OPEN ACCESS
Global Journal of Research in Agriculture & Life Sciences
ISSN: 2583-4576 (Online)
Volume 05 | Issue 01 | Jan.-Feb. | 2025
Journal homepage: https://gjrpublication.com/gjrals/
Research Article

Structure of Atom and Atomic Mass

*Jelenka Savkovic-Stevanovic

University of Belgrade, Faculty of Technology and Metallurgy, 11000 Belgrade, Karnegijeva 4, Serbia.

DOI: 10.5281/zenodo.14802249 **Submission Date:** 30 Dec. 2024 | **Published Date:** 04 Feb. 2025

Corresponding author: ***Jelenka Savkovic-Stevanovic***
University of Belgrade, Faculty of Technology and Metallurgy, 11000 Belgrade, Karnegijeva 4, Serbia.

Abstract
In this paper atomic structure and atomic mass were studied. A chemical reaction rearranges the atoms of the reactants to create different substances as products. Development of the concept of a chemical reaction had a primary role in defining the science of chemistry as it is known today. In this paper equation for the change atomic mass and quant energy were derived, the first time in literature. The structural equations of atoms were analyzed and parameters and terms were discussed and revised.

1. INTRODUCTION

Chemical reactions must be distinguished from physical changes. Physical changes include changes of state, such as ice melting to water and water evaporating to vapor. If a physical change occurs, the physical properties of a substance will change, but its chemical identity will remain the same. No matter what its physical state, water (H_2O) is the same compound, with each molecule composed of two atoms of hydrogen and one atom of oxygen. However, if water, as ice, liquid, or vapor, encounters sodium metal (Na), the atoms will be redistributed to give the new substances molecular hydrogen (H_2) and sodium hydroxide (NaOH). By this, we know that a chemical change or reaction has occurred.

The concept of chemical reactions involving the combination of elements clearly emerged from his writing, and his approach led others to pursue experimental chemistry as a quantitative science [1]-[6].

The other occurrence of historical significance concerning chemical reactions was the development of atomic theory [7], [8]. For this, much credit goes to English chemist John Dalton, who postulated his atomic theory early in the 19th century. Dalton maintained that matter is composed of small, indivisible particles, that the particles, or atoms, of each element were unique, and that chemical reactions were involved in rearranging atoms to form new substances. This view of chemical reactions accurately defines the current subject. Dalton's theory provided a basis for understanding the results of earlier experimentalists, including the law of conservation of matter (matter is neither created nor destroyed) and the law of constant composition (all samples of a substance have identical elemental compositions).

The concept of a chemical reaction dates back about 250 years. It had its origins in early experiments that classified substances as elements and compounds and in theories that explained these processes.

The first substantive studies in this area were on gases. The identification of oxygen in the 18th century by Swedish chemist Carl Wilhelm Scheele and English clergyman Joseph Priestley had particular significance. The influence of French chemist Antoine-Laurent Lavoisier was especially notable, in that his insights confirmed the importance of quantitative measurements of chemical processes. In his book Lavoisier identified 33 "elements"—substances not broken down into simpler entities. Among his many discoveries, Lavoisier accurately measured the weight gained when elements were oxidized, and he ascribed the result to the combining of the element with oxygen.

In this paper electromagnetic structure of atoms and atomic mass were examined.

2.The atomic mass and structure of atom

Atoms are the basic particles of the chemical elements. An atom consists of a nucleus of protons and generally neutrons, surrounded by an electromagnetically bound swarm of electrons. The chemical elements are distinguished from each other by the number of protons that are in their atoms. For example, any atom that contains 11 protons is sodium, and any atom that contains 29 protons is copper. Atoms with the same number of protons but a different number of neutrons are called isotopes of the same element.

Atoms are extremely small, typically around 100 picometers across. A human hair is about a million carbon atoms wide. Atoms are smaller than the shortest wavelength of visible light, which means humans cannot see atoms with conventional microscopes. They are so small that accurately predicting their behavior using classical physics is not possible due to quantum effects.

