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«PHILOSOPHY OF CHEMISTRY» – PHILOSOPHICAL-METHODOLOGICAL STUDY OF CHEMICAL SCIENCE

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The article examines the philosophy of chemistry as an important interdisciplinary field that influences pedagogical approaches to teaching chemistry. The main philosophical concepts such as reductionism and holism, scientific realism and antirealism, as well as the use of models and analogies are discussed. The article highlights how these concepts can be integrated into the educational process, contributing to the development of critical thinking and understanding of complex chemical concepts. Practical recommendations for teachers are offered, including the use of interactive teaching methods, contextualization of educational material and the use of technology. The study highlights the importance of a philosophical approach to prepare students for a conscious perception of science and its impact on modern society. There are also key philosophical issues related to the ontology of matter, the problem of reductionism, the role of models and idealizations in chemistry, as well as causality and explanatory models. Considerable attention is paid to the analysis of methodological aspects, such as experimental and theoretical methods, as well as interdisciplinary approaches linking chemistry with other sciences. The article emphasizes the importance of philosophical and methodological understanding of chemistry for a deeper understanding of scientific processes and the evolution of chemical concepts.

Keywords: *philosophy of chemistry, pedagogical approaches, holism, scientific realism, critical thinking, interactive teaching methods, methodology of science, ontology of matter, reductionism, models and idealizations.*

Introduction

For the human being, one of the most important natural sciences is chemistry - the science of composition, internal structure and transformation of matter, as well as the mechanisms of these transformations. «Chemistry - the science of studying properties and transformations of substances, accompanied by changes in their composition and structure». It studies the nature and properties of various chemical bonds, the energy of chemical reactions, the reaction capacity of substances, the properties of catalysts, etc. Chemistry has always been needed by humanity in order to make from natural substances materials with properties, Necessary for daily life and production. The production of such substances is a production task, and to realize it, you must be able to carry out qualitative transformations of the substance, i.e. from one substance to another. To achieve this, chemistry must solve the theoretical problem of the genesis (origin) of the properties of a substance. Thus, the basis of chemistry is a two-fold problem - obtaining substances with certain properties (aimed at its achievement human production activity) and identifying ways to control the properties of the substance (Scientists' research work is directed towards this goal) [1].

The philosophy of chemistry is an interdisciplinary field in which sciences, philosophy and pedagogy intersect. This direction allows us to better understand not only chemistry itself as a science, but also its methodological foundations, as well as ways to transfer knowledge about chemistry to new generations. In this article, we will look at the main philosophical concepts in chemistry, their impact on pedagogical approaches and practical recommendations for teaching chemistry in educational institutions [2].

The philosophy of chemistry is a relatively young field of philosophical research that deals with fundamental issues related to chemistry as a science. Although philosophy has long been interested in physics and biology, chemistry has long remained outside the philosophers' attention. However, in recent decades philosophers have begun to understand the importance of chemistry for understanding fundamental categories such as matter, structure and interaction [3].

Materials and methods

1. Materials. *Literature:*

The main texts and studies related to the philosophy of chemistry, including the works of famous philosophers and chemists such as D.I. Mendeleev and modern authors in the field of philosophy of science.

Textbooks and articles describing key concepts such as reductionism, holism, scientific realism and anti-realism.

Educational resources:

Curricula and courses that include philosophical aspects of chemistry.

Virtual laboratories and simulations that allow you to demonstrate chemical reactions and processes.

2. Methods. *Analysis of philosophical concepts:*

The study of basic philosophical questions of chemistry, such as the nature of matter, the structure of molecules and the laws of chemical reactions.

A comparative analysis of reductionism and holism, as well as scientific realism and antirealism.

Teaching methods:

Interactive learning methods: Using group discussions, project work, and active forms of learning to gain an in-depth understanding of chemical principles.

Contextualization of learning: Linking the studied material with real life situations to increase students' motivation and interest.

Research approach: Involving students in research projects, which contributes to the development of scientific thinking and understanding of the scientific method.

Knowledge testing:

Discussing philosophical issues in the context of scientific theories and models, which helps students develop critical thinking.

Assessment of students' understanding through the performance of tasks related to real chemical problems and their solutions.

