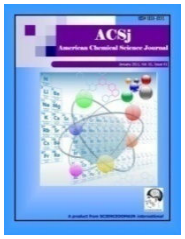

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Some Concepts about Substance, Chemical Compound and an Element

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Authors' contributions

This work was carried out in collaboration between all authors. Author BTU analyzed concepts concerning to General Chemistry, offer chemical individual and entered some adjustments. Author ENS study electro conductivity of aqueous solutions, microstructures of oxidic fusions and deductively used this experimental knowledge. Authors AU and NZ consider lattice structures of solids, managed the literature searches and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Chemistry is the science that deals with the composition and properties of matter. Properties of matter are generally grouped into two broad categories; these are physical and chemical properties. Physical property is the one that a sample of matter displays without changing its composition. The physical and chemical properties of a substance depend on its size and the arrangement of elements in the chemical compound. Considering physical and chemical properties of matter, it is demanded that the difference between atom and chemical element, chemical compound and substance concepts demand that we distinguish them. In this paper, these concepts are considered on microscopic and macroscopic levels.

Keywords: Chemical element; chemical compound; chemical individual; substance.

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1. INTRODUCTION

Chemistry is the study of matter, which includes us and everything around us. It involved in understanding the properties of substances, how they interact with one another, and how the combination of these elements produces compounds that may undergo chemical changes to generate new compounds [1-3].

Really, objects of chemistry include atom, element, composition, matter and properties, therefore, "chemistry is the science that deals with the composition and properties of matter". The chemical properties of matter display by molecules at microscopic level and physical properties related to substances, which represent macroscopic level. Taking into account microscopic -and macroscopic levels some definitions in the chemistry such as chemical element, chemical compound and substance should be corrected. Now physical and chemical properties of the substances are considered depending on of their size and the arrangement of elements in the chemical compounds [4]. All these factors earlier mentioned required formulations clear and corresponding to the main concepts.

The aim of this paper is to focus on to definitions of concepts between atom and chemical element, chemical compound and substance. In spite of these, there are certain definitions in chemistry, of which the essence should be corrected.

2. DISCUSSION

Well-known formulations of the concept of a chemical element are given as followings: A chemical element is a substance which is made up of only a single type of atom [5].An element is a substance consisting of atoms which all have the same atomic number [6]. A chemical element - is a pure chemical substance consisting of one type of atom distinguished by its atomic number which is the number of protons in its nucleus [7]. The recommended IUPAC name of an element states that "an element is a matter, whose atoms are alike in having the same positive charge on the nucleus" [8].A chemical element is a substance which is composed of specific type of atom. An element is a unique identifiable atom recognized by the number of protons in the nucleus [9,10,11].

Analysis of these formulations and adherence to the basic concepts of chemistry cause a pertinent question: such as "Why the same kind of atoms or a set of identical atoms, named a chemical element?" In fact, one, six or set of "N" atoms, irrespective of its quantity, concerns to the same kind of atom and the charge of nucleus inherent in it characterizes the given kind of atom.

Probably, the precondition of such a point of view promote statements in [1,9,11].

As matter of fact, the arrangement in the periodic table is not symbols of chemical elements but symbols of atoms in order of increasing atomic mass, where ordinary number corresponds to the charge of their nuclei**.** Although it is so, instead of periodic table of atoms, we normally call it periodic table of elements. However, we never used the expression "mass of chemical elements". Therefore, in our opinion; readers can make up their mind on the identity of atom and element.

John Dalton, one of founders of atomic model in his theory wrote: "Atoms of a given element are identical in size, mass, and other properties" [12]. Even this formulation has shown that

concepts of atom and element are not identical. In fact the word "element" (elementum) was used in antiquity as a part (of speech, as element of formation and etc.).It was from here – that this word originated from: under the name of some consonants in the Latin alphabet: l, m, n, t («el» - «em» - «en» - «tum»). From here, it is clear that chemical element represents a part of compound.

The concept that a chemical element close to true understanding was reflected by the new system of chemical philosophy stated by Robert Boyle in the book [13]. Robert Boyle has specified that neither four elements, nor three principles of alchemists cannot be recognized as elements. Elements, according to Boyle - are practically indecomposable bodies (substances) consisting similar homogeneous corpuscles. Thus, the concept of chemical element was introduced into science by scientists R. Boyle claimed that: “A chemical element is a component of substance”. D.I. Mendeleev's point of view concerning the definition of a chemical element is quoted: “A name of elements should mean those material components of simple and complex bodies which give them known set of physical and chemical properties.” [9].

A *chemical compound* is a substance consisting of particular chemical elements which determines its composition and a particular organization which determines its chemical properties [14].

In our opinion chemical compound characterizes chemical properties, but substance characterizes physical properties, although, composition of these matter consist of identical chemical elements.

Hence, a chemical element is conceptual expression to describe a composition of matter. In other words, a chemical element characterizes the state of atom as a part of a chemical compound in the form of an element [15].

