NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

AGROBIOLOGICAL FACULTY
DEPARTMENT OF ANALYTICAL AND BIOINORGANIC CHEMISTRY & WATER QUALITY

"APPROVED"
Dean of the Faculty of Plant Protection,
the Biotechnologies, and Ecology
Dr.Agr.Sci, Prof. _____ Y.V.Kolomiec
"___" _____, 2022

REWIED AND APPROVED
At the meeting of the department
of Analytical and Bioinorganic
Chemistry & Water Quality
Protocol # 12, " 23 " May, 2022
Head of the Department
Dr.Chem.Sci, Prof. _____ V.A.Kopilevich

"REWIED "
Guarantor of EP
Dr.Chem.Sci, Prof. _____ M.Pykovsky

WORK PROGRAM
Academic Discipline "INORGANIC AND ANALYTICAL CHEMISTRY"
For EQL (educational and skill level) "Bachelor"
Faculty of Plant Protection,
the Biotechnologies, and Ecology
Speciality – 202 Plant protection and Qurantine

Syllabus compiled by : Associate Prof. R.V. Lavrik, PhD in Chemistry

Kyiv, 2022

1. Academic discipline description

«Inorganic and Analytical Chemistry»

Field of knowledge, direction, specialty, education and qualification level		
Educational and Qualification level qualification	bachelor	
Direction	202 “Plant protection and Quarantine”	
Educational program	Plant protection and Quarantine	
Characteristics of training programme		
Type	olbligatory	
The total number of academic hours	135	
Number of ECTS credits allocated	4,5	
Number of modules	4	
Forms of control	Exam	
Indicators of academic discipline for full-time and part-time forms of training course		
	Full-time	**Part-time**
Year (course)	1	
Semester	1	
Number of lectures	45	
Number of seminars, practical classes		
Laboratory sessions (activities)	60	
Independent study	30	
Individual lessons		
Number of weekly in-class academic hours for full-time forms of training	7 2	

2. Goal and objectives of academic discipline

Goal is to build a good foundation in chemical knowledge that allows to make qualitative and quantitative inquiries into topics in natural science.

Learning objectives are:

- name ionic and covalent compounds;
- know the properties of acids, bases and salts;
- apply stoichiometry in determining quantity relationships for compounds and chemical reactions;
- demonstrate an understanding of chemical equilibrium;
- understand the structure of matter on atomic and molecular levels and its correlation to chemical and physical properties;
- describe the concentration of a solution in the way that is most appropriate for a particular problem or application;
- use laboratory equipment and make observations to identify chemical and physical changes.

Learning outcomes :

Upon completion of this course, students should:

know the basic principles and topics of Inorganic and Analytical Chemistry and their application to real world problems.

be able to

- Compose a proper formula for a compound;
- Describe and name inorganic compounds;
- Write and balance chemical equations;
- Determine the composition of any atom or ion;
- Explain periodicity;
- Distinguish ionic, polar and nonpolar covalent bond;
- Describe characteristics of solutions;
- Balance oxidation-reduction reactions using the electron balance method;
- Analyze the characteristic properties of non-metals and metals;
- Use standard laboratory equipment for qualitative and quantitative

analysis.

Competences

General competences

- Ability to apply chemistry knowledge and understanding to the solution of qualitative and quantitative problems of an unfamiliar nature.
- Ability to apply such knowledge and understanding to the solution of qualitative and quantitative problems.
- Ability to conduct risk assessments concerning the use of chemical substances and laboratory procedures.
- Ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to chemistry.

Professional competences

- Ability to interpret data derived from laboratory observations and measurements in terms of their significance and relate them to appropriate theory.
- Ability to recognize and analyze novel problems and plans strategies for their solution.
- Ability to recognize and implement good measurement science and practice.
- An in-depth knowledge and understanding of an specific area of chemistry.
- Awareness of major issues at the frontiers of chemical research and development.

3. Discipline Program

Module №1. Theoretical foundations of inorganic chemistry.

