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

Along with the "*Basic operations of laboratory and computer tools"* course, "General Chemistry" completes 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 + 6). Like other courses in the Basic module, General Chemistry allows the students to complete the 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 that the student has 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) provide students with the skills and abilities needed for further study of related subjects.

General Chemistry is an introductory course to the study of chemistry. The main objective is to introduce the basic concepts that will allow the student 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 reactions and the chemical equilibrium. Particular attention will be paid to the study of the thermodynamics involved in the phase transitions and solutions. The basics of electrochemistry and nuclear chemistry will also be presented. An important general objective is to promote in the students an interest in chemistry learning and to present the role of chemistry in nature and in today's society.

The subject will be taught by professors from the four areas of knowledge in the School of Chemistry. Particularly:

1. Prof. Mª Elena Lastra Bengochea, from the area of inorganic chemistry (Department of Organic and Inorganic Chemistry), will teach the introductory lesson (Basic concepts) and the first part of the block of contents I (Microscopic structure of the matter).

2. Prof. ….name to be determined…., from the area of physical chemistry (Department of Physical and Analytical Chemistry), will cover the second part of block of contents I (Microscopic structure of the matter) and the three first lessons of the block of contents II (Macroscopic structure of the matter and aggregation states).

3. Prof. Vicente del Amo Sánchez, from the area of organic chemistry (Department of Organic and Inorganic Chemistry), will be responsible for the teaching activities corresponding to the unit 9 (solutions: basic concepts and colligative properties) and the introductory block of contents III (Thermodynamics, chemical equilibrium and Chemical Kinetics fundamentals).

4. Prof. José Manuel Costa Fernández, from the area of analytical chemistry (Department of Physical and Analytical Chemistry), will teach the second part of the block of contents III (Thermodynamics, chemical equilibrium and Chemical Kinetics fundamentals), and will coordinate the cross-curricular activities.

3. Requirements

As mentioned in the previous section, because this is a subject in the first year, it has no administrative or academic pre-requirements, although it is highly recommended that students have completed the subjects of mathematics, physics and chemistry that are offered in the pre-university courses. As a guide, a set of chemical concepts that students should know at the beginning of this course would be:

(i) Chemical nomenclature.

(ii) Determination of chemical formulas.

(iii) Solutions. Ways to express the 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. Perform, 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 seminars 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 seminars 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 seminars 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 seminars 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 seminars and group mentoring sessions.

5. Contents

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

    1.1. Science and Scientific method. Theories and Models.

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

    1.3. Macro- and microscopic concepts of the matter.

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

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

Review material

Inorganic chemical nomenclature

Measurement of the properties of matter. Calculated magnitudes and experimental error.

The international system of units.

BLOCK OF CONTENTS I: MICROSCOPIC STRUCTURE OF THE MATTER

2. ELECTRONIC STRUCTURE OF ATOMS

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. ELECTRONIC STRUCTURE OF ATOMS

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. CHEMICAL BONDING

4.1. Introduction to chemical bonding. Atoms and molecules. Types of chemical bonds.

4.2. Formation of ionic bonds. Polarization.

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

4.4. Valence-shell electron-pair repulsion theory.

4.5. Polar Covalent Bonds. Electronegativity.

4.6. Order, length and strength of chemical bonds.

4.7. Valence bond theory. Orbital hybridization. Multiple Covalent bonds.

4.8. Molecular orbital theory.

4.9. Metallic bond.

5. INTERMOLECULAR FORCES

5.1. Ion-dipole interactions.

5.2. Van der Waals interactions.

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

)CK OF CONTENTS II: MACROSCOPIC STRUCTURE OF MATTER AND AGGREGATION STATES

6. GASES PROPERTIES

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

6.2. Laws governing the ideal gaseous state. The ideal gas equation.

6.3. Mixtures of gases. Dalton law.

6.4. Kinetic-molecular theory of gases.

6.5. Diffusion and effusion. Graham law.

6.6. Real gases. Equation of van der Waals.

7. WEIGHT AND VOLUMETRIC LAWS. STOICHIOMETRY

7.1. Atomic and molecular weights. Symbols and formulae.

7.2. Avogadro constant. Mol, density and molar volume.

7.3. Chemical reactions and chemical equations. Mass and charge conservation principles in chemical reactions.

7.4. Weight laws of chemical transformations.

7.5. Volumetric laws.

7.6. Stoichiometry and chemical equations. Limiting reactant. Yield of a chemical reaction.

Review material:

Determination of chemical formulas.

Balancing chemical equations.

8. SOLIDS AND LIQUIDS

8.1. Properties of liquids: surface tension, capillarity, viscosity and vapour pressure. Boiling point.

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

8.3. Liquefaction of gases. Critical temperature.

8.4. Properties of solids: Fusion, melting points. Sublimation.

8.5. Phase diagram. Phase rule.

8.6. Types of solids and properties: molecular, macromolecular or covalent, ionic and metallic.

8.7. Metallic, ionic, Covalent and molecular solids. Properties.

9. SOLUTIONS: BASIC CONCEPTS AND COLIGATIVE PROPERTIES

9.1. Solutions and colloids.

9.2. Intermolecular forces and dissolution processes.

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

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

9.5. Liquid-liquid solutions.

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

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

9.8. Changes in the freezing point and boiling point.

9.9. Osmosis. Osmotic pressure.

9.10. Vapour pressure of binary liquid mixtures.

9.11. Fractional distillation. Azeotropes.

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

Review material:

Ways to quantitatively term the concentration of the solutions.