For example, water. Water is formed from atoms of hydrogen and oxygen in the ratio of two to one. In this compound hydrogen and oxygen do not show property of the isolated atoms, but as chemical elements expressing composition and structure of water. Molecule of water, as chemical compound, is formed and interconverted by chemical reactions. Molecules of water by molecular bond form substance of water. Similarly, elementary structure of the crystalline of sodium chloride, as a chemical compound consists of chemical elements of sodium and chlorine. The chloride of sodium related to binary chemical compound and by molecular bond form crystalline lattice structure of substance table salt. That is why chemical compounds and substances of matter have the same composition!

It is necessary to note, that, the substance form from chemical compounds and can display physical properties. Chemical properties of substance display in chemical reactions by chemical compounds and their compositions are expressed by chemical formulas.

A chemical formula is a conditional sign of composition of substance by means of chemical symbols (is offered in 1814 by J. Berzelius) and indexes. Therefore, the chemical formula is a representation of a chemical compound, and also substance using symbols for its constitute of elements.

Thus, one or more kinds of matter are converted to new kinds with different compositions in considering system where a substance displays both macroscopic- and microscopic properties.

In order to operate with substances in macroscopic- and microscopic level we usually used an amount of substance referred to as a mole. The mole is a unit of measurement that contains as many elementary entities (atoms, molecules, ions, etc.) as there are atoms in 0.012 kilogram (or 12 grams) of carbon-12, where the carbon-12 atoms are unbound, at rest and in their ground state. This can either represent a counted quantity of objects or indirectly determined numbers of particles of a substance being dealt with such as how many atoms are contained in a sample of a pure substance. The latter quantity is described in terms of moles.

Modern development of science and applied researches cannot be presented without taking into consideration macro-and micro properties of substances. So far a lot of materials have been developed changing parameters of technological process and fixing changes of controllable characteristics. However, the achievements in nanotechnology allow one to operate with particles and structures of substance at macro- and microscopic levels [4].

Well-known, at diminution the size of particles, the attitude of a surface to volume increases and it is the facilitated courses of chemical reaction. In addition, at a level less than 100 nanometers there appear quantum effects. Quantum effects can influence the optical, electric or magnetic properties of substances. Therefore, one of the fundamental problems of chemistry is studying dependence between structure of chemical compounds consisting of elements and its properties display as substance. At chemical transformations of compounds the relative positioning and quantity of elements are changed which essentially influence their chemical properties and physical properties of substances. For example, from atoms of carbon, hydrogen with small amount of oxygen, nitrogen, phosphorus, etc. elements to form carbohydrates, bacteria, viruses, vitamins, fibers and all other organic substances. It is reflected in the theory of a chemical structure of organic compounds in such formulation: “The chemical nature of a complex compound is defined by the nature of elementary compound particles, their quantity and a chemical structure“ [16].

According to this theory elements easily explain distinction in properties of substances consisting of the same elements.

Influences of the structural factor on character of chemical compounds and substances are evidently shown with carbon, phosphorus, sulfur, etc. where the materials possess various physical and chemical properties, though their composition is expressed by the same elements. For example, diamond and graphite obtaining from carbon atoms being two allotropes, forms two simple substances. Well-known, carbon has a crystalline lattice structure. There are strong covalent bonds between its atoms. The different types of bonds between the atoms of carbon cause the differences in appearance and chemical properties of these chemical compounds. These chemical compounds are organized to diamond or graphite with inherent physical properties depending on its structure.

This is why it is important to focus attention on differences between the chemical compounds and substances. Hence, at chemical interaction between carbon atoms one obtained chemical compounds of carbon named chemical individuals of diamond or graphite, which differ in structure and chemical properties [15]. Graphite crystals have a layered structure that formed hexagonal carbon cycles from chemical individuals of graphite. Pure diamond is a transparent solid and has a crystalline lattice structure. Each carbon atom in the structure of diamond is bonded with strong bonds to four neighbor carbon atoms in the shape of tetrahedron. Therefore, cell of diamond lattice consist of chemical individuals of diamond.

Thus, chemical individuals are elementary structural molecule or a cell of crystalline lattice structure which display chemical and physical properties of matter.

Accordingly, white, red and black phosphorus or various modifications of sulfur consist of corresponding chemical individuals, though; their elementary structures are expressed by the same elements. The molecule of table salt has a crystalline lattice structure. Here, binary chemical compound chloride of sodium is representing to a chemical individual. This chemical individual is an elementary structural part of crystalline lattice structure of chloride of sodium and show corresponding physical and chemical properties of table salt. Enthalpy of formation of crystal lattice structure is equal about 763kJ/mol, and heat of hydrations at solving table salt also makes 773 kJ/mol. [17]. Close values formations of a crystal lattice and heat of hydrations to permit, indirectly, about identical structure of chemical compound of sodium chloride. Obviously, dissociation of table salt at dissolving in water do not occur on ions of sodium and chlorine. So, on the view point of H.G. Hertz individual properties of ions of sodium and chlorine in solution are not shown, and properties of table salt are kept [18].

