NATIONAL UNIVERSITY OF LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

Department of Analytical and Bioinorganic Chemistry And Water Quality

APPROVED

by the Dean of the Faculty <u>of Plant Protection, Biotechnology and Ecology</u> Yuliia KOLOMIIETS "19" 06 2025

CURRICULUM OF ACADEMIC DISCIPLINE CHEMISTRY (INORGANIC AND ANALYTICAL)

Area of knowledge <u>E «Natural Sciences, Mathematics and Statistics</u>" Specialty <u>E2 Ecology</u>

Academic programme Ecology

Faculty of Plant Protection, Biotechnology and Ecology

Developed by: Docent, Candidate of Chemical Sciences Larysa VOITENKO

(position, academic degree, academic rank)

Kyiv-2025

Description of the discipline Chemistry (inorganic and analytical)

Inorganic chemistry studies the theoretical foundations of the modern inorganic chemistry, including the chemical properties and transformations of macronutrients, micronutrients, toxic elements and their compounds. Chemical properties are described in terms of atomic-molecular studies, acid-base chemistry, redox processes and complexation. The laboratory course involves the preparation and study of a number of types of inorganic and complex compounds. Analytical chemistry (chemical analysis) is the area of chemistry responsible for characterizing the composition of matter, both qualitatively (what is present) and quantitatively (how much is present). Course includes: (1) the qualitative tests of cations and anions; (2) methods of identification of soluble and insoluble substances; (3) gravimetric analysis; (4) volumetry (neutralization, RedOx methods, precipitation titrimetry; complexonometry).

Area of knowledge, specialty, academic programme, academic degree					
Academic degree	Bachelor's				
Specialty	E2 Ecology				
Academic programme	Ecology				
Charac	cteristics of the disc	cipline			
Туре		Mandatory			
Total number of hours		150			
Number of ECTS credits		5			
Number of modules		4			
Form of assessment		exam			
Indi	cators of the discip	line			
for full-time and	part-time forms of	university study			
		University study			
	Full-time	Part-time			
Year of study	1				
Term	15 weeks				
Lectures	60 ho	ours hour			
Practical classes and seminars	ho	ours hour			
Laboratory classes	60 ho	ours hour			
Self-study	30 ho	ours hour			
Number of hours per week for full- time students	8 ho	ours			

1. Aim, competences and expected learning outcomes of the discipline

Aim <u>is to develop an understanding of the range and uses of inorganic chemistry and</u> <u>analytical qualitative and quantitative methods for the application in monitoring and research of</u> <u>the environmental objects, and formation of skills in chemical experiment performing.</u>

Competences acquired:

Integral competence (IC): <u>The ability to solve complex specialized tasks and solve practical</u> problems in the field of ecology, environmental protection and sustainable use of nature, or in studies that involve the application of basic theories and methods of environmental sciences and are characterized by the complexity and uncertainty of conditions.

General competence (GC):

GC08. Ability to conduct research at an appropriate level.

GC11. <u>Ability to evaluate and ensure the quality of work performed.</u> Special (professional) competence (SC): SC16. <u>Ability to critically reflect on the basic theories, methods and principles of the natural sciences.</u>

Expected learning outcomes (ELO):

ELO03. Understand the basic concepts, theoretical and practical problems in the field of natural sciences, which are necessary for analysis and decision-making in the field of ecology,

environmental protection and optimal nature use.

ELO21. Be able to choose the optimal methods and tools for conducting research, collecting and processing data.

