THE PUBLISHING HOUSE
OF THE ROMANIAN ACADEMY

PROCEEDINGS OF THE ROMANIAN ACADEMY, Series A,
Volume 25, Number 4/2024, pp. 301–306
DOI: 10.59277/PRA-SER.A.25.4.06

CONSTANT OF ATOMS AND NEW EQUATION OF ELECTROMAGNETIC FORCE

M.R. SANAD

National Research Institute of Astronomy and Geophysics, Astronomy Department, Helwan, Cairo, Egypt
E-mail: mrsanad1@yahoo.com

Abstract. We present new equations for atoms (new atomic constant connecting atomic area, number of electrons and atomic mass and new equation of calculating electromagnetic force) with new concepts and results of atomic radii in good agreement with known determined calculations. All atoms consist of a certain number of electrons & nucleons and have certain masses with certain diameters contained in a certain area with certain velocities with a certain uniform distribution with a certain constant hold and bound by a certain fundamental force (electromagnetic force), so the main equations of all atoms are controlled by these physical parameters. The calculations confirmed that the mass, the area and number of electrons of any atom give a constant value. The new equation with a new atomic constant is used to calculate previously undetermined atomic radii (van der Waals radii). A new equation of electromagnetic force of atoms can be determined by three main physical parameters (mass, distance, velocity of light).

***Key words**:* mass, area, radius, constant, force.

1. INTRODUCTION

Thomson (1897) discovered that the rays of cathode are not a form of light but consist of negatively charged particles because they can be deflected by electric and magnetic fields. He found that these particles are thousand times lighter than hydrogen atom. He called these new particles corpuscles and they were later renamed electrons. Thomson explained that an electric current is the passing of electrons from one atom to the next, and when there was no current the electrons embedded themselves in the atoms. This in turn leads to conclude that atoms were not indivisible [1].

Rutherford and his colleagues (1911) performed a series of experiments in which they bombarded thin foils of metal with a beam of alpha particles. They detected a small number of alpha particles being deflected. They proposed that the positive charge of the atom along with most of the mass of the atom is concentrated in a tiny nucleus at the center of the atom. Only such an intense concentration of positive charge with its high mass and separated from the negative charge (electron) could produce an electric field that could deflect the alpha particles [2, 3].

Atoms are the main particles of chemical elements consisting of positively charged nucleus surrounded by a cloud of negatively charged particles. The number of positively charged particles (protons) is equal to the negatively charged particles (electrons), so the atom is neutral. Atoms are very small in the range of Angstrom. More than 99.9 of an atom mass is in the nucleus.

Van der Waals radius is a measure for the size of an atom that is not chemically (ionically or covalently) bound. Generally, a van der Waals radius is defined as half the nearest distance of two equal, non-covalently bound, atoms. It is named after Johannes Diderik van der Waals, because he was the first to recognize that the atoms were not simply points and explained the physical consequences of their size through the van der Waals equation of state [4, 5].

At present there are 118 known elements which are typically classified on the periodic table of elements. Elements with atomic number 1 – 98 have all been shown to exist in nature while the remaining elements with atomic number 99 – 118 have only ever been produced artificially.

2. PHYSICAL FOUNDATIONS

Physical relations and laws can be expressed in terms of the main physical parameters responsible for their origin. Nucleus and electrons at certain distances contained in a certain area with a certain uniform distribution forming certain system (atom) with a certain constant. The electromagnetic force is acting only at certain distance in the range of a few Angstroms and its main role is to form and bound the atoms and is determined by three main physical parameters (mass, distance, velocity of light).