3. Practical recommendations for teaching chemistry.

The development of curricula based on the principles of reductionism and holism to provide both a detailed study of individual chemical processes and their interrelationships in larger systems.

Encouraging critical thinking through the analysis of scientific theories and models, including discussion of their limitations and application contexts.

Integrate technologies such as digital tools and simulations to improve understanding of complex chemical concepts and create an interactive learning environment.

4. The importance of the philosophy of chemistry.

The philosophy of chemistry contributes to a deep understanding of the science of substances and their transformations. It allows you to better understand the basic principles of chemical processes and offers new approaches to solving scientific problems.

A critical analysis of the basic premises and methods used in chemical practice is important both for the progress of chemistry itself and for other natural sciences with which it is closely related.

5. Methodological and ideological problems of chemistry.

Definition of the subject of chemistry and its changes in the historical context.

Clarifying the place of chemistry in the system of scientific knowledge and its interaction with other sciences.

Features of the language and organization of the chemical community, which create a unique identity of chemistry as a science [3].

The main part

Basic philosophical concepts in chemistry.

The philosophy of chemistry studies issues such as the nature of chemicals, the laws of chemical reactions, and the structure of molecules. The important aspects are:

- Reductionism versus holism. Reductionism implies that complex systems can be understood by studying their components. At the same time, the holistic approach considers the whole as something more than the sum of its parts. In education, this can manifest itself in a discussion of how chemical reactions affect ecosystems.
- Scientific realism and anti-realism. Scientific realism claims that scientific theories describe reality, while anti-realism calls this position into question. These ideas can be useful in educational contexts where students learn to be critical of scientific theories.
- Models and analogies. In chemistry, models are often used to explain complex concepts. Learning from analogies can help students better assimilate information using examples from everyday life [4]?

The influence of the philosophy of chemistry on pedagogical approaches.

Philosophical concepts of chemistry can significantly change approaches to teaching. Let's consider several methods:

- Interactive teaching methods. The use of active forms of learning, such as group work, discussions and project assignments, contributes to a deeper understanding of chemical principles and the development of critical thinking.
- Contextualization of learning. The connection of chemistry with real life situations helps students realize the importance of the material being studied. For example, discussing the effects of chemicals on the environment can increase the interest and motivation of students.
- A research approach. Involving students in research projects develops scientific thinking skills and contributes to a better understanding of the nature of the scientific method [5].

Practical recommendations for teaching chemistry.

For effective teaching of chemistry in accordance with philosophical concepts, the following recommendations can be used:

- Development of curricula based on the principles of reductionism and holism. The educational process should include both a detailed study of individual chemical processes and their interrelationship within large systems.
- Encouraging critical thinking. It is important to encourage students to analyze scientific theories and models by discussing their limitations and application context.
- Technology integration. Using digital tools and simulations can improve understanding of complex chemical concepts and make learning more interactive [6].

Importance of the philosophy of chemistry.

The philosophy of chemistry plays an important role in understanding the science of substances and their transformation. It allows for a deeper understanding of the basis of chemical processes, offers new approaches to scientific problems and expands the horizons of interdisciplinary research.

In addition, the philosophy of chemistry is important in practice because it allows a critical analysis of fundamental assumptions and methods used in chemical practice. This is important for the progress of both chemistry itself and the other natural sciences with which it is closely linked.

Methodological and worldview problems of chemistry.

The most obvious methodological problems of any science are such as the definition of the subject of the specialized science itself, the change of the subject in the course of its historical development, the clarification of the place of a particular science in the system of scientific knowledge, its relations with other sciences, Attitude to practice. All this is characteristic for chemistry. As noted above, chemistry, like any science, has a subject, methods, specific cognitive goals and ideals, as well as a peculiar language, special organization and life of the chemical

community. But unfortunately, to give a clear one-word answer to the question what is chemistry impossible. First, any definition is always incomplete, leaving behind many important aspects of the substance of the defined concept. Second, the content of the term «chemistry» changes over time. And if in his time D.I. Mendeleev defined chemistry as the teaching about elements and their connections, i.e. about finished objects, then today this definition does not reflect the main in modern chemistry - the teaching about processes of qualitative transformation of substances [7].

