Course: Basic chemistry

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Language of Instruction: English

I-CONTENTS:

The course aims to introduce the basic concepts of Chemistry and show their application into everyday life. The course will start introducing matter and its constituents, from atoms to molecules and the aggregation states (solids, gases and liquids). The basic concepts of chemical kinetics and thermodynamics required for the understanding of chemical processes, and the thermodynamic aspects involved in the phase transitions and the dissolution process will be provided. An introduction to organic chemistry, the chemistry of life molecules, solutions and redox processes will be given. The students will also learn the Green Chemistry principles and other related concepts such as Life Cycle, Circular Economy or Carbon foot-print.

The course is structured in different sections composed by several units. The topics of each unit will be explained through practical examples and applications. Some possible examples to develop in the course are given in *italics.*

SECTION I- ATOMIC STRUCTURE

***Unit 1:* Matter and their constituents:**

Pure substances and mixtures. Elements and compounds. The concept of mole. Avogadro's constant. Chemical reactions and stoichiometric calculations.

- *Some daily examples of chemical reactions*
- *Determination of Avogadro's number by observations on Brownian motion. .*

***Unit 2*: Atomic structure:**

Early atomistic theories. Dalton's atomic model. Electrons, protons and other discoveries in atomic Physics. Electromagnetic radiation.

- *Modelling the Rutherford experiment.*
- *Double slit experiment.*

***Unit 3*: Quantum mechanics:**

Atomic spectra. Planck's hypothesis. Photoelectric effect. Wave-particle duality. The uncertainty principle. Quantum numbers and atomic orbitals. Electron configurations.

- *Quantum mechanics, quantum computers, quantum tunnelling.*
- *Scanning electron microscope.*

***Unit 4:* Periodic table of the elements.**

Mendeleev and Moseley systemization attempts. Electron configurations and periodic table. Size of atoms and ions. Periodic properties.

- *A walk through the periodic table. Periodic table quiz.*
- *Occurrence and abundance of the elements.*

***Unit 5:* Chemical bonding**

Types of chemical bonding: Covalent, ionic and metallic. Lewis structures. Molecular geometry.

- *Lewis structures quiz.*

- **SECTION II- AGGREGATION STATES AND PHASE EQUILIBRIUM**

***Unit 6:* Aggregation states of matter**

Gaseous state. Equation of state of an ideal gas. Mixture of ideal gases. Intermolecular forces. Real gases. Liquid state. Interfaces. Solid state.

- *Gases law and weather.*
- *Syringes, burning candles and rising water.*
- *Bubbles, colloids and floating needles.*
- *Nanotechnology.*
- *Liquid crystals.*
- *Viscoelastic solids: corn-starch suspension*
- *Self-assembly of colloids.*

***Unit 7:* Phase equilibrium**

Phases and phase transitions. Phase diagrams of pure substances. Vapor pressure. Vapor pressure in mixtures.

- *Carbon Allotropes*
- *Distillation and other separation processes.*
- *Supercritical Fluid Extraction*

SECTION III- CHEMICAL REACTIONS: KINETICS AND THERMODYNAMICS

***Unit 8:* Chemical Kinetics**

Rate of a chemical reaction. Kinetic equations. Activation energy. Reaction mechanism.

- *Catalysis in the chemical industry.*
- *Enzymes and their role in life.*
- *Combustion and explosive reactions*

***Unit 9:* Nuclear Chemistry**

Isotopes. Radioactivity. Rate of radioactive decay. Nuclear reactions. Fission and fusion.

- *Radiocarbon dating.*
- *Cancer therapy.*
- *Radiation processing.*
- *Nuclear energy. Radioactive waste disposal. Nuclear safety.*

***Unit 10:* Chemical Thermodynamics**

Work, heat and internal energy. The conservation of energy principle. The second law of thermodynamics. Entropy, enthalpy and Gibbs energy. Equilibrium and spontaneity. Thermochemistry.

- *Thermal machines (motors and refrigerators) and thermodynamic cycles.*
- *The impossibility of perpetual motion machines.*
- *Thermochemistry of fossil fuels versus renewable sources of energy.*
- *The greenhouse effect.*

SECTION IV: CHEMISTRY OF LIFE AND SOLUTIONS

Unit 11: **Basic organic chemistry**

Structure and basic nomenclature for hydrocarbons and other compounds with the most important functional groups. Structural isomerism, stereoisomerism.

- *Building blocks of life: lipids, carbohydrates, proteins, nucleic acids.*
- *Polymers and the origin of life.*
- *Stereochemistry in the Pharmacy Industry*
- *Polymers and Plastics*
- *Petrochemistry. Raw materials. Renewable feedstocks.*

Unit 12: Solutions and their physical properties

Types of solutions. Concentration of a solution. Intermolecular forces and dissolution processes. Solubility of gases: Henry's law.

- *Colligative properties.*
- *Oxygen solubility in water and life.*

Unit 13: Acid-Base equilibrium and solubility

Nature of the chemical equilibrium. Equilibrium constant. Brönsted and Lowry theory. pH scale. Strength of acids and bases. Buffer solutions. Acid base titrations. Solubility product. The common ion effect. Dissolution of precipitates.

- *The importance of pH in biological systems*
- *Showering with hard water*
- *The pH in food industry*

Unit 14: Electrochemistry

Oxidation number. Redox reactions. Standard potentials. Electrochemical cells. Batteries and fuel cells.

- *Towards a post-lithium batteries era.*
- *Manufacturing the energy of our body.*

SECTION V: SUSTAINABILITY

Unit 15: Green Chemistry

- *The Green Chemistry Principles*
- *Green Engineering and Circular Economy*
- *Metrics: Life Cycle, Carbon foot-print,…*

II- METHODOLOGY

The contents of the course will be presented in **face-to-face lectures**. Focus will be placed on examples and applications into everyday life. The elaboration and presentation of a ***term paper*** **or some other alternative activity** about the contents of the course will be proposed as a **guided activity**.

The Virtual Campus will be used as a mean to promote a fluent communication between the lecturer and the students and as an instrument to make the course material available to students.

III.- BIBLIOGRAPHY

- Petrucci, R. H., Herring, F. G., Madura, J. D. y Bissonette, C.: "*General chemistry: principles and modern applications*", 11th ed., Pearson, 2017.
- Atkins, P. y Jones, L.: "*Chemical principles: the quest for insight*", 7th ed. New York: W.H. Freeman; 2016.
- Chang, R.: *"Chemistry",* 10th ed., McGraw-Hill, 2010
- Kean, S.; *"The Disappearing Spoon...and other true tales from the Periodic Table"*, Black Swan, 2011
- Atkins, P., "*Molecules"*, 2nd Cambridge, 2003.
- Atkins, P., *"Reactions. The private life of atoms"*, Oxford University Press, 20133.
- Notes provided through the virtual campus

IV.- ASSESSMENT

The student's academic performance and the final marks of the course will be computed in a weighted manner. The student's active participation in all teaching activities will be taken into account in the final evaluation.

The student will be able to choose among different options:

(A) Final Exam (50%) and personal work (50%)
(B) Final Exam (50%) and *term paper and presentation in class* (50%)
(C) Final Exam (100%)

In every option, a minimum score of 4 out of 10 in the final exam will be required to average with the remaining activities. An average of 5 out of 10 is required to pass the course.