3. MATHEMATICAL FOUNDATIONS

3.1. Constant of atoms

As a result of the uniform distribution of the particles (electrons & nucleons) inside atoms, the area of any atom and its number of electrons is proportional with its mass

$$a \times n \propto m \tag{1}$$

$$4\pi \times r^2 \times n = \text{const} \times m \tag{2}$$

$$\text{const} = \frac{4\pi \times r^2 \times n}{m} = 1.1 \times 10^8 \ \text{m}^2/\text{kg} \tag{3}$$

From which the following two equations (4) and (5) can be deduced

$$r = \sqrt{\frac{m \times \text{const}}{4\pi \times n}} \tag{4}$$

The calculated radius of any atom by using equation (4) is consistent and in good agreement with determined radii values of van der Waals as indicated in Table 1

$$m = \frac{4\pi \times r^2 \times n}{\text{const}} \tag{5}$$

The calculated mass of any atom by using equation (5) is identical with actual atomic mass values as indicated in Table 1, where *a* is the area of any atom, *m* is the mass of any atom, cons is constant value for any atom, *r* is the radius of any atom and *n* is the number of electrons.

3.2. Confirming constant of all atoms

All calculations confirmed that there is constant value for atoms relating to their area, number of electrons and mass. Table 1 lists the constant value of the atoms by using equation (3) and previous determined values of atomic radii [6–11].

Table 1

Physical parameters of atoms with van der Waals radius and new radius equation (4)

Atomic number	Symbol	Name	Atomic mass [kg]	van der Waals radius [m]	New radius [m]	Constant [m^2/kg]
1	H	Hydrogen	1.67×10^{-27}	1.20×10^{-10}	1.20×10^{-10}	1.1×10^8
2	He	Helium	6.68×10^{-27}	1.40×10^{-10}	1.70×10^{-10}	1.1×10^8
3	Li	Lithium	1.16×10^{-26}	1.82×10^{-10}	1.82×10^{-10}	1.1×10^8
4	Be	Beryllium	1.50×10^{-26}	1.53×10^{-10}	1.80×10^{-10}	1.1×10^8
5	B	Boron	1.80×10^{-26}	1.92×10^{-10}	1.75×10^{-10}	1.1×10^8
6	C	Carbon	2.00×10^{-26}	1.70×10^{-10}	1.70×10^{-10}	1.1×10^8
7	N	Nitrogen	2.34×10^{-26}	1.55×10^{-10}	1.70×10^{-10}	1.1×10^8
8	O	Oxygen	2.67×10^{-26}	1.52×10^{-10}	1.70×10^{-10}	1.1×10^8
9	F	Fluorine	3.17×10^{-26}	1.47×10^{-10}	1.75×10^{-10}	1.1×10^8
10	Ne	Neon	3.34×10^{-26}	1.54×10^{-10}	1.70×10^{-10}	1.1×10^8

