Systematics of Anomalies in the Filling of Electron Orbitals of Chemical Elements

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ABSTRACT

This article examines the systematized and defined laws of anomalies in the filling of the electronic orbitals of the periodic table of chemical elements. The particulars of the chemical compounds caused by these anomalies investigated. It is shown that the deviation from the accepted order of filling electron orbitals contribute to an increase in the activity of the elements. As a result, among the anomalous elements are so important for us elements such as copper, silver, gold, platinum, uranium, and others. The anomalous elements participating in the creation of complex chemical compounds lead to molecules of higher dimension.

KEYWORDS

Anomalies, Atom, Chemical Bond, Chemical Element, Electron, Energy Level, Molecule

INTRODUCTION

It is known that the sequence of filling the electron energy levels and sublevels in many-electron atoms is determined by increasing their energy sequence. The energy of electrons in a many-electron atom, depending on the principal quantum numbers $n$, which characterizes the energy level (shell), and orbital quantum number $l$, characterizing the shape of the electron cloud (orbital or sublevel). There are four kinds of forms orbitals $s$, $p$, $d$, $f$. Orbital orientation in space is characterized by the value of the magnetic quantum number $m_l$. Pointing to the value of the principal quantum number 1, 2, ..., 7, and type of forms of electronic orbitals, it is possible to record the serial number of the experimental increase in energy orbitals located at different energy levels (Gray, 1965).

$$1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d, 7p, 6f, 7d$$ (1)

If to look at the number (1) it can be seen, that the energy of the $d$ - orbital of the previous energy level is more energy of the $s$ - orbital subsequent energy level $nd > (n + 1)s$ (for example, $4d > 5s$). Besides the energy of the $f$ - orbitals of the certain energy level is less energy of the $d$ - orbital by increasing the number of the energy level on 2 (for example, $4f < 6d$). Consistently filling orbitals at different energy levels, taking into account the capacity of the orbitals (i.e. the presence of each orbital is a certain amount of quantum cells), it is possible in principle to obtain periods, groups and subgroups of the table of chemical elements of Mendeleev (1934). When filling out the orbital electrons it is recommended to use a number (1), as well as the Pauli’s principle (1925) and Hund’s rule (1927).

According to the Pauli’s principle (1925) in quantum cell cannot be more than two electrons with opposite spins (spin quantum number $m_s$ equal to $\pm 1/2$ respectively). The atom cannot have two
electrons with the same values of the four quantum numbers. The number of possible quantum cells at this sublayer (orbital) is \( m_l = 2l + 1 \). The maximum number of electrons in that sublevel equal to \( 2m_l \). The number of possible quantum cells at any level is equal to \( n^2 \), and the maximum number of electrons at this level is \( 2n^2 \).

According with Hund’s rule the filling of the orbitals it is at first by one electron in each quantum cell with the same orientation of the spins, and only after this the quantum cells it are filled with second electrons with opposite spins. Thus, the total spin orbitals must be maximized.

Filling the orbitals on the Pauli principle and Hund’s rule corresponds to the ground state of the atom with the lowest energy. When atom reporting additional energy than one or more electrons in the atom move to a higher energy level. In this case, the atom to become excited.

However, for increasing the number of electrons in the atom among of the chemical elements appearing elements in order to fill electron orbitals are the deviations at a number (1) and Hund’s rule. It is assumed that these anomalous cases are not significant as a whole for the entire table of chemical elements (Arkel, 1931; Karapet‘yants & Drakin, 1994). However, a detailed analysis of the electronic formulas of chemical elements table of D.I. Mendeleev shows that these anomalous elements are many and it is important that in their number reach elements with exceptional properties such as chromium, platinum, gold, silver, uranium, and others. In the light of the opening of all the new elements with many electrons is of interest to 1) organize the anomalies in the filling of the atomic electron orbitals, 2) try to find patterns in these anomaly-filled electron orbitals, and 3) determine the characteristics of the compounds of anomalous elements.

ANOMALIES IN FILLING THE ELECTRONIC ORBITALS AND THEIR ANALYSIS

For clarity, at the series (1) can represented an approximate schema depending of energy orbitals (Gray, 1965) on the principal quantum number \( n \) (Figure 1). However, taking into account that the electron energy \( E \) depends on two quantum numbers it is useful to further to present this dependence on two coordinates: the principal quantum number \( n \) and orbital quantum number \( l \). So, the orbitals \( s, p, d, f \) correspond to the values of the orbital quantum number \( l = 0, 1, 2, 3 \), reconstruct Figure 1 as a function \( E(n, l) \) (Figure 2). Figure 2 qualitatively shows that the energy of the electron \( E \) increases with increasing \( n \) as well as \( l \), but do the nature of these relationships is different from linear. Comparing the current data on the electronic formulas of chemical elements (Gray, 1965) with a number (1), you can make sure that all cases elements with anomalous filling of the atomic electron orbitals are \( d \) - and \( f \) - elements. Moreover, from the total number of this elements (68) near their third (21) are anomalous elements. In Table 1 and Table 2 shows the structure of the outer shell, built on a number of energy (1), and the actual structure of the outer electron shells, respectively, \( d \) - and \( f \) - elements that have anomalies in the order of filling of electron orbitals. We consider first an anomalous element in Table 1, i.e. chromium element. Situated in the table of the elements after vanadium, having in the outer shell electrons \( 3d^44s^2 \), chrome atom differs from vanadium atom the one additional electron. This electron, according to the number of the energy (1) and Hund’s rule must be to act on \( d \)-orbital of the third energy level. He there and goes, but one electron with \( s \)-orbital on the fourth energy level goes on \( d \)-orbital of the third energy level despite the Hund’s rule governing the sequential filling of quantum cells at this energy level. While at the same time in line with other approved of rules Hund atom acquires the maximum value of the total spin of the shell. This is points to the inconsistency Hund’s rule. As a result, the electronic formula of chromium atom is \( 3d^54s^1 \) instead \( 3d^44s^2 \), calculated on a number (1). Due to the transition of an electron from \( 4s \)-orbital in the \( 3d \) - orbital energy of the atom to become higher
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