Formation Of Concepts About the Periodic Law and the Structure of the Electronic Shells of Atoms of Elements

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ABSTRACT

The article is devoted to the formation of concepts about the periodic law and the structure of the electronic shells of the atoms of elements. The questions that allow students to generalize their knowledge about the structure of the atom are presented. Methodological recommendations aimed at mastering this material are given

Keywords: periodic law, periodic table, atom, electron, electron cloud, ionization energy, atomic radius, electronegativity

When starting to form students' concepts about the structure of matter, it is necessary to take into account that they have already received certain knowledge about the structure of atoms from the physics course. Therefore, in connection with the study of the periodic law, it is advisable to repeat the information from the physics course in order to use them in clarifying the physical essence of the periodic law and, in particular, the question of what the ordinal number of the element expresses. In order for repetition to be carried out purposefully, students can be asked the following questions: 1. What are the main parts of an atom? 2. Which atom particles have the smallest negative charge? 3. What is the nucleus of an atom as a carrier of mass and charge? 4. Why is an atom consisting of charged particles electrically neutral? 5. How to determine the charge of its nucleus by the number of electrons in an atom? 6. What are the main particles that make up the nuclei of atoms? 7. In which cases can atoms acquire positive and in which cases negative charges? 8. Why does an atom acquire a charge when an electron is attached or lost?

The discussion of these issues makes it possible to generalize the knowledge available to students about the structure of the atom, to bring them to an understanding of the physical essence of the ordinal number of the element, to explain the deviations from the sequential increase in the atomic masses of elements in the periodic system, as well as to form on a new basis the concept of the element. [1, 2, 4, 5]

Students remember that an electron is a negatively charged particle in motion, which means it has magnetic properties, that an electron is attracted by the nucleus of an atom and repels other electrons, that the movement of an electron prevents its separation from an atom, that the closer an electron is to the nucleus of an atom, the stronger it is attracted and the further away, the weaker. All this makes it possible for students to develop an idea of the complexity of the atom. The teacher informs that due to the totality of all these manifestations, the electron in the atom does not move in an orbit, but fills a certain volume of the atom. Its charge seems to be smeared, forming an electronic cloud. [3, 6, 7]

Demonstrating the scheme of a spherical cloud transmitting the motion of one electron in an atom, attention should be paid to the distribution of its density. It goes on to say that in multi-electron atoms, due to the interaction of electrons with each other, electron clouds can have different shapes and orient themselves differently in space. They can have the same shape and overlap each other. For example, you can use the distribution scheme of electron clouds in a neon atom. It shows that there are only five electron clouds in the atom of this element, although it has ten electrons. In the students' view, there is a contradiction between the physical law of mutual repulsion of particles with the same charges and the observed phenomenon. [8, 9]

To clarify the apparent contradiction, schemes with multidirectional arrows denoting the spins of electrons are used. Without going into the complexity of the definition of this concept, we can limit ourselves to explaining that the concept of "electron spin" implies a special magnetic property of this particle associated with its own rotation. By its nature, the spins of the electrons can be the same, then the clouds formed by these electrons do not combine. Such electrons are said to have parallel spins, and are indicated by arrows pointing in one direction. Electrons can also have antiparallel spins, they are denoted by multidirectional arrows. Such electrons can pair and give one common two electron cloud. Having shown how an electron cloud is graphically depicted, it is advisable to explain that cells can be depicted without electrons (without arrows indicating the electron spin). This means that there may be "free spaces" in the atoms to be filled with electrons.

The formation of such a representation is advisable for a number of reasons. This a) makes it possible to show later how the inner electron layers are completed by electrons; b) contributes to a more conscious perception of the material about the donor-acceptor mechanism of covalent bond formation; c) allows us to explain the reason for the change in the degrees of oxidation of the same electrons.

Having armed students with knowledge about the properties of electrons, the nature of their interaction with each other, the forms of electronic clouds and their graphical representation in the form of cells with arrows, it is necessary to further familiarize students with letter designations and with the forms of recording the electronic structure of atoms. Using the same scheme of electron clouds of the neon atom, students are drawn to the fact that it shows two differently distant spherical clouds and three equivalent dumbbell-shaped ones. Accordingly, they are called: *s* – and *p* – electron clouds. Such an image of clouds similar in shape, but at different distances, allows you to more clearly show the placement of electrons in the layers of the atom.