11	Na	Sodium	3.83×10^{-26}	2.27×10^{-10}	1.75×10^{-10}	1.1×10^{8}
12	Mg	Magnesium	4.10×10^{-26}	1.73×10^{-10}	1.72×10^{-10}	1.1×10^{8}
13	Al	Aluminium	4.51×10^{-26}	1.84×10^{-10}	1.73×10^{-10}	1.1×10^{8}
14	Si	Silicon	4.69×10^{-26}	2.10×10^{-10}	1.70×10^{-10}	1.1×10^{8}
15	P	Phosphorus	5.17×10^{-26}	1.80×10^{-10}	1.72×10^{-10}	1.1×10^{8}
16	S	Sulfur	5.35×10^{-26}	1.80×10^{-10}	1.70×10^{-10}	1.1×10^{8}
17	Cl	Clorine	5.92×10^{-26}	1.75×10^{-10}	1.73×10^{-10}	1.1×10^{8}
18	Ar	Argon	6.67×10^{-26}	1.88×10^{-10}	1.79×10^{-10}	1.1×10^{8}
19	K	Potassium	6.52×10^{-26}	2.75×10^{-10}	1.72×10^{-10}	1.1×10^{8}
20	Ca	Calcium	6.69×10^{-26}	2.31×10^{-10}	1.70×10^{-10}	1.1×10^{8}
21	Sc	Scandium	7.51×10^{-26}	2.11×10^{-10}	1.75×10^{-10}	1.1×10^{8}
22	Ti	Titanium	7.99×10^{-26}		1.77×10^{-10}	1.1×10^{8}
23	V	Vanadium	8.51×10^{-26}		1.79×10^{-10}	1.1×10^{8}
24	Cr	Chromium	8.68×10^{-26}		1.76×10^{-10}	1.1×10^{8}
25	Mn	Manganese	9.17×10^{-26}		1.78×10^{-10}	1.1×10^{8}
26	Fe	Iron	9.33×10^{-26}		1.76×10^{-10}	1.1×10^{8}
27	Co	Cobalt	9.84×10^{-26}		1.77×10^{-10}	1.1×10^{8}
28	Ni	Nickel	9.80×10^{-26}	1.63×10^{-10}	1.74×10^{-10}	1.1×10^{8}
29	Cu	Copper	1.06×10^{-25}	1.40×10^{-10}	1.78×10^{-10}	1.1×10^{8}
30	Zn	Zinc	1.09×10^{-25}	1.39×10^{-10}	1.77×10^{-10}	1.1×10^{8}
31	Ga	Gallium	1.16×10^{-25}	1.87×10^{-10}	1.79×10^{-10}	1.1×10^{8}
32	Ge	Germanium	1.21×10^{-25}	2.11×10^{-10}	1.81×10^{-10}	1.1×10^{8}
33	As	Arsenic	1.25×10^{-25}	1.85×10^{-10}	1.81×10^{-10}	1.1×10^{8}
34	Se	Selenium	1.32×10^{-25}	1.90×10^{-10}	1.83×10^{-10}	1.1×10^{8}
35	Br	Bromine	1.33×10^{-25}	1.85×10^{-10}	1.81×10^{-10}	1.1×10^{8}
36	Kr	Krypton	1.40×10^{-25}	2.02×10^{-10}	1.81×10^{-10}	1.1×10^{8}