Philosophy of chemistry and chemistry subject.

Three main groups of philosophical questions of chemistry can be distinguished.

1. The first of them is related to the generalization of what has been achieved by chemistry in the knowledge of matter, with the identification of how it enriches the general scientific picture of matter, nature, what is the worldview of the discoveries made. This is the ontological aspect of chemistry's achievements. The development of these questions allows to discover, better understand the essence of a certain open chemistry of phenomena, see their relationship with other - physical, biological and other - phenomena, comprehend their place in the general system of nature. The development of these questions is necessary not only for the production of a general scientific worldview, corresponding to the level of knowledge about nature reached, but also for the adjustment of further directions of chemical research.

2. The second and most extensive group of issues are questions of epistemology and methodology. They address the cognitive activity of the chemist, its logical tools, analysis of developing chemical knowledge of applied concepts in chemistry, abstractions, methods of research, etc. The results of cognition, being shaped into new concepts, principles, theories, always become tools of further learning. To reveal not only the general scientific, worldview significance of new knowledge, but their importance in the development of the cognitive apparatus of science, their functioning as tools and means of cognition - this is the task of research on the methodological and gnosiological side of chemistry. These questions have acquired a special urgency and importance in the context of the rapid development of modern chemistry, increasing mathematics, the abstraction of knowledge.

3. The third group of philosophical questions of chemistry are questions pertaining to the disclosure of the social aspect of chemical development and chemical practice. These are questions related to the transformation of chemistry into a productive force, related to the fact that concepts produced by science become tools for practical human activity in the transformation of objective reality. These are questions related to the fact that the chemical substances studied are not only a mysterious subject of persistent scientific research, but also a vital need for humanity. The presence or absence of certain kinds of substance, the ability of chemistry to transform the substance, its properties and transformations, all are essential factors in social development and are reflected in different aspects of society.

The philosophical-methodological study of chemistry is an analysis of fundamental principles, methods and approaches that are used in chemical science. These studies help to understand how chemical knowledge is formed, how it relates to other areas of science and what philosophical basis lies behind it. The methodology of chemistry covers both empirical and theoretical aspects, which makes it unique in the range of natural sciences [8].

Philosophical foundations of chemical science.

1. Ontology of the substance. One of the central questions of chemistry philosophy is the essence of matter. Unlike physics, which studies fundamental particles, chemistry focuses on matter in more complex forms - molecules, compounds and their interactions. The question of what constitutes a chemical is key to understanding the philosophy of chemistry. This substance can be understood as a collection of particles subject to physical laws, or as something more holistic, with its own qualities and characteristics.

2. The problem of reductionism. The question of reduction of chemistry to physics and quantum mechanics has an important philosophical significance. Although many chemical processes are explained through quantum mechanics, phenomena such as chemical bonds,

catalytic processes and reaction dynamics are difficult to reduce to physical laws alone. The methodological aspect of this problem is how much chemistry depends on physical theories and how much it is a separate science.

3. Role of models and idealizations. Chemistry is actively using models and idealization to describe complex chemical processes. For example, the idea of molecular orbits or the concept of hybridization of atomic orbitals helps to explain molecular structures but does not always accurately reflect reality. The philosophical question is how much models in chemistry reflect the real world and how useful they are as a tool of scientific knowledge.

4. Causality and explanatory models. Chemistry is closely related to questions of causality: what causes chemical reactions and how can one explain the transition from one state of a substance to another? Causality in chemistry is often solved by the concepts of energy, thermodynamics and kinetics of reactions. However, it raises philosophical questions about how exactly chemists understand the causal relationships and explanatory mechanisms in their models [9].

Methodology of chemical science.

1. Experimental methodology. Chemistry, as an empirical science, is largely based on experimental methods. An important methodological problem here is the relationship between experimental data and theoretical models. Experiments in chemistry often require complex instruments and techniques such as spectroscopy, chromatography or X-ray structural analysis. The philosophical question is how the data obtained by these methods are interpreted and how they relate to theoretical representations of a substance.