2.	Programme	and	structure	of t	he d	liscip	line

	Number of hours											
	full-time				part-time							
Modules and topics	including		including									
	s s	total	lec	lab	in d.	s.st.	al	1	p	la b	ind.	s.st.
Module 1. Theoretical Fo	undatio	ns of th	e Inorg	anic (Chemi	istrv. T	he Ge	nei	ral L	aws a	of Che	mical
		<i>1</i>	ransfor	matio	ns	0					5	
Topic 1. Chemistry as the science	1	5	2	2								
Topic 2. Atomic structure of chemical elements	1	6	2	2								
Topic 3. Periodicity of changes in structure and properties of elements and their compounds	2	5	2	2		6						
Topic 4. Chemical bonding and molecular structure	2	6	2	2								
Total for module 1		22	8	8		6						
Modu	le 2. <i>The</i>	e gener	al laws o	of che	mical	l transf	forma	tior	IS			
Topic 1. Chemical kinetics and equilibrium	3	5	2	2								
Topic 2. Solutions and their properties. Electrolytes and electrolytic dissociation. Ionic equations.	3	6	2	2		8						
Topic 3. Hydrolysis of salts. Notion of a pH	4	10	4	4								
Topic 4. RedOx processes	5	10	4	4								
Topic 5. Complex (coordination) compounds	6	9	4	4								
Total for module 2		40	16	16		8						
Module 3.	Chemist	ry of el	ements (and q	ualita	tive ch	emica	ıl a	naly	sis		
Topic 1. Subjects and objects of the chemical analysis (analytical chemistry). Methods of quantitative analysis of the chemical elements and their compounds.	7	6	2	2		6						
Topic 2. Chemical- analytical properties of the cations on the examples of s-elements	7-8	16	6	6								

belongs to IA and IIA												
groups, p-elements												
belongs to IIIA and IVA												
groups, and d-elements of												
the IIIB and VB groups.												
Topic 3. Chemical-												
analytical properties of												
the cations on the												
examples of p-elements												
belongs to VIIA, VIA,	0.10	16	0	0								
VA, and IVA groups.	9-10	16	8	8								
Qualitative analysis of												
inorganic substances												
(salts, acids, bases,												
oxides).												
Total for module 3		38	16	16		6						
Module 4. <i>Theoretical</i>	and exp	erimen	tal foun	datior	ns of t	the qua	ntitat	tive	cher	mical	analy	sis
Topic 1. Equilibrium in			U			-						
heterogeneous and												
homogeneous systems.												
Precipitation and sediment	11	10	4	4								
dissolving reactions; their												
application for qualitative												
and quantitative analysis												
Topic 2. Theoretical												
foundations of												
measurement and												
processing of results in												
chemical analysis. The	12	10	4	4								
essence and task of												
quantitative						10						
measurements and						10						
calculations.												
Topic 3. Titrimetric												
methods of quantitative												
analysis (volumetry). The												
application of volumetric	13	10	4	4								
methods in environmental												
analysis. Neutralization												
method.												
Topic 4. RedOxmetry in	14	10	4	4								
quantitative analysis.	17	10	т	т								
Topic 5.												
Complexonometry in	15	10	4	4								
quantitative analysis.												
Total for module 4		50	20	20		10						
Total hours			60	60		30						

3. Topics of lectures

No.	Topic	Hours
1	Chemistry as the science that deals with the properties, composition, and	2
	structure of substances.	
2	Atomic structure of chemical elements	2
3	Periodicity of changes in structure and properties of elements and their	2
	compounds	

4	Chemical bonding and molecular structure	2
5	Chemical kinetics and equilibrium	2
6	Solutions and their properties. Electrolytes and electrolytic dissociation. Ionic	2
	equations.	
7, 8	Hydrolysis of salts. Notion of a pH	4
9, 10	Foundations of RedOx processes	4
11,	Complex (coordination) compounds	4
12		
13	Subjects and objects of the chemical analysis (analytical chemistry). Methods	2
	of quantitative analysis of the chemical elements and their compounds.	
14,	Chemical-analytical properties of the cations on the examples of s-elements	6
15,	belongs to IA and IIA groups, p-elements belongs to IIIA and IVA groups,	
16	and d-elements of the IIIB and VB groups.	
17,	Chemical-analytical properties of the cations on the examples of p-elements	8
18,	belongs to VIIA, VIA, VA, and IVA groups.	
19,	Qualitative analysis of inorganic substances (salts, acids, bases, oxides).	
20		
21,	Equilibrium in heterogeneous and homogeneous systems. Precipitation and	4
22	sediment dissolving reactions; their application for qualitative and quantitative	
	analysis	
23,	Theoretical foundations of measurement and processing of results in chemical	4
24	analysis. The essence and task of quantitative measurements and calculations.	
25,	Titrimetric methods of quantitative analysis (volumetry). The application of	4
26	volumetric methods in environmental analysis. Neutralization method.	
27,	RedOxmetry in quantitative analysis.	4
28		
29,	Complexonometry in quantitative analysis.	4
30		