37	Rb	Rubidium	1.43×10^{-25}	3.03×10^{-10}	1.82×10^{-10}	1.1×10^{8}
38	Sr	Strontium	1.46×10^{-25}	2.49×10^{-10}	1.82×10^{-10}	1.1×10^{8}
39	Y	Yttrium	1.48×10^{-25}		1.81×10^{-10}	1.1×10^{8}
40	Zr	Zirconium	1.52×10^{-25}		1.81×10^{-10}	1.1×10^{8}
41	Nb	Niobium	1.55×10^{-25}		1.80×10^{-10}	1.1×10^{8}
42	Mo	Molybdenum	1.60×10^{-25}		1.81×10^{-10}	1.1×10^{8}
43	Tc	Technetium	1.64×10^{-25}		1.81×10^{-10}	1.1×10^{8}
44	Ru	Ruthenium	1.69×10^{-25}		1.82×10^{-10}	1.1×10^{8}
45	Rh	Rhodium	1.72×10^{-25}		1.81×10^{-10}	1.1×10^{8}
46	Pd	Palladium	1.78×10^{-25}	1.63×10^{-10}	1.83×10^{-10}	1.1×10^{8}
47	Ag	Silver	1.80×10^{-25}	1.72×10^{-10}	1.82×10^{-10}	1.1×10^{8}
48	Cd	Cadmium	1.88×10^{-25}	1.58×10^{-10}	1.84×10^{-10}	1.1×10^{8}
49	In	Indium	1.92×10^{-25}	1.93×10^{-10}	1.84×10^{-10}	1.1×10^{8}
50	Sn	Tin	1.98×10^{-25}	2.17×10^{-10}	1.85×10^{-10}	1.1×10^{8}
51	Sb	Antimony	2.03×10^{-25}	2.06×10^{-10}	1.85×10^{-10}	1.1×10^{8}
52	Te	Tellurium	2.13×10^{-25}	2.06×10^{-10}	1.88×10^{-10}	1.1×10^{8}
53	I	Iodine	2.12×10^{-25}	1.98×10^{-10}	1.86×10^{-10}	1.1×10^{8}
54	Xe	Xenon	2.19×10^{-25}	2.16×10^{-10}	1.87×10^{-10}	1.1×10^{8}
55	Cs	Cesium	2.22×10^{-25}		1.87×10^{-10}	1.1×10^{8}
56	Ba	Barium	2.29×10^{-25}		1.88×10^{-10}	1.1×10^{8}
57	La	Lanthanum	2.32×10^{-25}		1.87×10^{-10}	1.1×10^{8}
58	Ce	Cerium	2.34×10^{-25}		1.86×10^{-10}	1.1×10^{8}
59	Pr	Praseodymium	2.35×10^{-25}		1.85×10^{-10}	1.1×10^{8}
60	Nd	Neodymium	2.41×10^{-25}		1.86×10^{-10}	1.1×10^{8}
61	Pm	Promethium	2.42×10^{-25}		1.85×10^{-10}	1.1×10^{8}
62	Sm	Samarium	2.51×10^{-25}		1.87×10^{-10}	1.1×10^{8}
63	Eu	Europium	2.54×10^{-25}		1.86×10^{-10}	1.1×10^{8}
64	Gd	Gadolinium	2.63×10^{-25}		1.88×10^{-10}	1.1×10^{8}