The teacher, having informed the students that there is only one *s*-cloud in the first electron layer of the neon atom, and four in the second (one *s*– and three *p*-clouds), explains that, starting from the second electron layer, they are stratified into sublayers. So, the second layer has two sublayers: *s* and *p*. To denote sublayers, numbers are used showing the number of this layer. To indicate the number of electrons in each of the sublayers, put the numbers at the top right above the letters denoting the sublayer. All this is explained by the example of recording the distribution of electrons in a neon atom: $1s^2,2s^2,2p^6$. This entry is called an expanded electronic formula, it corresponds to an abbreviated formula: Ne – 2,8. In conclusion, a diagram of the graphical formula of the neon atom is shown.

Thus, using the example of the neon atom scheme, both the behavior of electrons in an atom and different forms of their conditional image are considered. The introduction ends with generalizing additions that students write down in notebooks for independent work. They will address them in the process of reviewing new material. The distribution of electrons in atoms follows the following patterns: 1. The number of electron layers in the atoms of any element corresponds to the ordinal number of the period in which it is located; if an element is in the third period, then its atoms can have no more than three electron layers. 2. The number of sublayers in each layer is determined by its number. If, for example, we consider the fourth electronic layer, then it has four electronic sublayers. 3. The maximum number of electrons in layers cannot be more than two in the *s*-, six in the *p*-, ten in the *d*- and fourteen in the *f*-sublayer. 4. In the outer electron layer of an atom of any element, only *s*- and *p*-sublayers are filled with a maximum number of electrons 8. 5. Starting from the third electronic layer, if it is internal, the 3*d* sublayer begins to build up (after the 4*s* sublayer). Similarly, 4*d* and 5*d* sublayers are built up. The 4*f* sublayer is filled in the atoms of the elements of the sixth period, and the 5*f* sublayer is filled in the atoms of the elements of the seventh period.

After such familiarization with the general laws of the distribution of electrons in atoms, independent work of students on the material on the electronic structure of the atoms of elements of the I – III periods is organized. The purpose of this work is to consolidate knowledge about the properties of electrons and teach them to acquire knowledge independently. [10, 11]

In order for students to work purposefully and achieve the necessary level of knowledge, they are recommended to prepare a graphical diagram of the distribution of cells and sublayers in an atom having three electronic layers. Here are examples of tasks for independent work of students.

Using the periodic system of D. I. Mendeleev, perform the following work:

1. Draw the structure of the electron shells of hydrogen and helium atoms. In the prepared scheme, mark the electrons with arrows, and then write down the expanded and abbreviated electronic formulas. In the same order, perform the following tasks to determine the electronic structure of atoms.

2. Determine the total number of electrons in the atoms of lithium and beryllium, boron and carbon, nitrogen and oxygen, fluorine and neon (see the sequence of the first task).

3. Based on the work performed, determine: a) in the atoms of which element the filling of the p-sublayer with electrons with parallel spins begins; b) in the atoms of which element the filling with electrons with antiparallel spins begins; c) in the atoms of which element the p-sublayer is completely built up.

4. Based on the total number of electrons needed to fill the outer electron layers of the atoms of the elements, try to determine the reason why there are only two elements in the first period, and eight in the second.

5. Pay attention to the total number of sublayers in the third electron layer of atoms of elements of the third period. Are all sublayers filled with electrons from the atoms of these elements?

6. Determine the total number of electrons from the atoms of the elements of the third period, and then do further work in the sequence provided by the first task.

7. Compare the outer electron layers of neon and argon atoms and determine how they are similar and how they differ.

8. Try to explain the reason why in the third period, as in the second, there are only eight electrons.

In the process of doing independent work, students, after reading the assignment, determine the place of the element in the periodic system, on the basis of which they establish the total number of electrons in atoms, the number of electronic layers and sublayers. Then fill in the graphic diagram with arrows and record electronic circuits (expanded and abbreviated) for each of the elements. Such three-fold reproduction allows already in this lesson not only to learn how to use the periodic system correctly, but also to consolidate previously acquired knowledge about the electronic structure of atoms, to comprehend the relationship between the periodic system and the features of the electronic structure of atoms.

After that, the teacher demonstrates a graphical electronic circuit of the third and fourth electronic layers, in which the 3*s*- and 3*p*-sublayers are filled with electrons. Using this scheme, he dwells in detail on the building of sublayers by electrons in atoms of elements of the fourth period. Students write down only expanded and abbreviated electronic formulas. Then the numbers of electrons in the argon atom and in the krypton atom are compared. This makes it possible to more clearly reveal the reason for the construction of the fourth period of 18 elements. The attention of students is also drawn to the reason for the greater number of electrons in the krypton atom than was the case with neon and argon. Then, using filled graphic diagrams of the electronic structure of xenon and radon atoms, the teacher focuses the students' attention on the electron-filled sublayers of the atoms of the elements of the fifth and sixth periods, comparing them with the number of elements they consist of.