Lecture # 1. Introduction. General laws of stoichiometry and types of chemical reactions - 2 hour

Chemistry as the central science. Matter, energy, and their interrelationship. Inorganic chemistry. Analytical chemistry. Some fundamental definitions. A chemical reaction. Energy and entropy. Stoichiometry. Types of chemical reactions.

Lecture #2. Atomic Theory. Atomic structure of chemical elements - 4 hours.

Investigating atoms and atomic theory. Atomic Models. Atomos theory. Timeline of atomic theory. Dalton’s model and theory. Thomson’s Plum Pudding Model. Rutherford’s Gold Foil Experiment. Rutherford’s Model. Bohr’s Model. Wave particle duality. Electron cloud. The atom as a nucleus with orbital

electrons (Nuclear Model). Subatomic particles (protons, neutrons and electrons). Atomic number, mass number and isotopes. Molar mass and Avogadro's number. Atomic structure: Electrons in the structure of the atom. Wave particle duality and the dual nature of electrons. Bohr theory and the atomic spectra of hydrogen. Limitations of the Bohr theory. The Heisenberg uncertainty principle. Orbitals. Quantum numbers. Pauli exclusion principle. Build-up of elements – Aufbau principle, Hund's rule. Sequence of energy levels. Electron configurations.

Lecture #3. The Periodic Law and Periodic Table of chemical elements- 3 hours.

The Periodic Law. Periodic Table of chemical elements. Classification of chemical elements. Periods. Groups and Familys. Electron configurations and the periodic table. The periodic table and the behavior of electrons. Atomic Radius. Ionization Potential. Electron Affinity. Periodic Table and Periodic Trends.

Lecture #4. Chemical bonding and structure of molecules - 2 hours.

Review of Chemical Bonding. Valence Electrons. Octet Rule. Ionic Bonding. Covalent polar- and non-polar bonds. Electronegativity. Molecular Polarity. Lewis Dot Structures. Bond Length. Bond Angles. Types of Bonds.

Lecture #5. Chemical kinetics and equilibrium - 2 hours.

Kinetics as the part of chemistry. Collision theory. Rate of chemical reactions. Factors affecting the rate of reaction. Concentration changes and chemical rate. Activation energy. The forward and reverse reactions. Chemical equilibrium. Phase equilibrium. Solution equilibrium. The Equilibrium Expression. Le Chatelier's Principle. Temperature changes and Le Chatelier's Principle. Entropy and Enthalpy. The Equilibrium Constant.

Module №2. The Main Laws of Chemical Transformations

Lecture #6. Solutions, their nature and properties - 3 hours.

Solutions, solvent and solute. Types of Solutions (Gas, liquid and solid). Solution Stoichiometry: expressing concentration in various units (mass per unit volume, moles per unit volume, percentage and fractions, normality, molarity, titre), reaction stoichiometry calculations involving solutions. Conversion between concentration measures.

Lecture #7. Electrolytes and reactions in their solutions - 3 hours.

Electrolytes and nonelectrolytes. Electrolytic dissociation. Strong, weak and moderate electrolytes. Hydration. Molecular equations. Ionic equations, net ionic equations. Steps in writing a net ionic equations. Arrhenius's Theory of Electrolytic Dissociation. Degree of Dissociation (Ionazation). Dissociation Constant or Ionization Constant. Ostwald's dilution law.

Lecture #8. Hydrolysis of salts- 4 hours.

Fundamental characteristics of water. Hydrogen Ions from Water. Self-Ionization of Water. Ionic product of water. Ion-product constant for water (Kw). Hydrogen-ion concentration. Basic, acidic and neutral solutions. The pH Concept. pH scale ranges. Hydrogen ions and pH. Calculating pH. Measuring pH. Acid-Base Indicators. pH Meters.

Neutralization opposite hydrolysis. Types of hydrolysis: anion-hydrolysis, cation-hydrolysis, cation-anion-hydrolysis, no hydrolysis. Degree of hydrolysis. Hydrolysis constant. Buffers.