More than 99.9994% of an atom's mass is in the nucleus. Protons have a positive electric charge and neutrons have no charge, so the nucleus is positively charged. The electrons are negatively charged, and this opposing charge is what binds them to the nucleus. If the numbers of protons and electrons are equal, as they normally are, then the atom is electrically neutral as a whole. If an atom has more electrons than protons, then it has an overall negative charge, and is called a negative ion (or anion). Conversely, if it has more protons than electrons, it has a positive charge, and is called a positive ion (or cation).

The electrons of an atom are attracted to the protons in an atomic nucleus by the electromagnetic force. The protons and neutrons in the nucleus are attracted to each other by the nuclear force. This force is usually stronger than the electromagnetic force that repels the positively charged protons from one another. Under certain circumstances, the repelling electromagnetic force becomes stronger than the nuclear force. In this case, the nucleus splits and leaves behind different elements. This is a form of nuclear decay.

Atoms can attach to one or more other atoms by chemical bonds to form chemical compounds such as molecules or crystals. The ability of atoms to attach and detach from each other is responsible for most of the physical changes observed in nature. Chemistry is the science that studies these changes.

3.The periodic of table and atomic mass

The periodic table of the elements from Dmitri Mendeleev's *Osnovy khimii* 1869; *The Principles of Chemistry*, one of the earliest periodic tables created [9],[10]. As more and more elements were discovered during the 19th century, scientists began to wonder how the physical properties of the elements were related to their atomic weights. During the 1860s several schemes were suggested. Russian chemist Dmitry Ivanovich Mendeleyev based his system on the atomic weights of the elements as determined by Avogadro's theory of diatomic molecules. In his paper of 1869 introducing the periodic law, he credited Cannizzaro for using "unshakeable and indubitable" methods to determine atomic weights.

The elements, if arranged according to their atomic weights, show a distinct periodicity of their properties. Elements exhibiting similarities in their chemical behavior have atomic weights which are approximately equal (as in the case of Pt, Ir, Os) or they possess atomic weights which increase in a uniform manner (as in the case of K, Rb, Cs).

Skipping hydrogen because it is anomalous, Mendeleyev arranged the 63 elements known to exist at the time into six groups according to valence. Valence, which is the combining power of an element, determines the proportions of the elements in a compound. For example, H_2O combines oxygen with a valence of 2 and hydrogen with a valence of 1. Recognizing that chemical qualities change gradually as atomic weight increases, Mendeleyev predicted that a new element must exist wherever there was a gap in atomic weights between adjacent elements. His system was thus a research tool and not merely a system of classification. Mendeleyev's periodic table raised an important question, however, for future atomic theory to answer: Where does the pattern of atomic weights come from.

4. Atomic mass and quant energy

Let, consider relation between mass and energy. What is difference?
Quant energy is emitted in discrete energy quant. Energy of one quant proportional is frequency radiation of electromagnetic waves.

Frequency is inversely proportional to wavelength, according to the equation:

$$v = f\lambda \qquad (1)$$

Low of atomic mass change of energy quant can be derived as follow.

$$\varepsilon = hf\ , \qquad E = nhf \qquad (2)$$

$$w_A = \frac{nhf}{\lambda} \qquad (3)$$

where h Planck's constant, $h = 6.62\ \ 10^{-34}\ \ Js$, f frequency $1/s$, λ wave length m , ε quant energy J , w_A mass of atom kg .

Atomic mass is proportional energy quant and inversely proportional wavelength.
Thus, substance is the high density electromagnetic waves.

Eq. (3) gives dependence atomic mass of energy quant and appear first time in the literature, in this paper.

