corresponding written test.

8. Resources, bibliography and complementary documentation

When necessary on-site activities will make use of the overhead projector. Teachers will upload in the e-Campus platform some documents used on support of the classes, as well as the series of exercises corresponding to each topic.

Recommended textbooks:

1.- **General Chemistry: Principles and Modern Applications.** Ralph H. Petrucci, F. Geoffrey Herring, Jeffry D. Madura, Carey Bissonnette, Prentice Hall; 10th edition (2011).

2.- **Chemical Principles: The Quest for Insight.** Sixth Edition**.** Peter Atkins, Loretta Jones. W. H. Freeman& Co , 2013.