

**MEDICAL UNIVERSITY – PLOVDIV**

**FACULTY OF PHARMACY**

**SYLLABUS**

**IN**

**GENERAL AND INORGANIC**

**CHEMISTRY**

**Approved by the Department Council on October 25, 2024**

**Confirmed by the Faculty Council on November 13, 2024**

# GENERAL AND INORGANIC CHEMISTRY

## Syllabus

| Discipline                      | Final exam/ semester | According to the Faculty of Pharmacy curriculum of MU-Plovdiv Academic hours |          |           |                | ECTS | Academic hours in semester |    |                |   |
|---------------------------------|----------------------|------------------------------------------------------------------------------|----------|-----------|----------------|------|----------------------------|----|----------------|---|
|                                 |                      | A auditorium                                                                 | Lectures | Practices | Non-auditorium |      | I semester                 |    | ..... semester |   |
|                                 |                      |                                                                              |          |           |                |      | L                          | P  | L              | P |
| GENERAL AND INORGANIC CHEMISTRY | I                    | 105                                                                          | 45       | 60        | 105            | 7.0  | 45                         | 60 | –              | – |

**DISCIPLINE:** General and Inorganic Chemistry

**TYPE OF DISCIPLINE ACCORDING TO THE UNIFORM STATE**

**REQUIREMENTS:** Mandatory

**LEVEL OF QUALIFICATION:** Master (MS)

**FORMS OF TRAINING:** Lectures, laboratory practices, self-training

**YEAR OF TRAINING:** First

**DURATION OF TRAINING:** One semester

**ACADEMIC HOURS:** 45 hours of lectures, 60 hours of laboratory practices, 105 hours of non-auditorium activities

**TECHNICAL EQUIPMENT APPLIED IN THE TRAINING:** Multimedia-based teaching, laboratory equipment, mineralogical collection

**FORMS OF EVALUATION:** On-going assessment, final written examination

**EVALUATION CRITERIA:** The assessment is formed based on three activities

**ASPECTS OF EVALUATION CRITERIA:**

The final grade is determined by the formula:

$$Q_{\text{final}} = 0.15Q_{\text{on-going assessment (lectures)}} + 0.15Q_{\text{on-going assessment (lab)}} + 0.7Q_{\text{final exam}}$$

If one of the components of the final grade is “Poor 2”, the final grade is automatically set to “Poor 2”.

**SEMESTER EXAM:**

Yes

**STATE EXAM:**

No

**LECTURER:**

Professor or associate professor at the Department of Chemical Sciences

**DEPARTMENT:**

Department of Chemical Sciences

**ANNOTATION**

The course content is presented in two sections. In the first section, *theoretical foundations of inorganic chemistry*, students are introduced to general principles, theories, and regularities in chemistry. In it, modern ideas about the structure of the atom, periodicity in the properties, chemical bonding, intermolecular forces, coordination compounds, as well as the peculiarities of various chemical systems and processes are advocated. In the second section, *inorganic chemistry*, the properties of chemical elements and their more important compounds are considered. Special attention is paid to s-, p- and d-elements, which are important from a biological and medical point of view. When presenting the teaching material, the lecturer and assistants adhere to the IUPAC recommendations. Laboratory experiments help to understand and assimilate the lecture material. By carrying out the planned experiments, students acquire experience, skills, and habits for working with chemical reagents, laboratory instruments,

equipment, and consumables. Solving stoichiometric problems and tests related to theory and practice, together with the development of a sense of order, responsibility and the need for self-training and improvement, complete the training in this fundamental discipline.

### **BASIC AIMS OF THE DISCIPLINE**

- To provide in-depth knowledge of the theoretical foundations of modern inorganic chemistry.
- To provide knowledge about properties of chemical elements and their compounds.
- To help acquire laboratory work habits and stoichiometric calculation skills.

### **EXPECTED RESULTS**

Students who have successfully completed the course will know:

- The theoretical foundations of inorganic chemistry.
- Properties of chemical elements and their compounds.

