UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

General and Inorganic Chemistry

2021-1-E3401Q004

Aims

The aims of the course are to provide the students the baisc knowledge concerning the structure matter, the chemical reactivity and the properties of the most important elements and chemical compounds, with a special enphasize to applications in the field of geology. Teh course also would provide the student with basic skills in solving stechiometric problems.

Knowledge and understanding
At the end of the course the student knows:

on the foundamental chemical properties such atomic mass and mole

on the electronic structure of atoms and their periodic properties

on the bond theories and the principles that regulate atom binding

on the nature of intermolecular interactions and their relation with the states of matter

on the energy transfer related to physical and chemical transformations, and the criteria to evaluate the spontaneity of a process.

on the properties of the different states of the matter and their law governing their transformations

on the properties of homogeneous and heterogeneous mixtures

on the ground concepts of chemical reactivity and the main classes of reactions (redox, acid-base, precipitation etc)

on the general principles of the chemical equilibria and chemical kinetics

on the ground elements of electrochemistry

on the descriptive chemistry of the most important elements

Applying knowledge and understanding
At the end of the course the student is able to:

write correctly a chemical reaction and perform simple stoichiometric calculations

Understand the behaviour and classify the substances on the basis of their chemical nature

Understand the bond types and tridimensional shapes of simple molecules

Predict the spontaneity of a chemical reaction, evaluate the energy tranfer related to such chemical transformation and describe the condition for the chemical equilibrium

Evaluate the behaviour of acids, bases and their mixtures in aqueous solutions, as well as the behavior of chemical species that produce insoluble salts

Making judgements
At the end of the course the student is able to apply the learned knowledge in different contexts than those presented during the course, and to elaborate on the topics of the course

Communication skills
At the end of the course the student should be able to describe a report in a clear and concise way, as well as to explain orally with a suitable language the objectives, the procedures and the results of the elaborations carried out.

Learning skills

At the end of the course the student should be able to apply the acquired knowledge to different contexts than those discussed during the course.

Contents

Matter, atomic theory, atomic and molecular mass, Avogadro constant and mole. Chemical compounds. Chemical nomeclature. The electronic structure of atoms and molecules. Atomic periodic properties. Ionic and Covalent bond. Bond theories; Lewis formalism, Valence Bond, and Molecular Orbital theories. Intermolecular interactions. Solids and Band theory. Gas. Thermochemistry. Mixtures and aqueous solutions. Colligative properties of solutions. Chemical kinetics. Chemical equilibrium and LeChatelier principle. Acids and bases (Arrhenius and Brønsted-Lowry definition, pH buffer solutions salt idrolysis, titrations, indicators). Solubility of salts and solubility product. Lewis acids and bases; complex ions. Redox reactions, Electrochemistry. Descriptive chemistry of main groups elements. Stoichiometry

Detailed program

The electronic structure of atoms. Bohr model, electron spin. Heisenberg principle and Schrodinger equation. Atomic orbitals.

The periodic table and the periodic properties of the elements; ionization energies, electron affinities, polarizabilities, atomic and ionic radii.

The chemical bond: ionic and covalent bonds. The electronic and geometrical structure of molecules; The Lewis formalism and the octect rule, resonance and hypervalent compounds, VSEPR theory. Valence bond theory, hybrid orbitals and sigma and pi bonds. Basic of molecular orbitals theory.

Atomic and molecular mass. Concept of mole. Chemical reactions, stoichimetric coefficients and and procedures to balance a reaction. Classes of reactions. Stoichiometric calculations to determine the mass of reagents and products, limiting reactant. Reactions in aqueous solution; precipitation reactions, acid-base reactions, redox reactions. Physical and chemical modes for the expression of concentrations.

Intermolecular interactions; dispersion interactions, dipole-dipole interactions, dipole-ion interactions, H-bonds.

The macroscopic chemical systems and basic of thermochemistry: definition of thermodynamic state of a system, state functions. Internal energy, work, heat and the first principle of thermodynamics. Enthalpy and Hess law. Standard state of a compound, reaction and formation sthandard enthalpies.

The states of the matter and state transformations. The Gas state; ideal and real gases, gaseos mixtures and Dalton law. Basic on the kinetic theory of gases and Maxwell-Boltzmann equation.

The solid state. The crystal lattice and the unit cell of a crystal.Classification of solids on the bases of their structure; ionic solids, metallic solids and band theory, covalent solids and molecular solids. Conductors,

semiconductors and insulators.

The liquid state; properties of liquids, vapor pressure and Clausius-Claypeiron equation. Phase diagrams and phase rule.

Solutions and colligative properties of solutions; Raoult law, boiling point elevation and freezing point depression, osmotic pressure.

Basic of chemical kinetics; reaction rate, activation energy and reaction pathways. Transition state theory, velocity law and reaction order, Arrhenius equation, catalysis.

The chemical equilibrium. Equilibrium constants as a function of concentrations, partial pressure and molar fractions. Equilibria in gas phase; methods to determine the amount of reactants and products at the equilibrium conditions. The LeChatelier principle and the effects on the equilibrium due to changes in the reactants and products amounts, temperature and pressure. Heterogeneous equilibria.

Acid and base theories; Arrhenius, Brønsted and Lewis definitions of acids and bases. Water protolysis and ionic product of water. pH and methods to calculate the pH and acids and bases. Buffer solutions and their applications. Idrolysis of salts. General method for the calculation of the concentration of species in a complex aqueous solution. Acid-base titrations and indicators

Solubility of salts and solubility product. Methods to calculate the solubility of a salt in aqueous solution. Common ion effect. Effect of pH on the solubility of a salt.

Second principle of thermodynamics; Carnot cycle, entrophy and Gibbs free energy. Methods to determine the spontaneous direction of a reaction. statistical definition of entrophy and the Boltzmann equation.

Electrochemistry; galvanic cells, the SHE electrode, standard reduction potentials and the Nernst equation.

Descriptive chemistry of the main elements; hydrogen, boron, carbon, nitrogen, oxygen. silicon, sulphur, phosphorous, alluminium, alkaline- and alkaline-earth metals

Basic of the transition metal chemistry and coordination compounds.

Prerequisites

Basic concept of mechanics

Basic mathematical concepts (algebra, exponential logarithms, trigonometry)

Units, conversion factors and dimensional calculations

Teaching form

Lectures in classroom (6 cfu; 42hours) and exercises on the topics of the lectures (2 cfu; 24 ore).

Tutoring activity, organized by the participants

Textbook and teaching resource

Textbooks:

M. S. Silberberg S. Licoccia "Chimica. La natura moleculare della materia e delle sue trasformazioni" Ed. McGraw-Hill

Slides shown during the lectures and notes on selected topics are available on the e-learning web-site

Semester

II semester (march - june)

Assessment method

The examination is divided into two parts. The first step is a written examination based on the solution of 5/6 exercises and the answer to 1/0 open questions. A score 0/5 is assigned to each question.

Students with a score equal or higher to 16 are admitted to the oral examinations with questions on the topics of the course

Office hours

Always, by appointment by phone or e-mail