5. Structural equations of the atom analysis

The Bohr model is a relatively primitive model of the hydrogen atom, compared to the valence shell model. As a theory, it can be derived as a first-order approximation of the hydrogen atom using the broader and much more accurate quantum mechanics and thus may be considered to be an obsolete scientific theory. However, because of its simplicity, and its correct results for selected systems, the Bohr model is still commonly taught to introduce students to quantum mechanics or energy level diagrams before moving on to the more accurate, but more complex, valence shell atom. A related quantum model was proposed by Arthur Erich Haas in 1910 but was rejected until the 1911 Solvay Congress where it was thoroughly discussed. The quantum theory of the period between Planck's discovery of the quantum (1900) and the advent of a mature quantum mechanics (1925) is often referred to as the old quantum theory.

The constitution of the nucleus was poorly understood at the time because the only known particles were the electron and the proton. It had been established that nuclei are typically about twice as heavy as can be accounted for by protons alone. A consistent theory was impossible until English physicist James Chadwick discovered the neutron in 1932. He found that alpha particles reacted with beryllium nuclei to eject neutral particles with nearly the same mass as protons. Almost all nuclear phenomena can be understood in terms of a nucleus composed of neutrons and protons. Surprisingly, the neutrons and protons in the nucleus move to a large extent in orbitals as though their wave functions were independent of one another. Each neutron or proton orbital is described by a stationary wave pattern with peaks and nodes and angular momentum quantum numbers. The theory of the nucleus based on these orbitals is called the shell nuclear model. It was introduced independently in 1948 by Maria Goeppert Mayer of the United States and Johannes Hans Daniel Jensen of West Germany, and it developed in succeeding decades into a comprehensive theory of the nucleus.

In this paper the newest mathematical model of atom by Savkovic Stevanovic was discussed and revised [11]. The new model involves particles: the electron, the proton, the neutron and quark. This mathematical model includes beside space velocities, and velocity of per some property. Probability distribution function of density and probability distribution function of temperature are included.

Mass conservation equation can be described as:

$$\frac{\partial\psi_\rho}{\partial t} + v_x\frac{\partial\psi_\rho}{\partial x} + v_y\frac{\partial\psi_\rho}{\partial y} + v_z\frac{\partial\psi_\rho}{\partial z} + \frac{\partial(v_i\psi_\rho)}{\partial\xi} - D(\frac{\partial^2\psi_\rho}{\partial x^2} + \frac{\partial^2\psi_\rho}{\partial y^2} + \frac{\partial^2\psi_\rho}{\partial z^2}) + \rho_n g + \rho_p g + \rho_e g + \rho_\varsigma g + e_m^{ep} + e_m^{np} + e_m^{p\varsigma} + R_r = 0 \qquad (4)$$

Energy wave can be described as:

$$\rho c_p(\frac{\partial\psi_T}{\partial t} + v_x\frac{\partial\psi_T}{\partial x} + v_y\frac{\partial\psi_T}{\partial y} + v_z\frac{\partial\psi_T}{\partial z} + \frac{\partial(v_i\psi_T)}{\partial\xi} - k_c(\frac{\partial^2\psi_T}{\partial x^2} + \frac{\partial^2\psi_T}{\partial y^2} + \frac{\partial^2\psi_T}{\partial z^2}) + H_n + H_p + H_e + H_\varsigma + H_{e_m}^{ep} + H_{e_m}^{np} + H_{e_m}^{p\varsigma} + S_r = \qquad (5)$$

where ψ_ρ probability density, v geometrical velocity, g - gravity, x, y, z spatial coordinates, ξ - some property, D - diffusivity, e_m^{ep} - electromagnetic force attracted between electrons and proton, e_m^{np} - electromagnetic force attracted between proton and neutron, $e_m^{p\varsigma}$ - electromagnetic force attracted between proton and quark, R_r - density generation, ψ_T temperature probability, c_p - heat capacity, k_c - conductivity, H - energy, S_r -heat generation, t - time. Indexes n, e, p, ς refer to neutron, proton, electron and quark, respectively.