Students who have successfully completed the course will be able to:

- ✓ To perform basic chemical operations.
- ✓ Write and balance chemical equations.
- ✓ To perform stoichiometric calculations necessary for pharmaceutical practice.
- ✓ Obtain target substances and purify them.
- ✓ To analyze the results of the performed chemical experiments

### **LECTURES**

LECTURE № 1 - 3 hours

INTRODUCTION TO CHEMISTRY. ATOMIC STRUCTURE

1. The early history of chemistry.
2. Fundamental chemical laws.
3. Dalton's atomic theory.
4. Early experiments to characterize the atom.

LECTURE № 2 - 3 hours

RUTHERFORD-BOHR MODEL. THE MODERN VIEW OF ATOMIC STRUCTURE.

1. The gold foil experiment.

2. Hydrogen spectrum and Rutherford-Bohr model.
3. Development of the Bohr's theory. Quantum numbers
4. The modern view of atomic structure. Quantum mechanics, Heisenberg uncertainty principle, de Broglie theory, Schrödinger equation, Pauli exclusion principle.

#### LECTURE № 3 - 3 hours

#### DISTRIBUTION OF ELECTRONS IN THE ELECTRON SHELL OF THE ATOM.

#### ATOMIC STRUCTURE AND PERIODICITY

1. Distribution of electrons in the electron shell of the atom.
2. The history of the Periodic table.
3. The Periodic law and Mendeleev's Periodic table.
4. The Moseley's law.
5. The modern Periodic tables.
6. Periodic trends in chemical properties of the main group elements: ionization energy, electron affinity, atomic and ionic radii, electronegativity.

#### LECTURE № 4 - 3 hours

#### CHEMICAL BONDING

1. General concepts.
2. Types of chemical bonds.
3. The views of Kossel and Lewis.
4. Chemical bond characteristics.
5. VSERP model

#### LECTURE № 5 - 3 hours

#### VALENCE BOND THEORY. INTERMOLECULAR FORCES

1. Valence bond theory (VB).
2. Hybridization of atomic orbitals. Examples.
3. Delocalized bonds.
6. Intermolecular forces. Dipole-dipole Interactions. Hydrogen bonding. Dispersion forces. Lennard-Jones equation.
7. Crystal and amorphous solids. Types of crystals.
8. Lattice systems.

LECTURE № 6 - 3 hours

COORDINATION COMPOUNDS

1. General characteristics.
2. Nomenclature.
3. Isomerism.
4. Crystal field theory

LECTURE № 7 - 3 hours

1. Colloquium 1.
2. Discussion on common mistakes.

LECTURE № 8 - 3 hours

SOLUTIONS. ACIDS AND BASES

1. Solutions.
2. Solubility. Factors that affect solubility.
3. Concentration.
4. Colligative properties. Vapor –pressure lowering. Boiling-point elevation. Freezing-point depression. Osmotic pressure.

LECTURE № 9 - 3 hours

ACIDS AND BASES. NEUTRALIZATION AND HYDROLYSIS

1. Concepts of acids and bases.
2. Strong and weak acids and bases. Monoprotic, diprotic and polyprotic acids
3. The dissociation of water and the pH scale.
4. Buffer solutions. Henderson–Hasselbalch equation
5. Neutralization and hydrolysis.
6. Hydrolysis of salts – examples.

LECTURE № 10 - 3 hours

PERIODIC TABLE GROUP 1 ELEMENTS

1. Hydrogen. General characteristics. Isotopes, occurrence, production, properties, compounds, biological role, and application.

2. Alkali metals: lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), francium (Fr). General characteristics, occurrence, production. properties, compounds, biological role, and application.