Lecture #9. Coordination compounds - 2 hours.

Coordination (Complex) Compounds. Structure of a Coordination Compound. Central metal atom, ligands. Coordination number. Complex charge. Charge of coordination compound. Forming complexes/complex ions. Werner's Theory. Electrolytic Dissociation of complex compounds. Instability, stability constants. Nomenclature of Coordination Compounds.

Module №3. Redox reactions. Chemistry of the elements.

Lecture #10. Oxidation-Reduction (Redox) reactions - 3 hours.

Introduction to Oxidation and Reduction. Oxidizing and redusing agents. Oxidation numbers of an atom in a molecules. Balancing redox reactions. General types of redox reactions. Disproportionation reactions. Halogen displacement reactions. Standard reduction potentials of half reactions.Most common oxidizing and reducing reagents. Redox reactions in everyday life.

Lecture #11. Hydrogen. The Halogens - 3 hours.

Hydrogen as the first element of the periodic table. Hydrogen production. Atomic structure and some physical propertyes of Halogens. Preparation of

Halogens. Chemical propertyes of Chlorine,Bromine and Iodine. Oxidizing propertyes. Oxoacids and oxoanions of the halogens. Oxoacids and oxoanions of the halogens. The oxoacids of bromine and iodine. Uses of halogens' compounds. Oxoacids and oxoanions of the halogens. Changing redox properties depending on the valence state of chlorine. Bleach Pouder. Hypochlorite. Chlorite. Chlorate. Perchlorate. Bromate, Iodate. The biological role of fluorine, chlorine, bromine and iodine.

Lecture #12. Group VIA. Oxygen, Sulfur, Selenium, Tellurium and Polonium -2 hours.

General characteristics of VI A group elements. Oxygen. Structure and properties of molecules and molecular ions of oxygen.Understanding the mechanisms of reactions involving oxygen, interaction with hydrogen, metals and nonmetals. Sulphur. Allotropic modifications. Physical and chemical properties. Redox duality elemental sulphur. Compounds of sulphur with hydrogen and metals. Hydrogen sulphide. Sulphur compounds with oxygen. Sulphur (IV) oxide. Compounds of sulphur (VI). Sulphur hexafluoride, sulphuryl chloride, chlorosulphonic acid. Sulphur (VI) oxide. Sulphuric acid. Selenium and tellurium as an analogs of sulfur. Selenium (IV) oxide. Its acidic and oxidizing properties. Salenic acid. Comparis on of properties selenic and selenous acids with sulphuric and sulphurous acids. The use of compounds.

Lecture #13-14. Group VA. Nitrogen, Phosphorus, Arsenic, Antimony and Bismuth. General properties of metels. - 4 hours.

General characteristics. Valence state of elements of V A. Nitrogen. Nitrogen molecule. Bonding energy and chemical activity. Nitrogen compounds with negative oxidation number. Ammonia, hydrazine, hydroxylamine. Amides and nitrides. Ammonium hydrate. Hydrolysis ammonium salts. Thermal decomposition. Qualitative reaction to ammonium cation. Nitrogen compounds with positive oxidation number. Oxides of nitrogen. The nature of chemical bonding and structure of molecules. Preparation. Structure and properties of nitric acid. Nitrous acid. Nitrites. Redox duality. Interaction of nitric acid with metals. "Aqua regia".

Phosphorus. General characteristics. Comparison properties of nitrogen, phosphorus and their compounds. Allotropic modifications of phosphorus. Chemical activity. Phosphine, phosphonium salt. Phosphides. Phosphorus compounds with positive oxidation number. Halides and their hydrolysis. Oxides, their interaction with water. Phosphorous acid. Ortophosphoric, metaphosphoric and diphosphoric acids. Elements of Arsenic subgroups. Arsenic, antimony and bimuth.