For stationary state of substance, the equations (4) and (5) were described:

$$v_x\frac{\partial\psi_\rho}{\partial x} + v_y\frac{\partial\psi_\rho}{\partial y} + v_z\frac{\partial\psi_\rho}{\partial z} + \frac{\partial(v_i\psi_\rho)}{\partial\xi} - D(\frac{\partial^2\psi_\rho}{\partial x^2} + \frac{\partial^2\psi_\rho}{\partial y^2} + \frac{\partial^2\psi_\rho}{\partial z^2}) + \rho_n g + \rho_p g + \rho_e g + \rho_\varsigma g + e_m^{ep} + e_m^{np} + e_m^{p\varsigma} + R_r = \qquad (6)$$

$$\rho c_p(v_x \frac{\partial \psi_T}{\partial x} + v_y \frac{\partial \psi_T}{\partial y} + v_z \frac{\partial \psi_T}{\partial z} + \frac{\partial (v_i \psi_T)}{\partial \xi} - k_c(\frac{\partial^2 \psi_T}{\partial x^2} + \frac{\partial^2 \psi_T}{\partial y^2} + \frac{\partial^2 \psi_T}{\partial z^2}) + H_n + H_p + H_e + H_\varsigma + H_{e_m}^{ep} + H_{e_m}^{np} + H_{e_m}^{p\varsigma} + S_r = 0 \quad (7)$$

Equations (4) - (7) are appear the first time in literature, in the previously paper [11].

6. Mass conservation

Thus, experiment and theory, the two cornerstones of chemical science in the modern world, together defined the concept of chemical reactions. Today experimental chemistry provides innumerable examples, and theoretical chemistry allows an understanding of their meaning.

When making a new substance from other substances, chemists say either that they carry out a synthesis or that they synthesize the new material. Reactants are converted to products, and the process is symbolized by a chemical equation. For example, iron (Fe) and sulfur (S) combine to form iron sulfide (FeS): Fe(s) + S(s) → FeS(s). The plus sign indicates that iron reacts with sulfur. The arrow signifies that the reaction “forms” or “yields” iron sulfide, the product. The state of matter of reactants and products is designated with the symbols (s) for solids, (l) for liquids, and (g) for gases.

In reactions under normal laboratory conditions, matter is neither created nor destroyed, and elements are not transformed into other elements. Therefore, equations depicting reactions must be balanced; that is, the same number of atoms of each kind must appear on opposite sides of the equation. The balanced equation for the iron-sulfur reaction shows that one iron atom can react with one sulfur atom to give one formula unit of iron sulfide.

Chemists ordinarily work with weighable quantities of elements and compounds. For example, in the iron-sulfur equation the symbol Fe represents 55.845 grams of iron, S represents 32.066 grams of sulfur, and FeS represents 87.911 grams of iron sulfide. Because matter is not created or destroyed in a chemical reaction, the total mass of reactants is the same as the total mass of products. If some other amount of iron is used, say, one-tenth as much (5.585 grams), only one-tenth as much sulfur can be consumed (3.207 grams), and only one-tenth as much iron sulfide is produced (8.791 grams). If 32.066 grams of sulfur were initially present with 5.585 grams of iron, then 28.859 grams of sulfur would be left over when the reaction was complete.

The reaction of methane (CH_4, a major component of natural gas) with molecular oxygen (O_2) to produce carbon dioxide (CO_2) and water can be depicted by the chemical equation CH_4(g) + $2O_2$(g) → CO_2(g) + $2H_2O$(l). Here another feature of chemical equations appears. The number 2 preceding O_2 and H_2O is a stoichiometric factor. (The number 1 preceding CH_4 and CO_2 is implied.) This indicates that one molecule of methane reacts with two molecules of oxygen to produce one molecule of carbon dioxide and two molecules of water. The equation is balanced because the same number of atoms of each element appears on both sides of the equation (here one carbon, four hydrogen, and four oxygen atoms). Analogously with the iron-sulfur example, we can say that 16 grams of methane and 64 grams of oxygen will produce 44 grams of carbon dioxide and 36 grams of water. That is, 80 grams of reactants will lead to 80 grams of products.