#### LECTURE № 11 - 3 hours

##### PERIODIC TABLE GROUP 2 ELEMENTS. PERIODIC TABLE GROUP 13 ELEMENTS

1. Periodic table group 2 elements: beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), radium (Ra). General characteristics, occurrence, production. properties, compounds, biological role, and application.
2. Periodic table group 13 elements: boron (B), aluminum (Al), gallium (Ga), indium (In), thallium (Th), and nihonium (Nh). General characteristics, occurrence, production. properties, compounds, biological role, and application.

#### LECTURE № 12 - 3 hours

##### PERIODIC TABLE GROUP 14 ELEMENTS

1. Periodic table group 14 elements – general characteristics.
2. Carbon (C). Occurrence. Production. Allotropes. Chemical compounds. Biological role. Applications.
3. Silicon (Si). Occurrence. Production. Properties. Chemical compounds. Classification of the natural silicates. Biological role. Applications.
4. Germanium (Ge), tin (Sn), and lead (Pb). Occurrence. Production. Properties. Chemical compounds. Applications

#### LECTURE № 13 - 3 hours

##### PERIODIC TABLE GROUP 15 ELEMENTS. PERIODIC TABLE GROUP 16 ELEMENTS

1. Periodic table group 15 elements – general characteristics.
2. Nitrogen (N). Occurrence. Production. Properties. Chemical compounds. Biological role. Applications.
3. Phosphorous (P), arsenic (As), antimony (Sb), bismuth (Bi), moscovium (Mc). Occurrence. Production. Properties. Chemical compounds. Biological role. Applications.
4. Periodic table group 16 elements – general characteristics.

5. Oxygen (O). Occurrence. Production. Properties. Chemical compounds. Biological role. Applications.
6. Sulphur (S), selenium (Se), tellurium (Te), polonium (Po), and livermorium (Lv). Occurrence. Production. Properties. Chemical compounds. Biological role. Applications.

#### LECTURE № 14 - 3 hours

##### PERIODIC TABLE GROUP 17 ELEMENTS. PERIODIC TABLE GROUP 18 ELEMENTS.

1. Periodic table group 17 elements: fluorine (F), chlorine (Cl), bromine (Br), iodine (I), astatine (At), and tennessine (Ts). Occurrence. Production. Properties. Chemical compounds. Biological role. Applications.
2. Periodic table group 18 elements: helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), radon (Rn), and oganesson (Og). Occurrence. Production. Properties. Chemical compounds. Applications.

#### LECTURE № 15 - 3 hours

##### d- AND f-BLOCK ELEMENTS

1. First-row transition metals – general characteristics and biological role.
2. Second- and third-row transition metals – general characteristics.
3. f-block elements. Lanthanides and actinides – general characteristics.
4. Colloquium 2.

## PRACTICES

#### LABORATORY PRACTICE № 1 – 4 hrs

##### GUIDELINES FOR SAFE LABORATORY PRACTICES. CHEMISTRY LABORATORY COMMON EQUIPMENT. BASIC LABORATORY PROCEDURES

#### LABORATORY PRACTICE № 2 – 4 hrs

##### THE DENSITY OF LIQUIDS AND SOLIDS

1. Determination of the density of liquids by a hydrometer.
2. Calculation of the density of water.
3. Determination of the density of a metal.

### LABORATORY PRACTICE № 3 – 4 hrs

#### PREPARATION OF AQUEOUS SOLUTIONS

1. Preparation of NaCl solution.
2. Preparation of CuSO<sub>4</sub> solution.
3. Preparation of HCl solution.
4. Preparation of Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> solution.

### LABORATORY PRACTICE № 4 – 4 hrs

#### CLASSICAL CHEMISTRY EXPERIMENTS

1. Determination of the equivalent mass of CaCO<sub>3</sub>.
2. Determination of the moles of water in copper(II) sulfate *n* hydrate.