Module №4. Analytical Chemistry

Lecture #15-16. Analytical chemistry as a science. Qualitative analysis - 5 hours.

Introduction. Chemical methods of analysis. Qualitative analysis as a process for identification of a substances. The characteristic qualitative analytical reactions that are used in the chemical methods of the qualitative analysis. Dry or wet analytical reactions. Flame test. Bead test. Conditions of the analytical reactions. Specific reactions. Fractional analysis. The systematic course of analysis. Parameters of sensitivity of chemical reactions. Ways to improve the sensitivity of the analytical reaction.Cations classification by ammino-phosphate method. General characteristic of the I - IV analytical groups of cations. Classifying anions. Applying the group reagents in the analysis of anions.

Lecture #17. Quantitative analysis - 3 hours.

Quantitative analysis as the set of experimental methods allowing to determine the quantitative content (concentration) of individual components and impurities in the sample of material to be researched. Chemical methods of analysis. Gravimetric (weight) methods. Precipitation methods. Titrimetry methods. Titration as the analysis process. Equivalent. The measurement of liquid volume. Neutralization method. Titration curve. Permanganatometry. Iodometry. Bromatometry. Complexometric method. Water hardness.

4. The structure of the curriculum of academic discipline for full-time form of training

Themes and modules to be covered	Number of hours											
	Full-time						Part-time					
	Total	including					Total	including				
		lect.	pract.	lab.	ind.	ind.		lect.	pract.	lab.	ind.	ind.
1	2	3	4	5	6	7	8	9	10	11	12	13
Theme module 1. **Theoretical foundations of inorganic chemistry**												
Theme 1. Introduction. General laws of stoichiometry and types of chemical reactions.	6	2		4		10						
Theme 2. Atomic structure of chemical elements.	6	4		2								
Theme 3. The Periodic Law and Periodic Table of chemical elements.	8	3		5								
Theme 4. Chemical bonding and structure of molecules.	6	2		4								

Theme 5. Chemical kinetics and equilibrium.	2	2		-								
Total with theme module 1.	**38**	**13**		**15**		**10**						
Theme module 2. **Solutions, their nature and properties**												
Theme 1. Solutions, their nature and properties.	6	3		2		10						
Theme 2. Electrolytes and reactions in their solutions.	6	3		4								
Theme 3. Hydrolysis of salts.	8	4		4								
Theme 4. Coordination compounds.	6	2		4								
Total with theme module 2.	**36**	**12**		**14**		**10**						
Theme module 3. **Redox reactions. Chemistry of elements**												
Theme 1. Redox reactions.	8	3		4		5						
Theme 2. Elements of VII-A sub-group.	7	3		2								
Theme 3. Elements of VI-A sub-group.	2	2		2								
Theme 4. Elements of V-A sub-group.	7	2		3								
Theme 6. General properties of metals.	8	2		2								
Total with theme module 3.	**34**	**12**		**13**		**5**						
Theme module 4. **Analytical Chemistry**												
Theme 1. Analytical chemistry as a science	4	2		2		5						
Theme 2. Qualitative analysis	7	3		6								
Theme 3. Quantitative analysis	11	3		10								
Total with theme module 4.	**27**	**8**		**18**		**5**						
Totally	**135**	**45**		**60**		**30**						