65	Tb	Terbium	2.65×10^{-25}		1.87×10^{-10}	1.1×10^{8}
66	Dy	Dysprosium	2.71×10^{-25}		1.88×10^{-10}	1.1×10^{8}
67	Ho	Holmium	2.75×10^{-25}		1.88×10^{-10}	1.1×10^{8}
68	Er	Erbium	2.79×10^{-25}		1.88×10^{-10}	1.1×10^{8}
69	Tm	Thulium	2.82×10^{-25}		1.88×10^{-10}	1.1×10^{8}
70	Yb	Ytterbium	2.89×10^{-25}		1.89×10^{-10}	1.1×10^{8}
71	Lu	Lutetium	2.92×10^{-25}		1.88×10^{-10}	1.1×10^{8}
72	Hf	Hafnium	2.98×10^{-25}		1.89×10^{-10}	1.1×10^{8}
73	Ta	Tantalum	3.02×10^{-25}		1.89×10^{-10}	1.1×10^{8}
74	W	Tungsten	3.07×10^{-25}		1.89×10^{-10}	1.1×10^{8}
75	Re	Rhenium	3.11×10^{-25}		1.89×10^{-10}	1.1×10^{8}
76	Os	Osmium	3.18×10^{-25}		1.90×10^{-10}	1.1×10^{8}
77	Ir	Iridium	3.21×10^{-25}		1.90×10^{-10}	1.1×10^{8}
78	Pt	Platinum	3.26×10^{-25}	1.75×10^{-10}	1.90×10^{-10}	1.1×10^{8}
79	Au	Gold	3.29×10^{-25}	1.66×10^{-10}	1.90×10^{-10}	1.1×10^{8}
80	Hg	Mercury	3.35×10^{-25}	1.55×10^{-10}	1.90×10^{-10}	1.1×10^{8}
81	Ti	Thallium	3.41×10^{-25}	1.96×10^{-10}	1.91×10^{-10}	1.1×10^{8}
82	Pb	Lead	3.46×10^{-25}	2.02×10^{-10}	1.91×10^{-10}	1.1×10^{8}
83	Bi	Bismuth	3.48×10^{-25}	2.07×10^{-10}	1.91×10^{-10}	1.1×10^{8}
84	Po	Polonium	3.49×10^{-25}		1.90×10^{-10}	1.1×10^{8}
85	At	Astatine	3.51×10^{-25}		1.89×10^{-10}	1.1×10^{8}
86	Rn	Radon	3.71×10^{-25}		1.93×10^{-10}	1.1×10^{8}
87	Fr	Francium	3.72×10^{-25}		1.92×10^{-10}	1.1×10^{8}
88	Ra	Radium	3.77×10^{-25}		1.92×10^{-10}	1.1×10^{8}
89	Ac	Actinium	3.79×10^{-25}		1.92×10^{-10}	1.1×10^{8}
90	Th	Thorium	3.87×10^{-25}		1.93×10^{-10}	1.1×10^{8}
91	Pa	Protactinium	3.86×10^{-25}		1.91×10^{-10}	1.1×10^{8}
92	U	Uranium	3.97×10^{-25}	1.86×10^{-10}	1.93×10^{-10}	1.1×10^{8}
93	Np	Neptunium	3.96×10^{-25}		1.92×10^{-10}	1.1×10^{8}
94	Pu	Plutonium	4.07×10^{-25}		1.93×10^{-10}	1.1×10^{8}
95	Am	Americium	4.06×10^{-25}		1.92×10^{-10}	1.1×10^{8}
96	Cm	Curium	4.12×10^{-25}		1.92×10^{-10}	1.1×10^{8}
97	Bk	Berkelium	4.12×10^{-25}		1.91×10^{-10}	1.1×10^{8}
98	Cf	Californium	4.19×10^{-25}		1.92×10^{-10}	1.1×10^{8}
99	Es	Einsteinium	4.21×10^{-25}		1.92×10^{-10}	1.1×10^{8}
100	Fm	Fermium	4.29×10^{-25}		1.92×10^{-10}	1.1×10^{8}
101	Md	Mendelevium	4.31×10^{-25}		1.92×10^{-10}	1.1×10^{8}
102	No	Nobelium	4.33×10^{-25}		1.91×10^{-10}	1.1×10^{8}
103	Lr	Lawrencium	4.44×10^{-25}		1.93×10^{-10}	1.1×10^{8}
104	Rf	Rutherfordium	4.36×10^{-25}		1.92×10^{-10}	1.1×10^{8}
105	Db	Dubnium	4.38×10^{-25}		1.92×10^{-10}	1.1×10^{8}
106	Sg	Seaborgium	4.44×10^{-25}		1.91×10^{-10}	1.1×10^{8}
107	Bh	Bohrium	4.41×10^{-25}		1.90×10^{-10}	1.1×10^{8}
108	Hs	Hassium	4.63×10^{-25}		1.89×10^{-10}	1.1×10^{8}
109	Mt	Meitnerium	4.63×10^{-25}		1.91×10^{-10}	1.1×10^{8}
110	Ds	Darmstadtium	4.71×10^{-25}		1.92×10^{-10}	1.1×10^{8}
111	Rg	Roentgenium	4.71×10^{-25}		1.91×10^{-10}	1.1×10^{8}
112	Cn	Copernicium	4.78×10^{-25}		1.92×10^{-10}	1.1×10^{8}
113	Nh	Nihonium	4.78×10^{-25}		1.91×10^{-10}	1.1×10^{8}
114	Fi	Flerovium	4.84×10^{-25}		1.92×10^{-10}	1.1×10^{8}
115	Mc	Moscovium	4.84×10^{-25}		1.91×10^{-10}	1.1×10^{8}
116	Lv	Livermorium	4.89×10^{-25}		1.91×10^{-10}	1.1×10^{8}
117	Ts	Tennessine	4.91×10^{-25}		1.91×10^{-10}	1.1×10^{8}
118	Og	Oganesson	4.93×10^{-25}		1.91×10^{-10}	1.1×10^{8}

