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Model Equation Based on the 8 Groups and the 7 Periods in the Periodic Table of Elements

Orwa Houshia (Corresponding author)
Department of Applied Chemistry, Arab American University
P.O. Box 240, Jenin, WestBank, Palestine
Tel: +972-59-282-5885 E-mail: orwa.houshia@aaup.edu

Harbi Daraghmeh
Department of Applied Chemistry, Arab American University
P.O. Box 240, Jenin, WestBank, Palestine

Naba Abuhafez
Institut des Sciences Chimiques de Rennes - UMR CNRS 6226
Université de Rennes 1
Campus de Beaulieu - Bât. 10B
F-35042 Rennes Cedex, France

Ahmad Abdelraouf Jrar
MedPlusLab, Jenin, WestBank, Palestine

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Abstract

The periodic table of chemistry contains all synthetic and naturally occurring elements. The elements are arranged in seven horizontal periods from left to right with increasing atomic number. The periodic table is divided into two groups: metals and nonmetals, within elements moving from left to right, the elements get less metallic, culminating in nonmetals on the far right side of the table. Further, the elements are also arranged in eight vertical columns or groups for those with similar physical and chemical properties. A model equation has been developed based on the 8-group and the 7-periods from which trends of elements has been calculated. Among the trends in the periodic table that were calculated are ionization energy, atomic size and effective nuclear charge. It has been discovered that the calculated theoretical values from the model equation rhyme well with the actual values for each element with few exceptions.

Keywords: Periodic table, Groups, Periods, Ionization energy, Atomic size, Nuclear charge

1. Introduction

The periodic table is the most important chemical reference for elements in existence. It organizes all known elements in an information matrix. The elements are arranged in the order of increasing ordinal number from left to right and from top to bottom. The order generally coincides with the increase in atomic mass. The periodic table is very important. The periodic table contains 119 elements in a very discrete order to show similarities and differences in chemical properties. There are 94 naturally occurring elements and the other 25 were made synthetically using particle accelerators. Elements are classified in the periodic table as metallic and non-metallic elements with a dark rung that corresponds to metalloids. metals are left and then none-metals. The rows are also organized so that items with similar properties are in the same columns. The table is a two-row block of elements that contain the lanthanides and actinides. These groups are classified as inner transition metals.

The position of the elements in the periodic table is very important due to the trends in chemical properties in groups and rows. An element's properties can essentially be projected based on its position in the periodic table. It's important to remember that trends work differently when moving vertically and horizontally across the table. Trends within groups are explained by the common arrangement of electrons in their valence shells, and thus have creates similarities in atomic radius, electronegativity and ionization energy. The atomic radii of the elements increase from top to bottom. Similarly, the ionization energy and electronegativity decrease due to the configuration of the electrons. The periods also show similar trends in terms of electronegativity and ionization energy, atomic radii and electron affinity. If you move from left to right within a period, the atomic radii fall and cause the ionization energy to increase. As you move from left to right, electronegativity and electron affinity also increase.

The periodic table was formerly known as the periodic table of the Russian chemist Dmitry Mendeleev (Dmitry Mendeleev), who first created the periodic table in 1869. However, the old periodic table is not as extensive as the modern periodic table. Since its first creation, new elements have been discovered and added to the original periodic table. Others, such as John Newlands in London, Alexander Beguerd Shancourtois in France and Julius Lothar Meyer in Germany, Made an important contribution to the first periodic table. In 1860, the publication of more precise atomic masses (such as relative atomic masses) helped everyone. First, only 60 elements were found (more than 100 are now known), and secondly, some information about these 60 elements were all incorrect. It was as if Mendeleev was doing a puzzle with one third of the fragments missing, and other pieces twisted!

Mendeleev had written the properties of the elements on pieces of cardboard and, according to tradition, after arranging the cards while patiently playing, suddenly realized that by arranging the element cards in the order of increasing atomic weight, certain types of objects were regularly presented to the Russian Physico-Chemical Society. They were read by Professor Menschutkin because Mendeleev was sick. His ideas were later published in the leading German chemical magazine of the time, the Zeitschrift für Chemie.What Mendeleev did not predict was the discovery of an entirely new group of elements, the noble gases, by the Scotsman William Ramsay and his collaborators in the last decade of the 19th century. Mendeleev was initially dismayed by this, but before he died in 1907, he realized that Ramsay's discoveries were further evidence for the periodic table, not a contradiction. Ramsay received a Nobel Prize for discovering five elements. Mendeleev never received this honor. The element, atomic number 101, is named after Mendeleev, an even rarer distinction. This is certainly deserved by the original formulator of the periodic table.