4. Themes of laboratory activities

#	Name of theme	Number of hours
1	General rules of activity in chemical laboratory. Rules of laboratory research. Control test – level of the secondary school knowledge.	2
2	Principles of classification of inorganic compounds and these ranges.	4
3	Studying of the chemical properties of different types of inorganic compounds. Control test – classification and properties of inorganic compounds.	4
4	Rules of composition of electronic formulas of the chemical elements, determination of their possible valence and oxidation numbers.	3
5	Types of chemical bonding and structure of molecules of acids, bases, salts, oxides. Control test – compilation of electronic formulas and determination of types of chemical bonding.	2
6	Solutions, their nature and properties. Units of concentration.	2
7	The rules of the chemical reactions compilation in the solutions of electrolytes. Control test: ionic reactions.	4
8	The rules of the chemical reactions compilation of the salts hydrolysis and determination of pH. Lecture's control test: hydrolysis of salts.	4
9	Rules of compilation of red-ox reactions. Control test.	4
10	Rules of compilation of coordinative compounds formulas and reactions with their participation. Studying of their properties. Control test.	4
11	Halogens and their compounds on the example of chlorine and bromine.	2
12	Oxygen, sulfur and their compounds.	2
13	Nitrogen, phosphorus and their compounds. Control Test.	3
14	Chemical properties of the same metals of main and secondary sub-groups. Control Test.	2
15	The first analytical group of cations	1
16	The second analytical group of cations	2
17	The third analytical group of cations	1
18	The forth analytical group of cations	1
19	The first analytical group of anions	2
20	The second analytical group of anions	1
21	The third analytical group of anions	1
22	Analysis of unknown substances	3
23	Determination of alkali solution normality	2
24	Complexometric titration	2
25	Permanganatometric determination of Iron(II) content in Mohr's salt	2
	Totally	**60**

5. Independent study

#	Name of theme	Number of hours
1	Molar ratios, molar masses, balancing and interpreting equations, conversions between grams and moles.	4
2	The electronic arrangements and dots-and-crosses diagrams.	2
3	Atomic number as the basis for the Periodic Law. Long form periodic table.	2
4	Lewis Structures. Exceptions to Regular Lewis Structures - resonance structures	2
5	Catalysts and catalysis. Dynamic equilibria.	2
6	Colligative properties of solution.	2
7	Dilute concentrations units: ppm, ppb,ppt.	5
8	Use of Hydrolysis in the "Real World".	2
9	Lewis Acid-Lewis base approach to bonding in complexes.	2
10	Half-reactions. Nernst Equation.	2
11	Metal halides. Interhalogen compounds.	2
12	Allotropes of Oxygen and Sulfur.	2
13	Occurrence of pnictogens.	2
14	Properties of alkali and alkali-earth elements.	2
	Totally	**30**

6. Test questions for final assessment

Екзаменаційні питання	
1. Atomic structure. Quantum numbers of electrons in atoms. Write complete electron configuration of the Sulfur atom and draw all possible exited states. Note valences, maximum and minimum oxidation numbers of this element.	
2. Bases. Classification, preparation and examples of bases. Which substances may react with each other: P_2O_5, NaOH, ZnO, HF, CaO? Write corresponding reactions.	
Тестові завдання	
1. Which formula contains error?	
A. $CaHSO_4$	**C. NH_4HSO_4**
B. $(NH_4)_2SO_4$	**D. $CaHPO_4$**
2. Point the correspondence between formula of compound and type of a chemical bond:	
A. $BaCl_2$	**1. A metallic bond**
B. Zn	**2. An ionic bond**
C. O_2	**3. A non-polar covalent bond**
D. NH_3	**4. A polar covalent bond**
A. , B. , C. , D. .	
3. Percent by mass of solution contained 15 g of $(NH_4)_2SO_4$ in 250 g of water, is:	
A. 3,9%	**C. 4,8%**
B. 1,5%	**D. 5,7%**
4. What is it necessary to add to K_3PO_4, so that K_2HPO_4 can be formed:	
A. KOH	**C. H_2SO_4**
B. KCl	**D. H_3PO_4**
5. Write all possible reactions between $Ba(OH)_2$ and H_2SO_4 (taking into account the possibility of neutral, acidic and basic salts forming).	
6. Note oxidation number and coordination number of the central atom in the complex compound - $[Cr(NH_3)_5Br]SO_4$.	
A. +2, 4	**D. +3, 6**
B. +2, 6	**E. +4, 6**
C. +3, 4	
7. Complete Redox reaction. Write electron balance. Determine oxidizing and reducing agents calculate sum of coefficients in equation: $Ca + H_2SO_{4(conc.)} \rightarrow$	
A. 16	**C. 17**
B. 18	**D. 10**
8. Calculate a sum of coefficients in the molecular equation for 1st step hydrolysis of Zinc Sulfate and write molecular, complete ionic, and net-ionic	

