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The Significance of Studying the Subject "Atomic Structure and Chemical Bonding" in Physics and Chemistry in Higher Education Institutions

(In the areas of railway transport and materials science and new materials technology)

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Abstract
This article highlights the importance of teaching students physics and chemistry because of the disconnect between theory and practice in the interdisciplinary study of the atom and atomic nucleus. In addition, the experiences of scientists in the fields of physics and chemistry are analyzed, and the relevance of the application of atomic structure and chemical bonding to students in physics and chemistry is explained in detail.

Keywords: physics, chemistry, matter, particle, electrolysis, atom, nucleus, electron, proton, neutron, radioactive, spin, bond, electron cloud, electronic configuration.

Introduction

The topic "Atomic structure and chemical bonding" is studied in technical higher education in accordance with the in-depth educational program. It is appropriate to study this topic from a historical and contemporary point of view, because future engineers need to study physics and chemistry in depth.

In the first lesson on the topic "Experimental confirmation of the complexity of the atomic structure", students will get acquainted with the following short information.

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LITERATURE ANALYSIS AND METHODOLOGY

It should be noted that hundreds of years ago, the atom was considered an indivisible particle, the limit of division of matter. This concept began to be rejected little by little as experimental materials were collected in science. For example, D. I. Mendeleev, after discovering the periodic law, wrote in 1871: "Although it is not yet possible to prove, it can be assumed that the atoms of simple bodies are complex substances formed by the combination of some smaller particles... The periodic connection I proposed in my opinion, it is not surprising if such a prediction is confirmed."

After that, important discoveries at the end of the 19th century, which put an end to the idea that an atom is an indivisible simple particle of an element: 1) electrolysis; 2) passage of electric current in gases; 3) they will have detailed information about the discovery of radioactive events.

After familiarizing yourself with the phenomenon of electrolysis, it will certainly be appropriate to consider Faraday's laws. This allows us to imagine that the atom is complex. After that, it is appropriate to study the experience of the English physicist J. Thomson. It is said that in 1897, this scientist discovered the existence of an electron in an atom, that this particle carries a negative charge, and finally, the French scientist A. Becquerel discovered the radioactive phenomenon, and two new elements polonium and radium were discovered thanks to the works of M. Skladovskaya Curie and P. Curie. Thanks to these great discoveries, it is concluded that the atom is a form of matter with a complex structure. In addition, naturally occurring nuclei include naturally occurring radioactive substances, but most radioactive nuclides are artificially produced by nuclear reactions. At the first stages of the study of this phenomenon, three types of incoming radiation were released during the decay of the atomic nucleus - α, β and γ. Positively charged α-particles consist of two protons and two neutrons and are helium nuclei, negatively charged β-particles are electrons, and neutral γ-quanta are high-energy photons.

Finally, it should be mentioned that several dozen elementary particles were isolated. In the second lesson dedicated to the study of the planetary model of the atom discovered by Rutherford, the students note that the English physicist E. Rutherford discovered the positively charged particle of the atom in 1911, and called it the atomic nucleus.

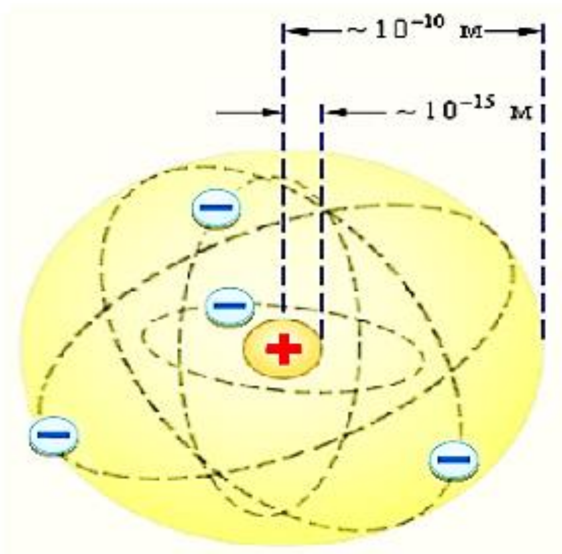

Figure 1. Planetary model of the atom.

In this lesson, E. Rutherford's experiment on the study of the flight trajectory of α-particles bombarding paper with a gold die is thoroughly reviewed. Of course, it should be noted that E. Rutherford was not only a brilliant experimenter, but also a keen analyst. According to the α-particles displayed on the screen, he determined that there is a positively charged particle with a much larger mass in the atom - the nucleus of the atom.

Based on the ideas about the structure of the atomic nucleus, we think it is appropriate to say that the entire mass of the atom is concentrated in the nucleus, that the nucleus is 10^{-15} of the atom, and to give examples showing the dimensions of the nucleus and the atom.

Now students will be introduced to the planetary model proposed by E. Rutherford. According to this model, the nucleus is located in the center of the atom, around which the electrons move in orbits, like the planets revolve around the Sun, equalizing the charges of the electrons, and the atom as a whole remains electroneutral.