The material about the periodic system of elements, including the characteristics of elements according to their position in the periodic system, is better assimilated by students with a combination of conversation, lecture presentation and independent work of students using tables from reference books on atomic radii, ionization energy, electron affinity and the electronic structure of atoms.

It is explained to students that the essence of the periodic law and the periodic system of elements can be better understood if we consider the nature of changes in the properties of hydroxides in periods in comparison with the values of nuclear charges, atomic radii and ionization energy, as well as the number of electrons in the outer electron layers of atoms. It is reported that each of the parameters does not provide exhaustive information about the possible properties of the elements, but the complex use of all the characteristics allows not only to explain the properties of the elements, but also to assume possible properties of unknown elements and their compounds.

Using the tables of the electronic structure of atoms, it should be shown by the example of the second period how the characteristics of atoms change in the order of increasing charges of nuclei. Attention is drawn to the fact that the sodium atom in the period has the smallest charge of the nucleus. One electron on the outer electron layer is significantly removed from the nucleus, as evidenced by the data on atomic radii. In this regard, the binding strength of the electron of the outer layer is the smallest. In this regard, the binding strength of the electron of the outer layer is the smallest. As the charges of the nuclei of the atoms of subsequent elements increase, the number of electrons in the outer layers also increases, and the atomic radii gradually decrease due to the stronger attraction of electrons by the nuclei. Accordingly, the binding energy of electrons increases. Chlorine and argon atoms have the highest binding strength of electrons.

Then attention is drawn to the fact that with a decrease in atomic radii and an increase in the ionization energy, the atoms of some elements exhibit a rather high ability to attach electrons. This makes it possible to make a preliminary generalization about the features of metallic and non-metallic elements. The atoms of metallic elements are characterized by relatively large atomic radii, a small number of electrons on the outer electron layers and low ionization energy values. Atoms of nonmetallic elements are characterized by small atomic radii, a significant number of electrons on the outer electron layers, high ionization energies, and the ability to attach electrons from atoms of other elements. For the purpose of generalization, the teacher allocates metallic elements on the periodic table and invites students to analyze how the atomic radii and ionization energies of the atoms of these elements change and how many electrons are in the outer layers of their atoms. Further, in experiments, students find out the properties of hydroxides formed by elements of the third period, and correlate their observations with the structure of atoms. They are convinced that with an increase in the charges of the nuclei of elements and an increase in the number of electrons in the outer electron layers, the atomic radii decrease, the ionization energy increases, and at the same time the properties of hydroxides change from pronounced basic (alkali) to pronounced acidic.

Having understood the essence of the relationship of changes in the properties of hydroxides with the structural features of the atoms of elements of the third period, students can complete the following series of tasks:

1. Follow the table, how the layers of atoms of elements of the fourth period are built up by electrons.

2. What is the effect on the change in the values of atomic radii and ionization energy of the building by electrons of the pre-outer electron layer of the atoms of the elements of the fourth period?

3. Compare how the values of atomic radii and ionization energies change in the third and fourth periods. Explain why in the fourth period the values of atomic radii and ionization energies change more slowly than in the third period.

4. Based on your conclusions from previous tasks, using data on the features of the electronic structure of atoms, atomic radii and ionization energies of elements of the fourth period, make an assumption about the nature of changes in the properties of hydroxides in the fourth period.

5. Check the correctness of the assumptions you have made on the experiments. To do this, test: a) potassium hydroxide, calcium hydroxide, iron (III) hydroxide, copper (II) hydroxide and zinc hydroxide with respect to water; b) solutions of potassium hydroxide and calcium hydroxide to the indicator; c) insoluble hydroxides to solutions of alkalis and acids.

6. Is it possible to draw a conclusion about the reason for a more gradual change in the basic properties of hydroxides in the fourth period based on the compared data on atomic radii, electronic structure and ionization energies of elements of the third and fourth periods?

Comparing the effect of filling the electronic layers of the atoms of the elements of the third and fourth periods on the values of atomic radii and ionization energies, students come to the conclusion that in large periods the atomic radii of the elements decrease much more slowly than those of the atoms of the elements of the third period. Their ionization energy is also slowly increasing. Considering that a faster decrease in radii and an increase in ionization energies with an increase in the number of electrons in the outer electron layers of atoms of elements of the third period leads to a rapid change in the basic properties of hydroxides through amphoteric to acidic, students easily come to the conclusion that the change of basic hydroxides to acidic elements of the fourth period should occur much slower. In experiments, students are convinced of the correctness of such assumptions.

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