reactions.	
A. 8	**C. 6**
B. 4	**D. 7**
9. What substances are strong electrolytes? **$Zn(OH)_2$ 2. HNO_3 3. HClO 4. HF 5. CH_3COOH 6. $CaCl_2$**	
A. 1 i 4	**D. 3 i 5**
B. 2 i 6	**E. 2 i 3**
C. 3 i 4	
10. Bonds of central atom with ligands in complex compounds are realized due to:	
A. Ionic bond;	**C. Covalent bond;**
B. Donor-acceptor covalent bond;	**D. Metallic bond.**

7. Teaching Methods

A **teaching method** comprises the principles and methods used for teaching. Commonly used teaching methods for studying subject Water Resources Management include class participation, demonstration, recitation, memorization, or combinations of these. The choice of teaching method or methods to be used depends largely on the information or skill that is being taught, and it may also be influenced by the aptitude and enthusiasm of the students.

Explaining, or lecturing, is the process of teaching by giving spoken explanations of the subject that is to be learned. Lecturing is often accompanied by visual aids to help students visualize an object or problem.

Demonstrating is the process of teaching through examples or experiments. For example, a science teacher may teach an idea by performing an experiment for students. A demonstration may be used to prove a fact through a combination of visual evidence and associated reasoning.

Demonstrations are similar to written storytelling and examples in that they allow students to personally relate to the presented information. Memorization of a list of facts is a detached and impersonal experience, whereas the same information, conveyed through demonstration, becomes personally relatable. Demonstrations help to raise student interest and reinforce memory retention because they provide connections between facts and real-world applications of those facts. Lectures, on the other hand, are often geared more towards factual presentation than connective learning.

Collaboration allows students to actively participate in the learning process by talking with each other and listening to other points of view. Collaboration establishes a personal connection between students and the topic of study and it helps students think in a less personally biased way. Group projects and discussions are examples of this teaching method. Teachers may employ collaboration to assess student's abilities to work as a team, leadership skills, or presentation abilities.

Collaborative discussions can take a variety of forms, such as fishbowl discussions. After some preparation and with clearly defined roles, a discussion may constitute most of a lesson, with the teacher only giving short feedback at the end or in the following lesson.

Learning by teaching is the method, when students assume the role of teacher and teach their peers. Students who teach others as a group or as individuals must study and understand a topic well enough to teach it to their peers. By having students participate in the teaching process, they gain self-confidence and strengthen their speaking and communication skills.

8. Forms of control

The main forms of knowledge control are control at the lectures at seminars and workshops, outside the classroom, at the consultations, tests and exams. I. Control of the lectures can be conducted as a selective oral questioning of students or tests using the previously laid material, particularly in sections of the course that are necessary for the understanding of the lecture topics, read, or to establish a degree of mastery of the material lectures (held by the manner of the late first or early second hour lectures). Testing during lectures designed to teach students to systematic elaboration covered material and prepare for the upcoming lectures, establish the degree of assimilation
theory to identify the most difficult students to read chapters from the following explanation of them. Control of the lectures has to subtract time. By spending time to control oral examination yields control, programmable for cards. II. Current control on practical, seminar and laboratory studies conducted to elucidate ready students for employment in the following forms:

1. Writing (45 min.) Control work.

2. Colloquium on separate sections of theoretical courses (modules or themes). III. Credits. Some subjects (theoretical courses, practical training) is applied differential test of performance appraisal on a five point scale. In a lecture course or
its individual parts, which are not accompanied by laboratory or practical classes, the teacher may conduct interviews or colloquium, offer oral or written (with tickets) questions. TeacherUseful browse the students' notes. Often, students are subject to crediting as minor, insignificant and do not give enough time to prepare for it. Of the major courses before credit of Colloquium useful.