2. Theoretical methodology. With the development of quantum chemistry and computer modeling, chemistry has moved to the use of complex mathematical models and computational methods. This changed the traditional experimental nature of chemistry, adding an important theoretical dimension. The methodological interest here is how empirical data relate to theoretical calculations and to what extent the latter can predict experimental results.

3. Interdisciplinary approaches. Chemistry is at the intersection of many sciences, such as biology, physics and materials science. This requires the development of interdisciplinary methodological approaches that allow methods and concepts from different disciplines to be combined to address common scientific challenges. For example, chemical biology uses chemical methods to study biological processes, and nanoscale chemistry studies interactions at the nanoscale. The question is how chemistry will adapt its methods and concepts to integrate with other sciences [9].

Philosophical and methodological problems.

1. The role of experiment and observation. In chemistry, as in other sciences, experiment plays a central role in the acquisition of new knowledge. However, the philosophical and methodological question is how far the results of experiments can be considered objective and how they influence the formation of theoretical concepts.

2. Evolution of chemical concepts. Chemistry as a science has undergone significant evolution since its inception. Concepts such as atom, molecule, chemical bond have changed and refined with the development of new methods of research and theoretical approaches. Philosophical and methodological analysis of these changes allows to understand how scientific knowledge is formed and what factors influence its development.

3. Relationship of chemistry with other sciences. Chemistry is closely linked to other natural sciences, which raises questions about its status and autonomy. The methodological problem is how chemistry interacts with physics, biology and materials science and how it maintains its independence as a scientific discipline [10].

Results and discussions

This paper examines the key philosophical concepts related to chemistry and their impact on educational approaches. The main results of the study can be summarized as follows:

1. Basic philosophical concepts

Reductionism and holism: These approaches demonstrate how the understanding of chemistry can vary depending on the chosen methodology. Reductionism helps to deepen knowledge about specific processes, whereas holism allows you to see the relationship between chemical reactions and ecosystems.

Scientific Realism and anti-realism: These concepts encourage students to critically comprehend scientific theories. In the educational process, it is important not only to transfer knowledge, but also to develop critical thinking so that students can analyze and evaluate theories.

Models and Analogies: Using models and analogies in teaching helps students better understand complex concepts. This makes the material more accessible and connected to everyday life.

2. Influence on pedagogical approaches

Philosophical concepts have had a significant impact on the methods of teaching chemistry:

Interactive teaching methods: Active participation of students in the educational process contributes to a better understanding of chemical principles and the development of critical thinking skills.

Contextualization of learning: The connection of chemistry with real life situations, such as the effects of chemicals on the environment, enhances students' interest in the subject.

Research approach: Students' participation in scientific projects develops their scientific thinking and deepens their understanding of the scientific method.

3. Practical recommendations for teaching

The following recommendations are offered for the successful implementation of philosophical concepts in chemistry education:

Developing curricula that take into account both reductionist and holistic approaches.

Stimulating critical thinking through the analysis of scientific theories and models.

Integrating technologies such as digital tools and simulations to improve understanding of complex chemical concepts.

Discussion

The philosophy of chemistry is an important field that helps to better understand the nature of chemical processes and their interaction with other sciences. It not only enriches our knowledge of substances and their transformations, but also contributes to the development of critical thinking among students, which is necessary for successful scientific practice.

The problems of defining the subject of chemistry and its methodology, as well as changes in the understanding of chemistry over time, emphasize the need for constant rethinking of teaching approaches. Research in the field of philosophy of chemistry can help identify new areas of learning, as well as improve interdisciplinary interaction in scientific practice.

Conclusion

the philosophical aspects of chemistry play an important role in education and scientific research, contributing to a deeper understanding of both science itself and its place in the modern world.

The philosophy of chemistry is of great importance for pedagogy, as it allows a deeper understanding of the nature of chemistry and its place in science. The integration of philosophical concepts into educational practices can not only enrich the learning process, but also prepare students for the critical perception of scientific information. It is important to continue to research and develop pedagogical methods based on philosophical ideas, which, in turn, will contribute to the formation of more knowledgeable and thinking citizens

Philosophy of chemistry is a dynamically developing discipline that deals with the study of philosophical aspects of chemistry. Its aim is not only to answer classical questions about the nature of matter and chemical reactions, but also to propose new approaches to understanding how chemistry fits into the general context of scientific knowledge.