4. Topic of laboratory classes

No.	Торіс	Hours
1	Introduction. Lab Safety rules. Semimicro qualitative lab techniques. The	2
	introduction testing.	
	General chemical properties of main classes of inorganic substances.	
	Chemical name Calculator application	
	(https://www.omnicalculator.com/chemistry/chemical-name)	
2	Electron formulas compiling. Determination of valence and oxidation number	2
	of the chemical elements as a function of their electron configuration.	
	Electron configuration simulation (i.e.,	
	https://www.wolframalpha.com/widgets/	
	gallery/view.jsp?id=bd4637e2261cbcdda20d9077e61c712f&reportprob=1)	
3	Periodicity as an expression of electron shell structures. Visualization of the	2
	periodicity (i.e., https://www.behance.net/gallery/46554621/Visualizing-the-	
	Periodic-System-of-Chemical-Elements)	
4	Qualitative assessment of chemical bonding types and molecular structure of	2
	acids, bases, salts, oxides. Virtual simulation of chemical bonds and	
	visualization of molecules (i.e. "Avogadro" tool	
	https://sourceforge.net/projects/avogadro/files/avogadro/)	
5	Experimental studding of strong and weak electrolytes from viewpoint of	2
	Avogadro's electrolytic dissociation theory. How to compile the ionic	
	equations. How to use the net ionic calculator (i.e.,	
	https://www.chemicalaid.com/tools/netionicequation.php?hl=en).	