It also serves as acknowledgement of the presence of a chemical individual of chloride of sodium. Crystals of table salt break up, and they, cooperate with molecules of water forming polarized chemical individuals. It looks like an ionic atmosphere in the theory of strong electrolytes. Indirectly, existence of the chemical individual of chloride of sodium shows experimental data with the melting of table salt. At evaporation of the melting table salt which must contain ions of sodium and chlorine (as follows from the theory of electrolytes) do not evaporate ions and in vapor prove to be only compound chloride of sodium in the form of NaCl. This circumstance, alongside with others, raises the doubts in the point of view of Arrhenius. The concept “chemical individual” was entered by authors of these lines in [15].

In fact, property of elementary, binary and other substances are defined by nature of chemical individuals.

Although, the composition of two or more modifications of substances is identical, their properties are defined by structures of a chemical compound or chemical individuals. Therefore, it is important to know what kind of compounds is formed by atoms at their interaction.

Usually, at chemical interaction of identical atoms elementary chemical compounds or chemical individuals (H-H, Fe-Fe, diamond, graphite, fullerene, etc.) will be produced. Interactions of various two atoms leads to formation of binary compounds (NaCl, HCl,CaO, etc.) At interaction of various binary compounds with each other (For example: CaO and CO_2; HCl and FeO, etc.) or binary compounds with the third particles such as atom, a radical, etc. (Zn + HCl; CH_4 + Cl_2; NaOH +HNO_3, etc.) leads to formation of a chemical compounds or complex compounds. Then, all these compounds form corresponding substances.

Thus, at reacting, there are disintegration of the initial substances to chemical compounds (chemical individuals). These chemical compounds interacted forming new chemical compounds or chemical individuals. Here particles of new compounds aggregate on to substances.

During the plural individual movement of elements from one chemical substance into others, there are chemical reactions with the quantum - chemical display at simultaneous combination of macroscopic - and microscopic properties. However, definitions available in

[1,11,19] do not give serious attention to distinctions between chemical compound and substance and formulations:

-simple substances–molecules consist of atoms of the same elements. Complex substances– molecules consist of atoms of various different chemical elements. Simple and complex substances referred to as chemical compounds. A chemical compound-homogeneous substance of constant or variable structure with qualitatively original chemical or crystalline lattice structure, formed by atoms of one or several chemical elements. Elements and compounds are called substances.

In these definitions chemical compound and substance are identical, and demands to concretize their specifications. In this write up we offer below - mentioned sequence of material formations from atom to substance*:*

Atom - chemical individual or a molecule - a cell of crystalline lattice structure of elementary, binary and chemical compounds (complex compounds)-pure elementary, binary and chemical substance (complex substance) - a mixture of substances.

For the substances that do not have allotropy or phase modifications (polymorphism), the concept of a chemical individual coincides with a chemical compound.

3. CONCLUSION

Thus, a chemical element characterizes the state of atom after their linkage to chemical compound in structure of a molecule, chemical individual, elementary, binary and chemical substance (complex substance) as their part in the form an element. A *substance* is a matter of macroscopic material formation in a firm body, a liquid, gas or plasma, consisting of *chemical compounds* and possessing physical properties. A chemical compound (chemical individual) – is a matter of microscopic material formation consisting of chemical elements and composition is represented by *chemical formula.* Chemical individuals are elementary structural elements of a cell of crystalline lattice structure, which display chemical and physical properties of matter. Nomenclature of substances is a critical part of the language of chemistry. Generally it refers to a system for naming chemical compounds. The standard nomenclature of chemical substances is set by the International Union of Pure and Applied Chemistry (IUPAC). There are well-defined systems in place for naming chemical species. Organic compounds are named according to the organic nomenclature system. Inorganic compounds are named according to the inorganic nomenclature system. In addition, the Chemical Abstracts Service has devised a method to index chemical substances. In this scheme each chemical substance is identifiable by a number known as its CAS registry number [20].

Though the composition of a chemical compound and a substance coincide, but, substances without impurities do not exist. Using concept of pure substance, is accepted that a substance of the certain degree of clearing. Besides, presence of impurity considerably influences its physical and chemical properties. For example, maintenances of carbon in iron up to 1,7 %significantly changes its properties and received firm solution refers as steel. With increasing amount of carbon in the maintenance raise the hardness of steel; the temperature of fusion goes down at the same time steel remains as steel. Probably forming chemical individual of iron with carbon being the elementary structural of the crystal cell of steel and entirely influences its properties. Similarly, water solution of table salt represents a new chemical individual of chloride of sodium. This chemical individual of chloride of sodium

with molecules of water qualitatively distinct from its origin constituent. Otherwise this solution would be the represented mixture of H_2O and NaCl, which properties develop from the properties of water and table salt, that, certainly, not so. It is so obvious, that the structures and the properties of any solution - depends on quantity of substances (mole) generating chemical individuals. In other words, at studying physical and chemical properties of substances it is necessary to consider its dimension, composition of chemical compounds, structural elements and their mutual arrangement in system. In addition, the knowledge of the nature of chemical individuals participating in elementary stages of chemical reactions will allow predetermining possible structure and properties of substances that will open new prospects in reception of materials with set properties in advance.

COMPETING INTERESTS

Authors have declared that no competing interests exit

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