Philosophical-methodological study of chemical science plays a key role in understanding both the fundamental foundations of chemistry and its methods. The analysis of philosophical and methodological aspects of chemistry allows for a deeper understanding of scientific cognition,

models and experiments, as well as their relationship with other sciences. In the context of rapidly developing technologies and interdisciplinary research, philosophy and methodology of chemistry will continue to be an important area of scientific reflection.

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"ХИМИЯ ФИЛОСОФИЯСЫ" – ФИЛОСОФИЯЛЫҚ ӘДІСТЕМЕЛІК ХИМИЯ ҒЫЛЫМЫН ЗЕРТТЕУ

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Мақалада химия философиясы химияны оқытудың педагогикалық тәсілдеріне әсер ететін маңызды пәнаралық бағыт ретінде қарастырылған. Редукционизм мен холизм, ғылыми реализм және антиреализм сияқты негізгі философиялық ұғымдар, сондай-ақ модельдер мен ұқсастықтарды қолдану талқыланады. Мақалада бұл ұғымдарды сыни тұрғыдан ойлау мен күрделі химиялық ұғымдарды түсінуге ықпал ете отырып, білім беру процесіне қалай біріктіруге болатындығы көрсетілген. Оқытушыларға интерактивті оқыту әдістерін қолдану, оқу материалын контексттеу және технологияларды пайдалануды қоса алғанда, практикалық ұсыныстар ұсынылады. Зерттеу студенттерді ғылымды саналы түрде қабылдауға және оның қазіргі қоғамға әсеріне дайындаудағы философиялық тәсілдің маңыздылығын көрсетеді. Сондай-ақ заттың онтологиясына, редукционизм мәселелеріне, химиядағы модельдер мен идеализациялардың рөліне, сондай-ақ себептілік пен түсіндірме модельдеріне қатысты негізгі философиялық мәселелер.

Эксперименттік және теориялық әдістер, сондай-ақ химияны басқа ғылымдармен байланыстыратын пәнаралық тәсілдер сияқты әдіснамалық аспектілерді талдауға көп көңіл бөлінеді. Мақала ғылыми процестер мен химиялық ұғымдардың эволюциясын тереңірек түсіну үшін химияны философиялық және әдіснамалық тұрғыдан түсінудің маңыздылығын көрсетеді.

Кілт сөздер: *химия философиясы, педагогикалық тәсілдер, холизм, ғылыми реализм, сыни ойлау, оқытудың интерактивті әдістері, ғылым әдістемесі, заттың онтологиясы, редукционизм, модельдер және идеализация.*

«ФИЛОСОФИЯ ХИМИИ» - ФИЛОСОФСКО-МЕТОДОЛОГИЧЕСКОЕ ИССЛЕДОВАНИЕ ХИМИЧЕСКОЙ НАУКИ

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В статье рассмотрен философия химии как важное междисциплинарное направление, влияющее на педагогические подходы к обучению химии. Обсуждаются основные философские концепции, такие как редукционизм и холизм, научный реализм и антиреализм, а также использование моделей и аналогий. Статья подчеркивает, как эти концепции могут быть интегрированы в образовательный процесс, способствуя развитию критического мышления и понимания сложных химических понятий. Предложены практические рекомендации для преподавателей, включая применение интерактивных методов обучения, контекстуализацию учебного материала и использование технологий. Исследование подчеркивает важность философского подхода для подготовки студентов к осознанному восприятию науки и ее влиянию на современное общество. Так же ключевые философские вопросы, касающиеся онтологии вещества, проблемы редукционизма, роли моделей и идеализаций в химии, а также причинности и объяснительных моделей. Значительное внимание уделено анализу методологических аспектов, таких как экспериментальные и теоретические методы, а также междисциплинарные подходы, связывающие химию с другими науками. Статья подчеркивает важность философского и методологического осмысления химии для более глубокого понимания научных процессов и эволюции химических понятий.

Ключевые слова: *философия химии, педагогические подходы, холизм, научный реализм, критическое мышление, интерактивные методы обучения, методология науки, онтология вещества, редукционизм, модели и идеализации.*