6	Even minimum to a trading of hydrolymic of solts in water modium. How to mediat	4
0	experimental studing of hydrolysis of saits in water medium. How to predict	4
	https://www.eeleuleteretez.com/en/enionie.selt.hvdrelwis	
	Coloulators/Coloulatoratoz.com/en/anionic-sait-nydroiysis-	
7	Calculators/Calculst-2011).	4
/	Experimental studing of RedOx processes; chemical nature of Reducing and	4
	oxiding agents. RedOx potential and its measuring in water medium. Electron	
	balance and half-reaction methods. How to use a RedOx calculator (i.e.,	
	https://calculator-online.net/redox-reaction-calculator/).	
8	Experimental studding of complexing processes. How to isolate and	4
	decompose the coordinative compounds. IUPAC nomenclature of coordinate	
	compounds (https://unacademy.com/content/jee/study-	
	material/chemistry/iupac-nomenclature-of-coordination-compounds/)	
9	Introduction to chemistry of elements and their qualitative analysis. The	2
	action of general group reagents on metal cations.	
10	Studding of chemical-analytical properties and qualitative tests of s-element	4
	cations (on the example of Na^+ , K^+ , Ca^{2+} , Sr^{2+} , Mg^{2+}) and ammonia cation	
	NH4 ⁺ . Studding of chemical-analytical properties and qualitative tests of p-	
	element cations (on the example of Al^{3+} , Pb^{2+}).	
11	Studding of chemical-analytical properties and qualitative tests of d-element	4
	cations (on the example of Zn^{2+} , Cu^{2+} , Mn^{2+} , Fe^{2+} , Fe^{3+} , Ag^+).	
12	Studding of chemical-analytical properties and qualitative tests of anions	4
	belongs to p-elements of VIIA, VIA, VA, IVA and IIIA groups (on the	
	example of B^{3+} , C^{4+} , $S^{i^{4+}}$, N^{5+} , P^{5+} , O^{-1} , S^{4+} , S^{6+} , C^{1-} , $B^{}$, I^{-}).	
13	Analytical classification of the main bioactive cations Separation and	4
15	identification of LIV cation groups according to the ammine-phosphate	•
	classification	
1/	Analytical classification of the main bioactive anions Separation and	1
17	identification of anions SO_{4}^{2-} SO_{2}^{2-} CO_{2}^{2-} PO_{4}^{3-} CI^{-} Br I^{-} NO_{2}^{-} NO_{2}^{-}	т
15	The identification methods of the inorganic substances qualitative analysis	1
15	Two symptometric control tools for the analysis of increasing synctroness.	4
16	Two experimental control tasks for the analysis of morganic substances.	4
16	Experimental strategies of quantitative analysis: weigning, measuring vessels,	4
	filtering. Volumetric analysis. Calculations in volumetric analysis.	
	Neutralization method. Preparation of primary and secondary standard	
	solutions.	
	Experimental control tasks:	
	- Concentration of alkali in water solution;	
	- Determination of temporary water hardness of water sample.	
17	RedOx volumetric methods of quantitative analysis. Preparation of primary	4
	and secondary standard solutions of Permanganatometry and lodometry.	
	Experimental control tasks:	
	- The permanganatometric determination of Fe(II) concentration in water	
	solution of Mohr's salt;	
	- The iodometric determination of Cu(II) content in solid copper vitriol.	
18	Complexonometric volumetric method of quantitative analysis. Preparation of	4
	primary and secondary standard solutions of Trilonometry method.	
	Experimental control tasks:	
	- Determination of total water hardness of water sample;	
	- Determination of Calcium content in water solution.	
	Total	60

5. Topics of self-study

No.	Торіс	Hours
1	Stoichiometric Laws. Application and limitation	2
2	History of atomistic theory developing.	2
3	The foundations of condensed matter chemistry	2
4	Chemical reactions rate and chemical equilibrium in the environmental systems	2
5	Solutions and expression of their concentrations	1
6	Intramolecular hydrolysis	1
7	Redox potentials. Standard electrode potentials of metals. Galvanic elements. The direction of redox reactions. Electrolysis as a redox process. Corrosion of metals as a redox process	2
8	Isomerism of complex compounds. The state of complex compounds in solution.	1
9	Special chemical properties and structure of water as medium of life origin. Features of the biological action and chemistry of selenium and its compounds	1
10	Inorganic chemistry of Arsenic subgroup	1
11	Silicon compounds in the biosphere. Borides and borates, polyborates. Aluminates and aluminosilicates.	1
12	Strontium and barium as Calcium analogues; their role in living nature. Lithium, Rubidium and Caesium and their compounds in plant and animal metabolism	1
13	Biological functions of Copper(II), Zinc, Manganese. Toxic effects of Cadmium and Mercury and their compounds.	2
14	Types of analytical reactions and reagents, their characteristics; classification of analytical reagents and calculations of reaction sensitivity indicators.	2
15	Experimental techniques of qualitative inorganic analysis. Dry and wet reactions. Semimicro apparatus and semimicro analytical operations. Micro apparatus and microanalytical operations. Spot test analysis.	1
16	Training calculations of concentration units recalculations in the environmental application (heavy metals analysis, salty waters mineralization, etc.)	1
17	The ionic strength of natural water systems (salty sea waters, blood, cell juice etc.). Osmosis and ionic strength. Calculation of common ion effect and environmental problems (how to immobilize the heavy metals in soils etc.). Ionic strength calculator (https://www.omnicalculator.com/chemistry/ionic-strength)	2
18	pH graphic method determination. How to prepare of buffer solutions. TRIS solution – preparation and application. How to calculate titration curves of acid mixture titration. Choice of the best acid-base indicators and their preparation.	1
20	Assessment of reliability of analytical data. Reproducibility and correctness of experimental data. Types of systematic errors. Individual and instrumental systematic errors. Determination of systematic error and its influence on the results of the analysis. Random error. Basic concepts of classical statistics.	2
21	RedOx calculation of ionic species of metals of changing valences in natural systems (iron, manganese). RedOx potential of natural waters and soils. Chemical oxygen demand (COD) of natural waters as application of RedOx volumetric methods in the environmental analysis.	1
22	Chelates as food additives, drugs, and analytical reagents. Using of complexones in environmental sanitation.	1
	Total	30