The ratio of reactants and products in a chemical reaction is called chemical stoichiometry. Stoichiometry depends on the fact that matter is conserved in chemical processes, and calculations giving mass relationships are based on the concept of the mole. One mole of any element or compound contains the same number of atoms or molecules, respectively, as one mole of any other element or compound. By international agreement, one mole of the most common isotope of carbon (carbon-12) has a mass of exactly 12 grams (this is called the molar mass) and represents $6.022140857 \times 10^{23}$ atoms (Avogadro’s number). One mole of iron contains 55.847 grams; one mole of methane contains 16.043 grams; one mole of molecular oxygen is equivalent to 31.999 grams; and one mole of water is 18.015 grams. Each of these masses represents $6.022140857 \times 10^{23}$ molecules.

7. Energy conservation

Energy plays a key role in chemical processes. According to the modern view of chemical reactions, bonds between atoms in the reactants must be broken, and the atoms or pieces of molecules are reassembled into products by forming new bonds. Energy is absorbed to break bonds, and energy is evolved as bonds are made. In some reactions the energy required to break bonds is larger than the energy evolved on making new bonds, and the net result is the absorption of energy. Such a reaction is said to be endothermic if the energy is in the form of heat. The opposite of endothermic is exothermic; in an exothermic reaction, energy as heat is evolved. The more general terms *exoergic* (energy evolved) and *endoergic* (energy required) are used when forms of energy other than heat are involved.

A great many common reactions are exothermic. The formation of compounds from the constituent elements is almost always exothermic. Formation of water from molecular hydrogen and oxygen and the formation of a metal oxide such as calcium oxide (CaO) from calcium metal and oxygen gas are examples. Among widely recognizable exothermic reactions is the combustion of fuels (such as the reaction of methane with oxygen mentioned previously).

The formation of slaked lime (calcium hydroxide, $Ca(OH)_2$) when water is added to lime (CaO) is exothermic: CaO(s) + H2O (l) → $Ca(OH)_2$(s). This reaction occurs when water is added to dry portland cement to make concrete, and heat evolution of energy as heat is evident because the mixture becomes warm.

Not all reactions are exothermic (or exoergic). A few compounds, such as nitric oxide (NO) and hydrazine (N_2H_4), require energy input when they are formed from the elements. The decomposition of limestone ($CaCO_3$) to make lime (CaO) is also an endothermic process; it is necessary to heat limestone to a high temperature for this reaction to occur: $CaCO_3$(s) → CaO(s) + CO_2(g). The decomposition of water into its elements by the process of electrolysis is another endoergic process. Electrical energy is used rather than heat energy to carry out this reaction: 2 H_2O(g) → 2 H_2(g) + O_2(g). Generally, evolution of heat in a reaction favors the conversion of reactants to products. However, entropy is important in determining the favorability of a reaction. Entropy is a measure of the number of ways in which energy can be distributed in any system. Entropy accounts for the fact that not all energy available in a process can be manipulated to do work.

A chemical reaction will favor the formation of products if the sum of the changes in entropy for the reaction system and its surroundings is positive. An example is burning wood. Wood has a low entropy. When wood burns, it produces ash as well as the high-entropy substances carbon dioxide gas and water vapor. The entropy of the reacting system increases during combustion. Just as important, the heat energy transferred by the combustion to its surroundings increases the entropy in the surroundings. The total of entropy changes for the substances in the reaction and the surroundings is positive, and the reaction is product-favored.

When hydrogen and oxygen react to form water, the entropy of the products is less than that of the reactants. Offsetting this decrease in entropy, however, is the increase in entropy of the surroundings owing to the heat transferred to it by the exothermic reaction. Again because of the overall increase in entropy, the combustion of hydrogen is product-favored.

