UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Chemistry

2526-1-E3005Q003

Aims

1. Knowledge and Understanding
By the end of the course, students will acquire:
• Knowledge of fundamental chemistry concepts at an introductory level, including stoichiometry, chemical bonding, molecular geometry, and the basic reactivity of chemical equilibria.
• Understanding of the thermodynamic and kinetic laws governing bond formation and chemical reactions.
• Familiarity with the recognition of chemical elements and their fundamental properties.
2. Applied Knowledge and Understanding
Students will develop the ability to:
• Determine the basic properties of elements and chemical compounds
• Identify the properties of chemical equilibria and the energy contributions in chemical reactions.
• Address basic problems of chemical stoichiometry.
3. Independent Judgment
Students will be able to:
• Correctly interpret the chemical behavior of substances and evaluate numerical results obtained when solving problems.
4. Communication Skills
Students will be able to:
• Explain the concepts covered in the course clearly and precisely, using chemical and scientific language correctly.
• Present and argue the solutions to exercises and theoretical questions clearly, orderly, and rigorously.
5. Learning Skills
The course will provide:
• The methodological skills needed to approach the study of subsequent years' courses that intersect with chemistry.
• The ability to consult specialized texts to independently explore the concepts presented in class.****

Contents

Matter and chemistry

Nomenclature of chemicals

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

Chemical reactions in solution

Fundaments of Electrochemistry

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 and analysis 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 with 28 two-hour lectures, in person, of delivered didactics and exploit video projection of schemes, diagrams, plots, pictures and movies complementing the teaching actions. Lectures and problem solving activities may be performed on the blackboard or equivalent tools to improve the interaction with students.

Textbook and teaching resource

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

John C. Kotz, Paul M. Treichel, John R. Townsend *CHIMICA* Edises

For consultation or supplementary materials
Silberberg and P. Amateis, Chemistry – The molecular nature of matter and change, 8?? edition The McGraw Hill Companies, Inc., 2018.

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. Before starting the exam the student's identity will be verified.

The examination is performed through a written and optional oral tests.

Written part (30 points): the written exam consists of excercizes regarding the numerical and symbolic chemical aspects and basic chemical problems (3-4) to evaluate the problem solving skills, multiple choice questions and open questions to evaluate the knowledge of the course topics. Exam duration: 60 minutes. Consultation of the periodic table and the use of non-programmable, non-graphical scientific calculators are allowed. Consultation of texbooks, and the use of calculators available on cell phones, smart Phones, tablets, laptops, or any other devices with math processors and/or web compatible are not allowed.

Oral part (optional): colloquium on the topics of the course (15-20 min). The completness and quality of students' answers are evaluated. Students can opt to do the oral exam if they pass the written exam (grade higher than 18/30).

A positive final grading ranges from 18/30 to 30/30, and results from a holistic evaluation of the written and oral (if opted) parts.

Office hours

The teachers Livia Giordano (email: livia.giordano@unimib.it) and Giovanni Di Liberto (email:giovanni.diliberto@unimib.it) are available by appointment for questions related to the course.

Sustainable Development Goals

QUALITY EDUCATION | AFFORDABLE AND CLEAN ENERGY | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION