KH1120 General and Physical Chemistry 15.0 credits

Allmän och fysikalisk kemi

This is a translation of the Swedish, legally binding, course syllabus.

If the course is discontinued, students may request to be examined during the following two academic years

Establishment

Course syllabus for KH1120 valid from Autumn 2011

Grading scale

A, B, C, D, E, FX, F

Education cycle

First cycle

Main field of study

Technology

Specific prerequisites

Completed upper secondary education including documented proficiency in Swedish corresponding to Swedish B, and English corresponding to English A. For students who received/will receive their final school grades after 31 December 2009, there is an additional entry for mathematics as follows:
documented proficiency in mathematics corresponding to Mathematics A.
And the specific requirements of mathematics, physics and chemistry corresponding to Mathematics D, Physics B and Chemistry A.

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

This course aims to consolidate and deepen the knowledge of general chemistry and provide the necessary basis of physical and inorganic chemistry for application in future courses in organic and analytical chemistry and in the chemical engineering subjects. The course will also provide training in using laboratory equipment and some of the methods used in a chemical laboratory.

After the course the student should be able to:

- Name and identify chemical compounds based on systematic nomenclature of inorganic compound and represent chemical compounds with different techniques, such as molecular formulas, empirical formulas and structural formulas.
- Classify inorganic reactions and predict what products that from the reaction of some key reactants, and decide what works as an acid / base, oxidant / reductant, ligand / central atom. Students should also be able to describe coordination complexes and point out some important ligands and describe the concepts and multinuclear and chelate complexes.
- Make relevant observations of chemical reactions and convey them orally and in writing, and write correctly balanced chemical reaction formulas as well as assign oxidation states of elements in compounds.
- Make stoichiometric calculations, including mole-ratio, limiting reactant, yield, excess and concentration calculations.
- Perform calculations on a traditional, aquatic analysis, including titrimetric analysis, gravimetric analysis, ion-exhange analysis, couloumetric titrations, back titrations and analysis in several steps, and give the answer with the correct number of significant digits.
- Recognize and describe the use of laboratory equipment, such as burettes, pipettes and flasks.
- Describe chemical equilibrium, and perform calculations on the equilibria (acid / base equilibria, gas phase equilibria, complex formation equilibria, solubility equilibira, Henry's law, redox equilibira), including simple, coupled equilibria and buffer systems.
- Using the MEDUSA / HYDRA to create and interpret chemical equilibrium diagram for the solution of chemical problems.
- Using the ideal gas law for calculations and know when it is applicable. Students should also be able to explain the basics of the kinetic theory of gases.
- Define and exemplify colligative properties and vapour pressure, using Raoult's law for calculations and estimate boiling / freezing point changes of solutions.
- Describe the electrochemical cells with cell diagrams and anode / cathode reactions, calculate cell potentials and describe and illustrate galvanic cells, electrolytic reactions and fuel cells. Students should also be able to use the electrochemical series to determine which redox reactions that occur spontaneously.

- Describe the structure of atoms and relate systematic variations in the properties of the elements to the periodic table. Students should also be able to specify the electron configuration, depict valence electrons and propose which atomic ions that forms from elements.
- Describe and distinguish between different models of chemical bonding (ionic, covalent, Lewis, metal) and propose dominant bonding type in compounds.
- Establish Lewis structures, including resonance and alternative forms, determining VSEPR-formulas and geometry of chemical compounds and (for simple compounds) indicate hybridization.
- Describe the intermolecular forces, and discuss which ones are important for a given chemical compound. Students should also be able to describe the relationship between intermolecular forces and physical properties, such as boiling.
- Describe thermodynamics, first and second principle of thermodynamics and thermodynamic quantities, such as enthalpy and entropy, and describe how the latter relates to temperature and state.
- Make thermodynamic calculations involving enthalpy, entropy, internal energy, heat and work, and from these draw conclusions about the reaction heat / work exchange with the environment and calculate the Gibbs' free energy and determine when chemical reactions occur.
- Explain and practically use the relations between thermodynamics, equilibrium and electrochemistry, and apply the thermodynamics to solve quantitative problems in general chemistry and chemical engineering.
- Define reaction rate and calculate it from the empirical rate expression, explain the concept of reaction order and explain and calculate the evolution of concentration with time in a closed reaction system.
- Explain what is meant by the reaction mechanism and elementary reactions and from these proposed rate expressions, use the Arrhenius relation to describe and calculate the temperature dependence of reaction rates, and describe what is meant by catalysis and explain its chemical background and implications.
- Describe the basic chemical and physical properties of some selected elements, their compounds, their production and use, and the systematic variations in the properties of the periodic system, with emphasis on how this affects the state and chemical reactivity.
- Finding chemical information in the literature and compile and present this in writing and orally in a way that is appropriate for an engineer.

Course contents

Theory
Part 1:
Basic inorganic nomenclature, theory of reactions, basic stoichiometry.

Systematic nomenclature compounds including complex ions, common name, oxidation state, acid-base reactions, redox reactions, complexation reactions, dissolution / precipitation reactions, chemical equations, the mole, concentration units, the preparation of aqueous solutions, mole calculations, limiting reactant, yield, glassware.

Part 2:
Applied stoichiometry and chemical equilibrium

Calculations of gravimetric analysis, ion exchange, coloumetric and volumetric titrations, back titration, analysis in several steps. The mass action law, Le Chatelier's principle, equilibrium calculations, solubilities, complexation equilibira, acid/base equilibira, introduction to redox equilibira, coupled equilibria, pH buffer, equilibrium diagrams.

Part 3:
Gases and solutions, electrochemistry, atomic structure and bonding, chemical kinetics and thermodynamics

Ideal gas law, introduction to kinetic theory of gases, basic electrochemistry, galvanic cells and electrolysis, electrochemical voltage, orbital, electron configurations, valence electrons, electronic structure, multiple bond, resonance, VSEPR and molecular geometry, hybridization, reaction rate, Arrhenius relation, catalysis, elementary reactions, rate expressions, integrated rate expressions, thermodynamics, first and second principle of thermodynamics, enthalpy and entropy, Gibbs' free energy, work and heat, thermodynamics related to equilibrium and electrochemistry

Laboratory:
Practical exercises in applied equilibrium
Computer exercise in chemical equilibrium
Computer exercise in chemical reactions

Course literature

Burdge, J: Chemistry, 2th Edition. McGraw-Hill, 2010.

Laboration compendium, Nuclear Chemistry, KTH

Examination

- INL1 - Exercises, 1.5 credits, grading scale: P, F
- LAB1 - Laboratory Work, 4.5 credits, grading scale: P, F
- LAB2 - Laboratory Work, 1.0 credits, grading scale: P, F
- LAB3 - Laboratory Work, 1.0 credits, grading scale: P, F
- PRO1 - Group Work, 1.0 credits, grading scale: P, F
- TEN1 - Examination, 3.0 credits, grading scale: A, B, C, D, E, FX, F
- TEN2 - Examination, 3.0 credits, grading scale: A, B, C, D, E, FX, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

Other requirements for final grade

Passed exams (TEN1; 3 cr.) and (TEN2; 3 cr.). Passed exercises (INL1; 1,5 cr.). Passed lab sessions (LAB1; 4,5 cr.). Passed computerized lab session and team work (LAB2; 1 cr. And LAB3; 1cr) and team work (PRO1;1 cr)

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.