6. Methods of assessing expected learning outcomes:

- Oral or written survey;
- Interview;
- Test;
- Defending laboratory works;
- Peer-to-peer assessment.

7. Teaching methods:

- Problem-based method;
- Practice oriented studying method;
- Case method;
- Research based method;
- Learning discussions and debates method.

8. Results assessment

The student's knowledge is assessed by means of a 100-point scale converted into the national grades according to the "Exam and Credit Regulations at NULES of Ukraine" in force

8.1. Distribution of points by types of educational activities

Educational activity	Results	Assessment					
Module 1. Theoretical Foundations of the Inorganic Chemistry. The General Laws of							
Chemical Tra Lab work 1. Introduction. Lab Safety rules. Semimicro qualitative lab techniques. The introduction testing. Lab work Report. General chemical properties of main classes of inorganic substances Lab work 2. Electron formulas compiling. Determination of valence and oxidation number of the chemical elements as a function of their electron configuration Lab work 3. Periodicity as an expression of	ELO03 For understanding of the basic concepts, theoretical and practical problems in the field of natural sciences: to know and understand the subject area and professional activity: to be able to work and analyze scientific and educational literature on the Chemistry; Gain practical skills and be able monitor and evaluate current condition of environment based on chemical concepts; to have skills for	5 15 10 5					
electron shell structuresLab work 4. Qualitative assessment ofchemical bonding types and molecularstructure of acids, bases, salts, oxides.	analysis and decision-making in the field of ecology, environmental protection and balanced nature management	5					
Module control work		50					
Self-study 2 Testing via Elern		10					
Total for module 1		100					
Module 2. The general laws of	of chemical transformations						
Lab work 5. Experimental studding of Avogadro's electrolytic dissociation theory on the examples of the interactions in aqua solutions. Lab work Report.	5						
Control work. Ionic equations compilation.	compounds for the analysis and	10					
Lab work 6. Experimental studding of hydrolysis of salts in water medium. Lab work Report.	5						