In the next lesson, the basics of the quantum-mechanical theory of atomic structure will be studied. In this lesson, the Danish physicist N.Bohr It is checked by the theory created in 1913. This scientist discovered a model of the hydrogen atom based on the quantum theory of radiation. According to this theory, electrons move only in fixed orbits, which depend on the energy of the atom. In the ground state, the atom has a lot of its own energy, and the electron moves in the orbit closest to the charge. When an atom receives additional energy, it can move to one of the orbits away from the nucleus. But this process does not last long, and the electron occupies its previous orbit again. Such a transition is accompanied by a decrease in the energy of the atom, and this energy is released in the form of electromagnetic radiation.

According to the N.Bohr theory, such a change in atomic energy occurs only when an electron moves from a more distant orbit to an orbit closer to the nucleus. An electron rotating in the same orbit does not emit energy, and this ensures that the atom is in a stable state. The theory of N.Bohr allows to explain that the electron has two-sided properties, that is, it exhibits the property of a material particle and complete properties.

Therefore, it is not correct to say that the electron moves around the nucleus along a certain trajectory, but it is reasonable to think that there is a possibility that the electron can be at a certain point in space.

After a brief introduction to the theory of N. Bohr, students will be able to consider the main rules of the modern quantum-mechanical theory of atomic structure. Special attention is paid to the fourth quantum number called electron spin. According to the Pauli principle, no more than two electrons can be in each orbit in an atom, while their spins will have different signs. Students need to know this conclusion well, because covalent bonds involve electrons with different spins.

After that, the distribution of electrons in steps and steps, as well as the configuration of electrons, will be discussed.

Based on the Pauli principle, it is possible to calculate how many electrons can be in each energy shell and level in an atom. For example, the first energy step K has one step. Let's call it *1s*. The number 1 means that the principal quantum number is $n=1$, and s means that the electrons occupy a certain sphere around the nucleus. The electron has the same probability of being in this sphere, but the maximum density is at a distance of 0.529 Å from the nucleus. The first level contains only *s*-electrons, their number does not exceed two. The second energy level with quantum number

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n=2 has 2^2=4 levels. One of these steps consists of *2s* and three *2r* steps. The *2s*-level electron cloud is spherical like that of 1s, and the *2r*-electron cloud is dumbbell or eight-shaped.

The third electron level with quantum number *n=3* has 3^2=9 levels: one *3s* - , three *3r* - and five *3d* levels.

d and *f* electrons are not considered due to their complex spatial arrangement and shape. Thus, based on the above, the following conclusions can be drawn:

1. There are only two *s*-electrons in the first energy level. From the second there will be *s* and *r* - electrons, from the third - *s, p, d* - electrons, from the fourth - *s, p, d, f* - electrons, and so on.
2. Taking into account that there are no more than two electrons in each position, we can write:
3. One s - two electrons in the step, three *p* - 6 electrons in the step, five *d* - 10 electrons in the step, seven *f* - 14 electrons in the step.

DISCUSSION AND RESULTS

At the end of this lesson, students should learn to fill the rows and rows of atoms of elements of D.I. Mendeleev's periodic law and periodic system with electrons.

Students are reminded once again that the electron size of an energy level is determined by the formula $N=2n^2$ and the maximum number of electrons in an energy level with the number of holes N is *n*. This formula allows to determine the maximum number of electrons in each energy level. From this formula, it is concluded that the first *K* energy level close to the nucleus will have two electrons, the second *L* level will have eight, then the *M* level will have 18 electrons, and the *N* level will have 32 electrons, etc.

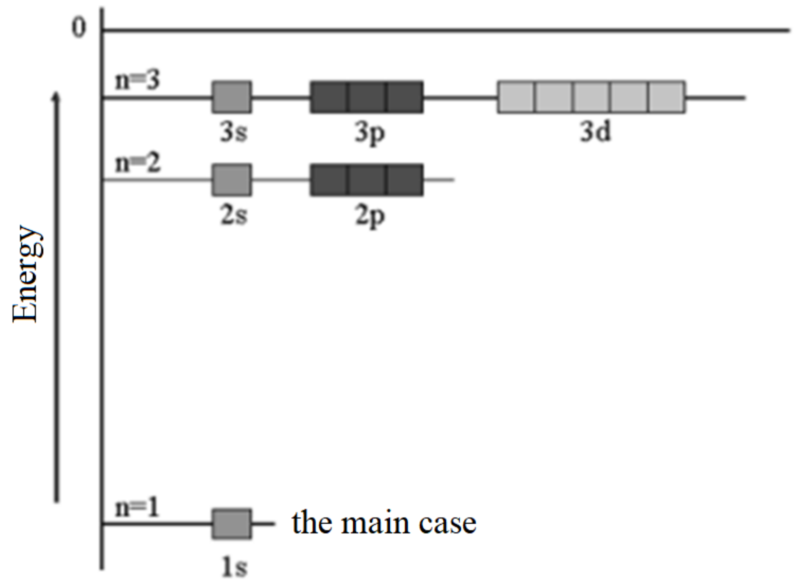

Figure 2.

