UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

## Chemistry

**2021-1-E3001Q038**

### Aims

The course introduces students to fundamental concepts of general chemistry, providing the tools required for understanding basics of stoichiometry, chemical bonding, molecular geometry and reactions of chemical equilibria

### Contents

Matter and chemistry

Naming chemical compounds

Chemical equations and stoichiometry

Atomic structure

The Periodic Table of the elements

Chemical bonding

Intermolecular forces

Properties of gasses, liquids and solids

Solutions

Chemical equilibria: acid-base, solubility, redox reactions

Electrochemistry: voltaic cells

## Detailed program

Mixtures, elements, compounds. The mole. Atomic mass unit and mMolar mass. Empirical, molecular and condensed formulas. Naming binary and simple ternary compounds. Stoichiometry: mass balance in chemical equations. The limiting reagent. Yield of a chemical reaction.

Electronic structure of atoms. Atomic orbitals for the hydrogen atom. Many-electron atoms. Atomic properties and their periodicity: atomic size, ionization energy, electron affinity, electronegativity. The periodic system of elements. The ionic and covalent bonds.

Lewis structures and the octet rule. Multiple bonds and resonance. Molecular geometry (VSEPR model) and polarity of molecules. Valence Bond theory. Hybrid atomic orbitals.

Intermolecular forces. Ideal gas law. Partial pressure of mixtures of ideal gasses. State diagrams of single-component systems; P-T phase diagrams. The hydrogen bond. Ionic, molecular and covalent solids. Liquids and solvation. Solutions. Concentration in solution expressed as mass %, molar fraction, molarity, parts per million.

Chemical kinetics: reaction rate, reaction order. Transition state and activation energy. The role of temperature and catalysts.

Chemical equilibria: the law of mass action and the equilibrium constant of a chemical reaction. Homogeneous and heterogeneous equilibria. Chemical composition at equilibrium. Response of equilibria to external perturbations.

Br?nsted-Lowry theory of acids and bases. Role of water in acid-base equilibria: the proton exchange reaction. Strength of acids and bases. pH of strong and weak acids and bases. Buffer solutions. Neutralization reactions.

Solubility equilibria. Solubility and saturation. The solubility product of sparingly soluble salts. Effect of common ions and acid/base equilibria on solubility. Precipitation reactions.

Oxidation state and redox reactions. Oxidants and reductants. Electrochemistry: electrochemical cells,

standard potentials and Nernst equation.

***Student learning objectives:***

1. Make conversions of chemical quantities mastering dimensional analysis

2. Use the mole concept to interconvert among mass, moles, number of molecules or atoms, volume of gas following the ideal gas laws, density and molarity

3. Name compounds according to the most common rules

4. Write and balance chemical equations if given the formulas of reactants and products

5. Calculate theoretical yield, actual yield, percent yield; determine which reactant is the limiting reagent

6. Understand the organization of the Periodic Table. Identify elements as metals, non-metals, metalloids and noble gases

7. Predict the relative magnitude (low, average, high) of the periodic properties (electronegativity, electron affinity, ionization energy, ionic and covalent radius) from the position in the Periodic Table

8. Use the Periodic Table to predict the ionic charge or oxidation state of an element in a compound; write formulas of chemical compounds using ionic charges or oxidation states

9. Draw Lewis structures for covalent compounds

10. Use the VSEPR model with the pertinent Lewis structure to predict intramolecular bond angles, overall geometry and the hybridization scheme of atomic orbitals

11. Use Valence Bond Theory to describe the bonding between atoms in a molecule, including hybridization of atomic orbitals

12. Identify the types of intermolecular forces and use them to predict properties of solids and liquids (e.g. viscosity, surface tension, solvent/solute properties)

13. Classify compounds according to the type of chemical bonding: molecular, salt, strong or weak acid, strong or weak base, electrolyte, non-electrolyte

14. Calculate the equilibrium composition for acid/base reactions and solubility equilibria

15. Manage mass balance in simple redox reactions and calculate the redox potential in voltaic cells

16. Understand the parameters affecting the rate of chemical reactions

## Prerequisites

No previous knowledge of chemistry is assumed, though it can be helpful. As to mathematics, fluency in high school algebra is mandatory. Proper use of: rules for significant figures with numbers in calculations, numbers in scientific notation, converting between different metric (IS) units, equations including algebra, exponential numbers, logarithms, ratio and proportion, reading and preparing graphs.

## Teaching form

Lectures in the classroom are given in italian and exploit video projection of schemes, diagrams, plots, pictures and movies complementing the teaching actions. Problem solving activities are performed on the blackboard or equivalent tools to improve the interaction with students.

***In the period of Covid-19 emergency lessons will be provided in blended mode: some in class and some in remote.***

***The lessons will be recorded in order to make them available online for those who are unable to attend the University even when the frontal teaching.***

## Textbook and teaching resource

A textbook is recommended but not required. Lessons are based on:

Martin S. Silberberg and P. Amateis, Chemistry – The molecular nature of matter and change, 8th edition The McGraw Hill Companies, Inc., 2018. This textbook includes a relevant amount of problems and exercises.

or

John C. Kotz, Paul M. Treichel, John R. Townsend, David A. Treichel *Chemistry & Chemical Reactivity,* Ninth Edition, Cengage Learning, ISBN-13: 978-1-133-94964-0, 2015

Slides (power point) are available in the e-learning site

## Semester

2nd semester

## Assessment method

The teacher assesses if and to what extent the student has reached the course objectives, through a formal knowledge-based evaluation of the general topics delivered and problem solving skills. The examination is performed through a written test including an open question on general topics and several problems concerning numerical and symbolic chemical aspects. The exam is scheduled starting at the end of the course without midterm exams and it is proctored to verify a student's identity. A positive final graduation ranges from 18/30 to 30/30 based on quality and completeness level of the answers provided by the student. When the score reached in the written exam is equal to or greater than 18/30, the student can ask for an oral examination, i.e. an interview about the topics introduced during the classroom acitivities.

During the exam only non-programmable, non-graphical scientific calculators are allowed. Calculators available on cell phones, laptops, iPads, tablets, iPhones, Blackberries and all other devices with math processors and/or web compatible are not allowed.

***In the period of the Covid-19 emergency the exams will be performed in remote, utilizing the WebEx program available from the e-learning webpage of the course.***

***The exam will be constituted by a written and oral part. In particular:***

- ***A time-schedule will be organized in order to allow to perform the exam to maximum 20 students simultaneously;***

- ***The text of the exercises will be sent to each student in conjuction with the fixed time according to the time-schedule;***

- ***The written part will be constituted by 3 exercises for a maximum duration of 45 min.***

- ***After the correction of the written part, there will be an oral with a maximum duration of 15 min.***

## Office hours

The teacher is available for help and discussions on Tuesdays from 1:30-2:30 pm via Webex at https://unimib.webex.com/meet/livia.giordano or by scheduling a meeting via email at: livia.giordano@unimib.it.