### LABORATORY PRACTICE № 5 – 4 hrs

#### CHEMICAL KINETICS AND CHEMICAL EQUILIBRIUM

1. Concentration as a factor that controls the rate of a chemical reaction.
2. Light as a factor that controls the rate of a chemical reaction.
3. Catalytic action of water on the reaction between magnesium and iodine.
4. Inhibitory action of urotropine on the corrosion of iron in hydrochloric acid solutions.
5. Autocatalysis (reduction of KMnO<sub>4</sub> by oxalic acid)
6. The effect of concentration on chemical equilibrium.
7. The effect of pH on chemical equilibrium.

### LABORATORY PRACTICE № 6 – 4 hrs

#### ELECTROLYTIC DISSOCIATION, ELECTROLYSIS AND HYDROLYSIS

1. Electroconductivity of individual liquids and aqueous solutions.
2. Electroconductivity of a solid and melted salt.
3. Electrolysis of KI solution.
4. Hydrolysis of salt obtained from weak acid and strong base.
5. Hydrolysis of salt obtained from strong acid and weak base.
6. Hydrolysis of salt obtained from weak acid and weak base.

### LABORATORY PRACTICE № 7 – 4 hrs

#### SELF-IONIZATION OF WATER, PH AND BUFFER SOLUTIONS

1. Colorimetric determination of pH.
2. Preparation and use of acetate buffer solutions.
3. Buffering capacity.
4. COLLOQUIUM 1.

#### LABORATORY PRACTICE № 8 – 4 hrs

##### COORDINATION COMPOUNDS

1. The difference between simple, double, and complex salts.
2. Aqua complexes.
3. Hydroxido complexes.
4. Acido complexes.
5. Formation of a chelate complex
6. Hydrate isomerism in coordination compounds.

#### LABORATORY PRACTICE № 9 – 4 hrs

##### ALKALI AND ALKALINE EARTH ELEMENTS

1. Reactions of p-metals with sodium hydroxide.
2. Properties of sodium peroxide.
3. Hydrolysis of alkali and alkaline earth metal salts.
4. Properties of barium peroxide.

#### LABORATORY PRACTICE № 10 – 4 hrs

##### ELEMENTS OF GROUPS 13 AND 14

1. Reaction of aluminium with acids.
2. Preparation of carbon dioxide.
3. Reaction of lead with acids.
4. Preparation of insoluble compounds of lead(II).

#### LABORATORY PRACTICE № 11 – 4 hrs

##### ELEMENTS OF GROUPS 15 AND 16

1. Preparation and properties of  $\text{HNO}_2$ .
2. Properties of  $\text{HNO}_3$ .
3. Qualitative reactions for nitrate and nitrite ions.
4. Oxidation-reduction properties of  $\text{H}_2\text{O}_2$ .

LABORATORY PRACTICE № 12 – 4 hrs

ELEMENTS OF GROUPS 5, 6, AND 7: VANADIUM, CHROMIUM, AND MANGANESE

1. Vanadium(V) reduction by nascent hydrogen.
2. Oxidation properties of  $K_2Cr_2O_7$ .
3. Preparation of insoluble  $V^V$  and  $Cr^{VI}$  compounds.
4. The effect of acidity on the oxidation properties of  $KMnO_4$ .

LABORATORY PRACTICE № 13 – 4 hrs

GROUP 11 ELEMENTS: COPPER AND ZINC

1. Preparation and properties of copper(I) hydroxide.
2. Preparation and properties of copper(II) hydroxide  $Cu(OH)_2$ .
3. Preparation of basic copper carbonate.
4. Preparation of Tutton's salt.

LABORATORY PRACTICE № 14 – 4 hrs

PREPARATION OF INORGANIC COMPOUNDS OF PHARMACEUTICAL INTEREST

1. Preparation of  $ZnSO_4 \cdot 7H_2O$ .
2. Preparation of  $MgSO_4 \cdot 7H_2O$ .
3. Preparation of potassium alum.
4. Preparation of sodium bicarbonate.