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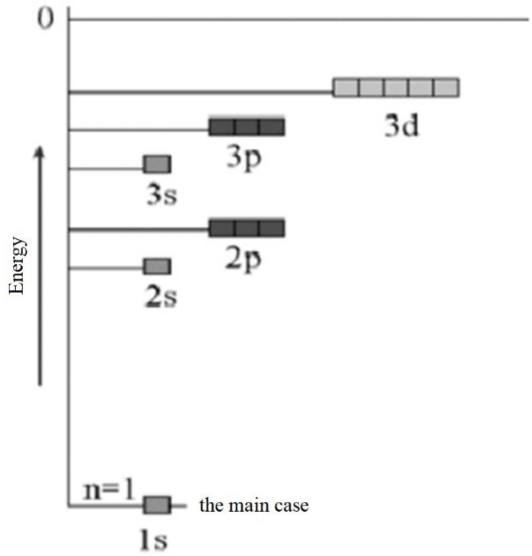


Figure 3. Filling the orbitals of multi-electron atoms with electrons.

For example, students are given an example of the filling of atomic energy levels with electrons:

$$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2, 4p^6, 4d^{10}, 4f^{14}, 5s^2, \ldots$$

Students practiced writing electron configurations of other atoms.

Oxygen atom	$1s^2$	$2s^2$	$2p^4$				
	K	L					
Potassium atom	$1s^2$	$2s^2$	$2p^6$	$3s^2$		$3p^6$	$4s^1$
	K	L			M		N
Copper atom	$1s^2$	$2s^2$	$2p^6$	$3s^2$	$3p^6$	$3d^{10}$	$4s^1$
	K	L			M		N

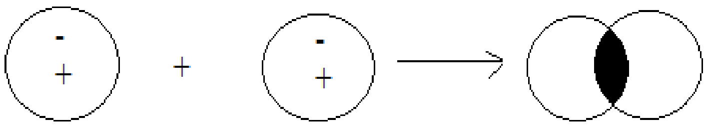
The next four lessons will explore the types of chemical bonds and the formation of molecules. All types of chemical language (homopolar, heteropolar, coordination and hydrogen bonds), ionic bonds, metallic bonds are considered with students. Among these, the most difficult for students to understand is covalent bonding. In the formation of covalently bonded molecules, electrons are not transferred from one atom to another, but one or more shared electron pairs are formed between two atoms. Valence electrons of both atoms participate in the formation of electron pairs. In the hydrogen (N) molecule, the electrons form a common pair of electrons moving in both nuclear fields. In the study of this issue, a molecule is considered to be the smallest particle that contains the main properties of matter. Since this is the case, it is appropriate for the substance to be in the form of molecules rather than atoms.

In the outer energy level of an atom, there are one to eight electrons. The eight-electron step is considered complete. Therefore, only inert gases do not tend to chemical interactions and can exist in atomic form. Since the atoms of other elements are incomplete, they tend to become complete during chemical reactions. This is achieved by electron loss or attachment, as well as the formation of shared electron pairs.

Now let's look at the formation of the simplest molecular hydrogen molecule. We will ask the students such a question. What causes two hydrogen atoms to bond? Why can't hydrogen exist as single atoms?

The answer to these questions is that the formation of each mole of hydrogen is accompanied by the release of 431 kD of energy. So it is convenient for hydrogen to be a molecule rather than an atom.

The mechanism of homeopolar or nonpolar binding is then considered. According to the modern theory of chemical bonding based on quantum-mechanical concepts, one of the possible ways of interaction between two atoms is the existence of unpaired, non-parallel spins in atoms. Therefore, when two hydrogen atoms with different values of s-electron spins approach each other, their electron clouds are covered. The electron density of the clouds increases in the space between the nuclei. This increases the force of attraction between the nucleus and the electrons. This process occurs with the formation of a stable molecule composed of two atoms due to the release of energy. This process can be shown schematically as follows:



After that

$$N\cdot + \cdot N \rightarrow N{:}N + 431\ kD$$

In this scheme, the electron pair is located symmetrically between the two atomic nuclei, and such molecules are called symmetric molecules, and the bond is called nonpolar and homeopolar bond. The structure of halogens, oxygen, nitrogen molecules is also considered in the same order as above. It should be noted that the more electrons involved in the formation of common electron pairs, the more stable the molecule. Polar covalent bonding is studied in this way.

CONCLUSION

After studying the subject material, control work is conducted. Ten years of work experiences in the areas of chemistry have confirmed that they can thoroughly master the materials of the topic "Atom structure and chemical bonding". Skillful presentation of these issues allows students to consciously understand the structure and properties of inorganic and organic substances.

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