It is noticed that all atoms have the same value (1.1×10^8). This means and indicates that all atoms have the same constant value relating to the area, number of electrons and mass.

4. ELECTROMAGNTIC FORCE OF ATOMS

The electromagnetic force of atoms with its constituents as certain masses (electrons & nucleons) at certain distances with spin and orbital velocities comparable to the velocity of light can be determined by the following equation.

$$F = \frac{4c^2 \times (m_1 + m_2)}{d} \tag{6}$$

where m_1 is the mass of the first particle and m_2 is the mass of the second particle, c is the velocity of light, d is the distance between particles.

From equation (6)

$$\frac{F \times d}{4 \times (m_1 + m_2)} = c^2 \tag{7}$$

This means that the three main physical parameters (electromagnetic force, distance, mass) for any two particles equals square of velocity of light.

4.1. Calculating electromagnetic force for hydrogen atom

By using equation (6) for hydrogen atom (proton and electron) with their known determined values:

– electron mass = 9.1×10^{-31} kg,

– proton mass = 1.7×10^{-27} kg,

– distance between electron and proton ~10^{-10} m

– c is the velocity of light ~3×10^8 m/s,

it is found that the value of electromagnetic force for hydrogen atom is approximately 6 N, as follows

$$F = \frac{4c^2 \times (m_1 + m_2)}{d} = 6 \text{ N}$$

and by using equation (7)

$$\frac{F \times d}{4 \times (m_1 + m_2)} = 9 \times 10^{16} = c^2 \text{ (square of velocity of light).}$$

According to the above calculations and results by increasing the number of particles for heavy atoms, the electromagnetic force is linearly additive as binding energy of atomic nucleus and the result of three physical parameters (force & distance & mass) in equation (7) for any atom gives constant value square of velocity of light.

5. CONCLUSIONS

The uniform distribution of electrons and nucleons (protons & neutrons) inside nucleus with certain masses and certain area in each atom leads to the existence of a common constant for all atoms.

The atomic mass, the atomic area and number of electrons for any atom give a constant value in calculations and results in atomic radii in good agreement with known determined values (van der Waals radii). The new equation of atoms with new atomic constant is used to calculate previously undetermined atomic radii.

The electromagnetic force is produced as a result of existing electrons and nuclei at certain distance in the range of angstrom and the main role of electromagnetic force is to form and bound the atom and can be calculated with main physical parameters (masses of any two particles, distance between them and the velocity of light).

REFERENCES

[1] Thomson JJ. Cathode rays. Philosophical Magazine. 1897; 44(269): 293–316.
[2] Rutherford E. The scattering of α and β particles by matter and the structure of the atom. Philosophical Magazine. 1911; 6: 669–688.
[3] Heilbron JL. Ernest Rutherford: and the explosion of atoms. Oxford University Press; 2003, pp. 64–68.
[4] Bondi A. Van der Waals volumes and radii. The Journal of Physical Chemistry. 1964; 68(3): 441–451.
[5] Rowland RS, Taylor R. Intermolecular nonbonded contact distances in organic crystal structures: comparison with distances expected from van der Waals radii. J. Phys. Chem. 1996; 100(18): 7384–7391.
[6] Mantina M, Chamberlin AC, Valero R, Cramer CJ, Truhlar DG. Consistent van der Waals radii for the whole main group, The Journal of Physical Chemistry A. 2009; 113(19): 5806–5812.
[7] Riedel S, Pyykkö P, Patzschke M. Triple bond covalent radii. Chem. Eur. J. 2005; 11(12): 3511–3520.
[8] Cotton FA, Wilkinson G. Advanced inorganic chemistry. 5th ed. Wiley; 1988, p. 1385.
[9] Clementi E, Raimondi DL, Reinhardt WP. Atomic screening constants from SCF functions. II. Atoms with 37 to 86 electrons. The Journal of Chemical Physics. 1967; 47(4): 1300–1307.
[10] Slater JC. Atomic radii in crystals. The Journal of Chemical Physics. 1964; 41(10): 3199–3204.
[11] Alvareza S. A cartograph of the van der Waals territories, Dalton Transactions. 2013; 42(24): 8617–8636.

Received September 11, 2024