Control work. Compilation of molecular and ionic equations of the salt hydrolysis;	for analyzing the influence of acid base processes on the water systems state: acid-base equilibrium and	10
Lab work 7. RedOx processes. Lab work	complexing for monitoring and evaluate current condition of	5
Report.	environment; the concept of strong	
Control work. Compilation of RedOx	and weak electrolytes, complexing	20
processes; balancing using method of electron	processes for the description of	
balance	degree of electrolytic dissociation	
Lab work 8. Experimental studding of complexing processes I ab work Report	and a pH values; to calculate a RedOx potential in natural water	5
Control work Compilation of complexing	bodies and it's influence of the alive	15
equations Structure of complexes and their	matter.	15
requations. Structure of complexes and then		
Module control work 2		20
Salf study 1 Testing via Elem		20
Self-study I Testing via Elem		5
Total for module 2		100
Module 3. Chemistry of elements	and qualitative chemical analy	SIS
Lab work 9. Introduction to chemistry of	ELO 03, ELO 21: For	5
elements and their qualitative analysis.	and principles of qualitative analysis	
Studding of chemical-analytical properties and	of chemical compounds and	
qualitative tests of s-element cations (on the	separate ions in water medium,	
example of Na^+ , K^+ , Ca^{2^+} , Sr^{2^+} , Mg^{2^+}) and	soils, air at the organizing of the	
ammonia cation NH ₄ +. Studding of chemical-	environmental monitoring; how to	
analytical properties and qualitative tests of p-	of semimicro qualitative tests:	
element cations (on the example of Al^{3+} , Pb^{2+}).	understand the importance of	
Lab work Report.	sensitivity and selectivity of test	
Lab work 10. Studding of chemical-analytical	analytical reactions; to understand	5
properties and qualitative tests of d-element	inorganic substances qualitative	
cations (on the example of Zn^2 , Cu^2 , Mn^2 ,	analysis; the importance of the	
Fe ² , Fe ³ , Ag ³). Lab work Report.	chemical analysis in the	_
Lab work 11. Studding of chemical-analytical	environmental sciences and	Э
properties and qualitative tests of anions	planning of the environment	
belongs to p-elements of VIIA, VIA, VA, IVA	monitoring strategy.	
and IIIA groups (on the example of B, C, S^{4+} N ³⁺ N ⁵⁺ D ⁵⁺ O ⁻¹ S ⁴⁺ S ⁶⁺ C ¹⁻ D ^{*-} I ⁻)		
\mathbf{S} \mathbf{N}		
Control work Chemical properties and		10
transformation of the main biogenic chemical		10
elements		
Lab work 12 Studding of analytical		5
classification of the main bioactive cations		5
Separation and identification of I-IV cation		
groups according to the ammine-phosphate		
classification. Lab Work Report.		
Lab work 13. Experimental examination of a		5
Analytical classification of the main bioactive		÷
anions. Separation and identification of anions		
SO_4^{2-} , SO_3^{2-} , CO_3^{2-} , PO_4^{3-} , Cl^- , Br ⁻ , I ⁻ , NO ₂ ⁻ .		
NO ₃ ⁻ . Lab Work Report.		

Lab work 14. Two experimental control tasks		20
for the analysis of inorganic substances. Lab		
Work Report.	-	
Module control work 3.		40
Self-study 3 Testing via Elern		5
Total for module 3		100
Module 4. Theoretical and experimental foun	dations of the quantitative che	mical analysis
Lab work 15. Experimental strategies of quantitative analysis: Volumetric analysis. Neutralization method. Preparation of primary and secondary standard solutions. Experimental control tasks: - Concentration of alkali in water solution; - Determination of temporary water hardness of water sample. Lab Work Report	ELO03 for understanding of the basic concepts, theoretical and practical problems in the field of natural sciences: monitoring of the hydrosphere, pedosphere parameters, soil properties etc. such as water hardness, content of calcium, magnesium, chemical oxygen demand, soil organic matter.	10
Lab work 16. RedOxmetric titration in quantitative analysis. Experimental control task: Determination of Iron(II) content in Mohr's salt. Lab Work Report Topic 5. Complexonometry in quantitative analysis.		10
Lab work 17. Complexonometric titration in quantitative analysis. Experimental control tasks: - Determination of Calcium content in model solution; - Determination of total water hardness. Lab Work Report		10
Solf study 4 Testing vis Elem	4	10
Class work	(N1 + N2 + N2 +	10 14)/4*0 7 < 70
Class WOFK	(1V11 + 1V12 + 1V13 + 1V13)	$\frac{(14)}{4}, \frac{14}{5}, $
Exam/credit		30
Total for year	(Class work	$+ exam) \le 100$

8.2. Scale for assessing student's knowledge

Student's rating, points	National grading (exam/credits)
90-100	excellent
74-89	good
60-73	satisfactory
0-59	unsatisfactory

8.3. Assessment policy

Deadlines and exam retaking rules	Works that are submitted late without valid reasons will be assessed with a lower grade. Module tests may be retaken with the permission
	of the lecturer if there are valid reasons (e.g. a sick leave).
Academic integrity rules	Cheating during tests and exams is prohibited (including using mobile
	devices). Term papers and essays must have correct references to the
	literature used

Attendance rules	Attendance is compulsory. For good reasons (e.g. illness, international internship), training can take place individually (online
	by the faculty dean's consent)

9. Teaching and learning aids:

E-learning course of the discipline https://elearn.nubip.edu.ua/enrol/index.php?id=4107 1. Methodological guidelines "Inorganic and analytical chemistry for bachelor students specialty 101 Ecology / Voitenko L.V., Kopilevich V.A., Prokopchuk N.M., Savchenko D.A., Kravchenko O.O. – Kyiv: Експо-Друк., 2023. - 219 p.