LABORATORY PRACTICE № 15 – 4 hrs

COLLOQUIUM 2

**BIBLIOGRAPHY**

1. Julia Burdge, Chemistry, 4rd Edition, McGraw Hill, New York, 2017.
2. Steven Zumdahl, Susan Zumdahl, Chemistry, 9th Edition, Cengage Learning, Boston, 2014.
3. Duward Shriver, Mark Weller, Tina Overton, Jonathan Rourke, Fraser Armstrong, Inorganic Chemistry, 6th Edition, W. H. Freeman and Company, New York, 2014.

**CONSPECTUS**

1. The early history of chemistry. Fundamental chemical laws. Dalton's atomic theory. Early experiments to characterize the atom.
2. The modern view of atomic structure. Quantum mechanics, Heisenberg uncertainty principle, De Broglie theory, Schrödinger equation, Quantum numbers and atomic orbitals, electron density distribution, Pauli exclusion principle.
3. Atomic structure and periodicity. Periodic trends in chemical properties of the main group elements: ionization energy, electron affinity, atomic and ionic radii, electronegativity.
4. Chemical bonding. General concepts. Types of chemical bonds. The views of Kossel and Lewis. Chemical bond characteristics.
5. VSEPR model. Valence bond theory. Hybridization of atomic orbitals: Examples. Delocalized bonds.
6. Intermolecular forces. Hydrogen bonding. Crystal structure. Types of crystals.
7. Coordination compounds. General characteristics. Nomenclature. Isomerism
8. Solutions. Types of solutions. Concentrations and related quantities. Solubility.
9. Colligative properties. Vapor-pressure lowering. Boiling-point elevation. Freezing-point depression. Osmotic pressure.
10. Electrolyte solutions. Strong and weak electrolytes.
11. Acids and bases. The pH scale. Acid-base indicators. Buffer solutions.
12. Neutralization. Hydrolysis of salts – examples.
13. Colloids: classification, basic concepts and properties. Methods for preparation of hydrophobic colloids. Stability of colloidal solutions. Lyophilic colloids.
14. Hydrogen. General characteristics. Isotopes. Occurrence. Production. Properties. Compounds. Applications.
15. Alkali metals: lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), francium (Fr) – general characteristics. Occurrence. Production. Properties. Chemical compounds. Applications.
16. Periodic table group 2 elements (group IIA). Beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), radium (Ra) – general characteristics. Occurrence. Production. Properties. Chemical compounds. Biological role. Applications.

17. Periodic table group 13 elements (group IIIA). General characteristics. Boron. Isotops. Properties. Occurrence. Production. Chemical compounds. Applications.
18. Aluminum, gallium, indium, thallium – general characteristics. Occurrence. Production. Properties. Chemical compounds. Applications
19. Periodic table group 14 elements (group IVA). General characteristics. Carbon – characteristics. Occurrence. Production. Allotropes. Chemical compounds. Applications.
20. Silicon, germanium, tin, and lead – general characteristics. Occurrence. Production. Properties. Chemical compounds. Applications.
21. Periodic table group 15 elements (group VA). General characteristics. Nitrogen – characteristics. Occurrence. Production. Properties. Chemical compounds. Applications.
22. Phosphorous, arsenic, antimony, bismuth – characteristics. Occurrence. Production. Properties. Chemical compounds. Applications
23. Periodic table group 16 elements (group VIA). General characteristics. Oxygen – characteristics. Occurrence. Production. Properties. Chemical compounds. Applications.
24. Sulphur, selenium, tellurium, polonium – characteristics. Occurrence. Production. Properties. Chemical compounds. Applications
25. Periodic table group 17 elements (group VIIA). Fluorine, chlorine, bromine, iodine, astatine – characteristics. Occurrence. Production. Properties. Chemical compounds. Applications.
26. Periodic table group 18 elements (group VIIIA). Helium, neon, argon, krypton, xenon, radon – characteristics. Occurrence. Production. Chemical compounds. Applications.
27. Transition metals. First-row transition metals. Second- and third-row transition metals. Characteristics. Applications.
28. Lanthanides and actinides. Characteristics. Applications.

**Prepared by:** Prof. Kiril Gavazov