Term papers are the product of many days of work. They include elements of scientific research. Protecting course work - a special form of offset in the commission of two or three teachers. Best of coursework submitted for scientific student conference.
IV. Examinations. Exam is the final step in the study of the whole or part of the discipline and are designed to test students' knowledge on the theory and identify the skills apply the acquired knowledge in solving practical problems, as well as independent work skills with educational and scientific literature.

Student’s rating of knowledge of an academic discipline consists of training work rating – 70 points and attestation rating – 30 points. Thus, rating of content modules, that are constituents of an academic discipline, makes 70 points. Rating of content modules as well as attestation rating are also measured by 100-point-scale.

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10. Distribution of points received by students. Assessment of student knowledge is on a 100-point scale and is translated into national assessments according to table. 1 "Regulations on examinations and tests in NULES of Ukraine" (order of entry into force of 27.12.2019 № 1371)

Evaluation and grading
Grading system: National and ECTS

National grade	Grade according to national system	Percentage score
passed	Excellent	90 – 100
	Good	74-89
	Satisfactory	60-73
Not-passed	Unsatisfactory	0-59

To determine the rating of the student (listener) for mastering the discipline $\mathbf{R_{dis}}$ (up to 100 points), the received rating from the attestation (up to 30 points) is added to the rating of the student (listener) from
educational work **Rew** (up to 70 points): **Rdis**= **Rew** + **Rat**

11. Technology and methodological requirements

1. Inorganic Chemistry. Manual. Voytenko L., Kosmatiy V., Kopilevich V., Prokopchuk N. - Kyiv: NAU Publish., 2014. - 148 p.
2. Workbook on Inorganic Chemistry. Voytenko L., Kosmatiy V., Kopilevich V., Prokopchuk N. - Kyiv: NAU Publish., 2014. - 85 p.

12. Required and recommended literature

Basic

1. Introduction in General, Organic and Biochemistry, 7th Edition, by Morris Hein, Leo R. Best, Scott Pattison and Susan Arena, Brooks/Cole Publishing Co., 2001, 872 pp.
2. Inorganic Chemistry, second edition, D. F. Shriver, P. W. Atkins, and C.H. Langford; W. H. Freeman and Co., New York, 1994, 913 pp.
3. Glinka N.N. General Chemistry. Moscow: Nauka, 1966, 432 pp.

Supplemental

1. Concepts and Models of Inorganic Chemistry, third edition, B. E. Douglas, D. H. McDaniel and J. J. Alexander; John Wiley & Sons, Inc., New York, 1994. 993 p.
2. Inorganic Chemistry, A Modern Introduction, T. Moeller; John Wiley & Sons, New York, 1982. 846 p.
3. Chemistry of the Elements, N. N. Greenwoo and A. Earnshaw; Pergamon Press, New York, 1984. 1542 pp.

13. Normative literature

1. ISO 6353-2:1983 Reagents for chemical analysis -- Part 2: Specifications -- First series.
2. ISO 6058:1984, Water quality - Determination of calcium content - EDTA titrimetric method ISO 6058:1984, Water quality - Determination of calcium content - EDTA titrimetric method.
3. ISO 6059 – 1984 Water quality – Determination of the sum of calcium and magnesium – EDTA titrimetric method.

14. IT resources

1. https://elearn.nubip.edu.ua/course/view.php?id=1185
2. http://www.informika.uatext/database/chemy/Enu/Data/Ch1-7.html
3. http://dbhs.wvusd.k12.ca.us/AcidBase/Kw.html
4. http://dbhs.wvusd.k12.ca.us/AcidBase/Hydrolysis.html
5. http://hyperphysics.phy-astr.gsu.edu/hbase/chemical/bond.html
6. http://chemlab.pc.maricopa.edu periodic/triangletable.html
7. http://www.pc.chemie.uni-siegen.de/pci/versuche/english/kapite14. htm