

CHEMISTRY

GENERAL CHEMISTRY

1. Mass and number of moles

- 1.1 Atomic mass, atomic mass unit, molar mass
- 1.2 Atomic masses of isotopes, average masses
- 1.3 Number of moles and Avogadro's constant

2. Concentration of substance in solutions

- 2.1 Mass percent concentration
- 2.2 Volume percent composition
- 2.3 Mole fraction
- 2.4 Molarity – molar concentration
- 2.5 Dilution of solutions

3. Molecular formula of compounds

- 3.1 Inorganic acids and bases
- 3.2 Inorganic salts
- 3.3 IUPAC nomenclature of salts
- 3.4 Molecular formula vs. weight percent composition

4. Chemical reactions and stoichiometry

- 4.1 Balancing chemical equation (mass and charge balance)
- 4.2 Typical reactions of inorganic synthesis, analysis and exchange
- 4.3 Reaction yield
- 4.4 Limiting reactant
- 4.5 Reactions with chemical mixtures (alloys, oxides)

5. Ideal gas laws

- 5.1 Standard and normal conditions
- 5.2 Clapeyron's equation
- 5.3 Density of gas phase
- 5.4 Isothermal, isobaric and isochoric transformation of gases

6. Chemical equilibrium

- 6.1 Equilibrium constant

7. Acid-base equilibria in aqueous solution

- 7.1 Auto-ionisation of water and pH scale
- 7.2 Electrolytic dissociation of weak acids and bases (acidity and basicity constants)
- 7.3 Dissociation degree
- 7.4 Poorly soluble electrolytes – solubility product

8. Oxidation-reduction reactions

- 8.1 Oxidation numbers and balancing redox equations
- 8.2 Redox potentials and electrochemical series of metals
- 8.3 Voltaic cell potentials

9. Thermochemistry

- 9.1 Calculations based on Hess law

10. Electronic structure of atoms

10.1 *Periodic table*

10.2 *s-, p- and d-block elements*

10.3 *Electron configuration of elements*

Key words:

Element, proton, neutron, electron, cation, anion, isotope, atomic mass, atomic mass unit, molar mass, mole, Avogadro's constant, molar concentration, molarity, mass concentration, molar fraction, metals, nonmetals, ionic compounds, salt, IUPAC nomenclature, limiting – reactant, solute, solution, yield of reaction, standard and normal conditions, Clapeyron's equation (ideal gas law), density, isothermal transformation, isobaric transformation, isochoric transformation, molecular equation, ionic equation, equilibrium constant, pH, hydronium ion, hydroxide anion, strong and weak electrolytes, dissociation constant, solubility product, oxidation, reduction, oxidation numbers, galvanic (voltaic) cells, cathode, anode, cell diagram, standard reduction potentials, hydrogen electrode, exo- and endothermic reactions, Hess law, reaction enthalpy, valence shell, valence electrons, ionic bond, covalent bond, polar molecules, electron configuration, s orbitals, p orbitals, d orbitals.

Textbooks recommended:

1. regular chemistry text books

2. Kaplan Essential Review: High School Chemistry by Dana R. Freeman, William Yu Wang Paperback, 304 Pages, Published 1999, ISBN-10: 0-684-86821-0 / 0684868210, ISBN-13: 978-0-684-86821-9 / 9780684868219

3. Peter Atkins, Loretta Jones, Leroy Laverman: Chemical Principles, Publisher: W. H. Freeman; 6th edition, ISBN-13: 978-1429288972, ISBN-10: 1429288973

4. IUPAC basic definitions of chemical properties and quantities:

<http://goldbook.iupac.org/PDF/goldbook.pdf>

5. IUPAC nomenclature of inorganic compounds:

https://www.iupac.org/fileadmin/user_upload/databases/Red_Book_2005.pdf, pages 68 - 83

ORGANIC CHEMISTRY

1. Structure and bonding in organic chemistry

- a) Hybridization and molecular shapes, isomerism, homologous series
- b) Carbon skeletons with single and multiple bonds, structural and skeleton formulas of organic compounds
- c) Functional groups
- d) Lewis structures, formal charges, resonance

2. Classification and properties of organic compounds

- a) Hydrocarbons (alkanes, alkenes, alkynes, aromatic compounds), alkyl halides, nitro compounds
- b) Alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids and their derivatives
- c) Amines, amino acids, peptides and proteins
- d) Lipids, carbohydrates, heterocyclic bases, nucleotides, nucleic acids

3. Nomenclature of organic compounds

- a) Hydrocarbons of various classes
- b) Compounds with one functional group
- c) Compounds with more functional groups, preferences in naming

4. Stereochemistry

- a) Conformations
- b) Z/E stereoisomers
- c) Enantiomers and diastereomers
- d) Models and notations to represent stereoisomers

5. Organic reactions

- a) Mechanisms of organic reactions, nucleophiles and electrophiles
- b) Nucleophilic substitution versus elimination
- c) Electrophilic substitution in aromatic compounds
- d) Reduction and oxidation in organic chemistry
- e) Radical processes, rearrangements

Key words:

Organic chemistry:

Isomers; sp^3 , sp^2 and sp hybridization; homologous series; tetravalent carbon; single, double and triple bonds; conjugated systems of multiple bonds; resonance; aromaticity; hydrocarbons; alkanes, alkenes, alkynes, substituents, heteroatoms, alkyl halides; alkyl group; primary, secondary and tertiary alcohols and amines; aldehydes and ketones; carbonyl group; carboxyl group; acids; esters; amides; anhydrides; nitro compounds; conformers; Z/E stereoisomers; enantiomers; diastereomers; Fischer projections; nucleophiles, electrophiles, reaction mechanisms; carbocation; radical; leaving group; addition; substitution; elimination; reduction; oxidation; rearrangement; biomolecules; fatty acids; lipids; soaps; waxes; micelles; mono-, oligo- and polysaccharides; triose; tetrose; pentose; hexose; aldose; ketose; hemiacetals; acetals; pyranose; furanose; amino acids; isoelectric point; α -helix; primary, secondary, tertiary, and quaternary structures of proteins; double helix, complementary base pairs, ribonucleic acid and deoxyribonucleic acid.

Textbooks recommended (three following positions for choice, the fourth one for more ambitious pupils):

1. Hrvoj Vančik

Basic Organic Chemistry for the Life Sciences (179 pages)

Springer International Publishing Switzerland 2014

ISRN: 978-3-319-07604-1

2. Graham Patrick

BIOS Instant Notes in Organic Chemistry (328 pages)

Garland Science, Taylor & Francis Group 2012

ISBN 978-1-8599-6264-0

3. Andy Parsons

Keynotes in Organic Chemistry (300 pages)

Wiley (second edition) 2014

ISBN: 978-1-119-99914-0

4. David J. Hart, Christopher M. Hadad, Leslie E. Craine, Harold Hart

Organic Chemistry A Short Course (608 pages)

BROOKS/COLE CENGAGE Learning (13th Edition)

ISBN: 13:978-1-111-42556-2