8. Discussion

In this paper the law of atomic mass change and energy of quant was derived.

Energy quant is proportional atomic mass and inversely proportional wavelength.

Varying frequency can produce signals different wavelength.

Also, substance can produce as high density energy.

The equations of atom structure and state were analyzed and parameters and terms were discussed and revised.

9. Conclusion

In this paper atomic mass and atomic structure were examined. The law of atomic mass change and energy of quant was derived.

Structural electromagnetic equations were analyzed and parameters and terms were discussed and revised.

Periodic table explanating the periodic law between atom electronic structure of the elements and properties was provided.

Energy conservation and mass conservation were discussed. Entropy analyze as important in determining the favorability of a reaction was performed.

Notation

w_A -atomic weight, kg

c_p - heat capacity, J / kgK

D - diffusivity, m^2 / s

e_m^{ep} - electromagnetic force attracted between electrons and proton, N

e_m^{np} - electromagnetic force attracted between proton and neutron, N

$e_m^{p\varsigma}$ - electromagnetic force attracted between proton and quark, N

f - frequency, s^{-1}

g -gravity acceleration, m / s^2

$h = 6.62 \ \ 10^{-34} \ Js$ -universal Plank's constant

k_c - conductivity coefficient, J/mKs

v - geometrical velocity, m/s

x, y, z - spatial coordinates, m

R_r - density generation, kg/m^3

H - energy, J

S_r -heat generation, J

t - time, s.

Greek symbols

ε -quant energy, J

λ - wave length, m

ξ - some property

ψ_ρ - probability density, kg/m^3

ψ_T - probability of temperature, K

Indexes

n, p, e, ς, refer to neutron, proton, electron and quark, respectively.

REFERENCES

1. B. Pullman, The Atom in the History of Human Thought. Oxford, England: Oxford University Press. pp. 31–33. ISBN 978-0-19-515040-7. Archived from the original on 5 February 2021. Retrieved 25 October 2020, 1998.
2. B. Pullman, The Atom in the History of Human Thought, p. 201, 1998.
3. Holbrow et al., Modern Introductory Physics, pp. 65–66, 2010.
4. Melsen, From Atomos to Atom, p. 137,1952.
5. J. J. Thomson, "On bodies smaller than atoms". The Popular Science Monthly: 323–335, 1901. Archived from the original on 1 December 2016. Retrieved 21 June 2009.
6. J. Savkovic Stevanovic, Chemical reaction and constituent atoms, Global Journal of Research in Agriculture & Life Sciences, 4(1)40-44, 2024, ISSN2583-4576, https://doi.org/10.5281/zenodo.10010671.
7. J. Savkovic-Stevanovic, Chemical reaction and periodic system of elements,, IES2024 Proceedings-29th- Symposium and Seminar on Information and Expert Systems in the Process Industries, pp. 83-89, October 23-24, 2024, ISBN 978-86-80072-14-2.
8. J. Savkovic Stevanovic, Kinetic models, Faculty of Technology and Metallurgy, Belgrade University, p. 54, 2005.
9. M. Gordin, A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table. New York: Basic Books, 2004,ISBN978-0-465-02775-0.
10. D. I. Mendeleyev, W. B. Jensen, Mendeleev on the Periodic Law: Selected Writings, 1869–1905. Mineola, New York: Dover Publications,2005, ISBN 978-0-486-44571-7.
11. J. Savkovic Stevanovic, The new model of atom, International Journal of Research and Scientific Innovation, 11 (9), 1033-1030, 2024, ISSN 2321-270

CITATION

J. Savkovic Stevanovic. (2025). Structure of Atom and Atomic Mass. In Global Journal of Research in Agriculture & Life Sciences (Vol. 5, Number 1, pp. 56–61). https://doi.org/10.5281/zenodo.14802249