2. Laboratory manual on Inorganic and Analytical Chemistry. Savchenko D.A., Voytenko L.V., Prokopchuk N.M.- Kyiv: Експо-Друк., 2017. - 216 р.

3. Неорганічна та аналітична хімія: підручник / В.А. Копілевич, Д.А. Савченко, Т.І. Ущапівська. – К.: Редакційно-видавничий відділ НУБіП України. 2020. – 596 с.

4. Неорганічна та аналітична хімія: навчальний посібник у формі лабораторного практикуму// Д.А. Савченко, В.А. Копілевич, Т.І. Ущапівська, Н.М. Прокопчук. – К.: ДДП «Експо-Друк». 2021. – 329 с.

5. Analytical Chemistry. Workbook for Bachelor's Students // Voitenko l.V., Kosmaty V.E., Savchenko D.A., Kopilevich V.A. – Kyiv: NUBiP Publ., 2014. – 140 pp.

10. Recommended sources of information

 General and Inorganic Chemistry: textbook/V.O. Kalibabchuk, V.V. Ohurtsov, V.I. Halynska et al.; edited by V.O. Kalibabchuk. – Kyiv : AUS Medicine Publishing, 2019. – 456 p.
Introduction in General, Organic and Biochemistry, 7th Edition, by Morris Hein, Leo R. Best, Scott Pattison and Susan Arena, Brooks/Cole Publishing Co., 2021. – 872 pp.

3. Inorganic Chemistry, second edition, D. F. Shriver, P. W. Atkins, and C.H. Langford; W. H. Freeman and Co., New York, 2004, 913 pp.

4. Harvey D. Modern Analytical chemistry (electron copy). McGraw-Hill Education, 2000. – 556 pp.

5. Harvey D. An Electronic Textbook for Introductory Courses in Analytical chemistry. http://www.freebookcentre.net/chemistry-books-download/An-Electronic-Textbook-for-Introductory-Courses-in-Analytical-Chemistry.html

6. Quantitative Analysis Analytical Chemistry by Dr. Michael J. Prushan http://www.freebookcentre.net/chemistry-books-download/Quantitative-Analysis-Analytical-Chemistry.html

7. Prof. Clemens F Kaminski Analytical Chemistry Notes http://www.freebookcentre.net/chemistry-books-download/Analytical-Chemistry-Notes-(PDF-55P).html

8. ISO 6058:1984. Water quality – Determination of calcium content – EDTA titrimetric method.

9. ISO 6059:1984 Water quality – Determination of the sum of calcium and magnesium – EDTA titrimetric method.

10. Periodical Table - http://www.webqc.org/periodictable.php.

11. Calculator of Molar weight (FW) http://www.graphpad.com/quickcalcs/Molarityform.cfm

12. Units convertor - http://www.webqc.org/unitconverters.php.

13. pH calculator - http://www.webqc.org/phsolver.php.

14. Calculating titrating curves

http://chemwiki.ucdavis.edu/Core/Physical_Chemistry/Equilibria/Acid-

Base_Equilibria/pH_Titration_Curves.

15. Acid-base indicators - http://www.ch.ic.ac.uk/vchemlib/course/indi/indicator.html

16. RedOx indicators choice

http://community.asdlib.org/imageandvideoexchangeforum/2013/07/26/selecting-an-indicator-for-8a-redox-titration