CK OF CONTENTS III: THERMODYNAMICS, EQUILIBRIUM AND KINETICS FUNDAMENTALS

10. BASIC CONCEPTS AND FIRST LAW OF THE THERMODYNAMICS

10.1. Basic concepts in thermodynamics.

10.2. Energy, heat and work.

10.3. The first law of thermodynamics. Internal energy.

10.4. Calculation of magnitudes included in the first principle.

10.5. Reaction enthalpy. Standard States.

10.6. Laws of Thermochemistry. Calorimetry.

10.7. Standard enthalpy of formation.

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

11.1. Spontaneous and non-spontaneous processes.

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

11.3. Third law of thermodynamics. Absolute entropies.

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

11.5. Standard free energy of reaction. Standard free energy of formation.

12. CHEMICAL EQUILIBRIUM

12.1. Dynamic equilibrium and equilibrium constant.

12.2. Relationship between KC and the balanced chemical equation.

12.3. Equilibrium constant of reactions between gases.

12.4. Heterogeneous equilibrium.

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

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

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

13. ACID-BASE EQUILIBRIUM

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 EQUILIBRIUM

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 REDOX EQUILIBRIUM

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

16. CHEMICAL KINETICS

16.1. The rate of chemical reactions.

16.2. Rate law and order of the reaction.

16.3. Theoretical models of the kinetics of chemical reactions.

16.4. Influence of temperature on the rate of a reaction.

16.5. Mechanisms of chemical reactions. Molecularity.

16.6. Catalysis.

6. Methodology and working plan

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

a) **Expositive class:** based primarily on the lecture. In these classes 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 analysis of 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 class.

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

c) **Group mentoring: Attendance to the group mentoring seminars is mandatory** and the sessions will be held in small groups of students. In group mentoring sessions students will ask the professor questions and doubts. This activity will be planned trying to stimulate analysis and critical reasoning. Therefore, a series of questions and exercises will be proposed in advance to the students. Students must then try to solve these questions/problems previously and, later, they should discuss the proposed resolution in these seminars. The questions and exercises to be evaluated will be provided in advance by the professor to the student.

d) **Joint activities with other courses**. 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.) are available to the students in electronic format (available through virtual campus).

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

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

	Attendance	Non attendance	TOTAL	
Expositive classes	84	100	184	
Classroom practices	14	24	38	
Group mentoring	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 seen in the particular guides of each of these activities.

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

		Attendance work				Non-attendance work			
UNITS	**TOTAL HOURS**	**CE**	**PA**	**TG**	**TOTAL**	**CE**	**PA**	**TG**	**TOTAL**
1.- INTRODUCTION TO CHEMISTRY. ATOMIC STRUCTURE OF MATTER.	7.75	2	0.5	0.5	3	3.75	0.5	0.5	4.75
2. THE ATOM AND THE ATOMIC NUCLEUS. NUCLEAR CHEMISTRY	18	4	0.5	0.5	5	10	2	1	13
3. ELECTRONIC STRUCTURE OF THE ATOMS	30	8	1	0.5	9.5	15	3.5	2	20.5
4. CHEMICAL BONDING	19.5	13	1	0.5	14.5	2	2	1	5
5. INTERMOLECULAR FORCES	11.5	3	1	0.5	4.5	5	1	1	7
6. PROPERTIES OF GASES	14	3	1	0.5	4.5	8	1	0.5	9.5
7. WEIGHT AND VOLUMETRIC LAWS, STOICHIOMETRY.	13.5	5	1	0.5	6.5	5	1	1	7
8. LIQUIDS AND SOLIDS	12.5	4	1	0.5	5.5	5	1	1	7
9. SOLUTIONS: BASIC CONCEPTS AND COLIGATIVE PROPERTIES	18	7	1	0.5	8.5	7	1.5	1	9.5
10. BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS	16	5	0.5	0.5	6	7.5	1.5	1	10
11. SECOND AND THIRD LAWS OF THERMODYNAMICS. EQUILIBRIUM AND SPONTANEITY CONDITIONS.	15.75	6	0.5	0.5	7	6.25	1.5	1	8.75
12. CHEMICAL EQUILIBRIUM	15.25	5	1	0.5	6.5	6.25	1.5	1	8.75
13. ACID-BASE EQUILIBRIUM	13.25	3	1	0.5	4.5	6.25	1.5	1	8.75
14. SOLUBILITY AND COMPLEXATION EQUILIBRIUM	13.75	6	1	0.5	7.5	3.75	1.5	1	6.25
15. GALVANIC CELLS AND REDOX EQUILIBRIUM	16.25	6	1	0.5	7.5	6.25	1.5	1	8.75
16. CHEMICAL KINETICS	11	4	1	0.5	5.5	3	1.5	1	5.5
TOTAL	246	**84**	**14**	**8**	**106**	**100**	**24**	**16**	**140**

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).

7. Evaluation of the student's learning results

Aspect	**Criteria**	**Instrument**	**Weight**
Contents of units 1 to 7	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 8 to 16.	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 students in the group mentoring sessions, the preparation of material to be presented-discussed in the sessions and the ability to communicate with their peers and with the teacher are the aspects to be considered in the evaluation of this activity	In each group mentoring session each student will solve a number of problems and/or exercises proposed previously, which shall be subject to evaluation in the session.	20%
Joint cross-curricular activities with other subjects	See joint activities Guide	See joint activities Guide	10%
Contents of all units	Solving numerical problems and explain issues relating 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 relating 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%

Activities to be carried out during the group mentoring sessions will be based on the series of exercises for each topic that the professors proposed in advance to students that should resolve them prior to the correspondin g 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 could be required by the professor before the corresponding group mentoring seminar.

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 seminars 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

All on-site activities will make use of the overhead projector. Teachers will upload in the Virtual Campus platform various 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.