In this work a unitless equation used as a coding of some of the physical properties of elements is introduced, and can be used in high school textbooks to show various trends of elements in periodic table. The theoretical data obtained from using this equation goes hand in hand with actual data for each element the periodic table trend.

2. Methodology

The researchers used Computer Excel sheet to perform calculation by applying on the theoretical equation:

$$\frac{9-\text{Group Number}}{8}+\frac{\text{Period Number}}{7}=S \qquad \text{(Equation 1)}$$

Where,

S: Special Number for each elements.

8 = eight groups of the periodic table

7 = seven periods of the periodic table

9 = factor

2.1 Atomic Size

To compare atomic sizes between the elements, we substitute the location for each element (i.e. group number and period number) in the Eq.1 and compare the result of the element with other. The element which has the biggest number is the largest in size, then the next one and so on.

2.2 Effective Nuclear Charge

To compare between the elements in the effective nuclear charge, we substitute the location of the element in the periodic table (group and period) Eq.1 and compare the result of the element with other, the element which has the biggest number is the largest in effective nuclear charge, then the next one and so on.

2.3 Ionization Energy

To compare data between the elements in the ionization energy, compensate for each element in the Eq.1 and compare the result of the element with other, the element which has the lowest number is the largest ionization energy, then the next one with taking the consideration for the case of anomalies in the group 5 with 6, and 2 with 3, (If the group number of the element is 5 turned into 6 also If the group number of the element is 2 turned into 3, and the vice versa. After the conversion compensated in the equation and compare with other elements, but at the first; the first ionization energy compared).

3. Results

By using Excel program and the Eq.1 we obtain the following data show in Table 1. Using this data and the atomic size, the effective nuclear charge and the ionization energy definition elements arrange as shown in Tables 2, 3 and 4, sequentially, also there is a unique number for each elements.

Table 1. Theoretical data acquired by applying Equation (1) on the periodic table for each elements

Element	*S*	*Element*	*S*	*Element*	*S*
Hydrogen	1.142857	**Argon**	0.553571	**Cesium**	1.857143
Helium	0.267857	**Potassium**	1.571429	**Barium**	1.732143
Lithium	1.285714	**Calcium**	1.446429	**Thallium**	1.607143
Beryllium	1.160714	**Gallium**	1.321429	**Lead**	1.482143
Boron	1.035714	**Germanium**	1.196429	**Bismuth**	1.357143
Carbon	0.910714	**Arsenic**	1.071429	**Polonium**	1.232143
Nitrogen	0.785714	**Selenium**	0.946429	**Astatine**	1.107143
Oxygen	0.660714	**Bromine**	0.821429	**Radon**	0.982143
Fluorine	0.535714	**Krypton**	0.696429	**Francium**	2
Neon	0.410714	**Rubidium**	1.714286	**Radium**	1.875
Sodium	1.428571	**Strontium**	1.589286	**Ununtrium**	1.75
Magnesium	1.303571	**Indium**	1.464286	**Flerovium**	1.625

Aluminium	1.178571	**Tin**	1.339286	**Ununpentium**	1.5
Silicon	1.053571	**Antimony**	1.214286	**Livermorium**	1.375
Phosphorus	0.928571	**Tellurium**	1.089286	**Ununseptium**	1.25
Sulfur	0.803571	**Iodine**	0.964286	**Ununoctium**	1.125
Chlorine	0.678571	**Xenon**	0.839286		

After we apply the equation, we compare each number of element with other by using Excel and arrange them descending; that means from the biggest atomic size to the smallest one, to have the final order shown in Table 2.

Table 2. Arranging the Atomic size of the elements (which has the biggest number is the largest size)

Element	S	Element	S	Element	S
Francium	2	**Tin**	1.339286	**Radon**	0.982143
Radium	1.875	**Gallium**	1.321429	**Iodine**	0.964286
Cesium	1.857143	**Magnesium**	1.303571	**Selenium**	0.946429
Ununtrium	1.75	**Lithium**	1.285714	**Phosphorus**	0.928571
Barium	1.732143	**Ununseptium**	1.25	**Carbon**	0.910714
Rubidium	1.714286	**Polonium**	1.232143	**Xenon**	0.839286
Flerovium	1.625	**Antimony**	1.214286	**Bromine**	0.821429
Thallium	1.607143	**Germanium**	1.196429	**Sulfur**	0.803571
Strontium	1.589286	**Aluminium**	1.178571	**Nitrogen**	0.785714
Potassium	1.571429	**Beryllium**	1.160714	**Krypton**	0.696429
Ununpentium	1.5	**Hydrogen**	1.142857	**Chlorine**	0.678571
Lead	1.482143	**Ununoctium**	1.125	**Oxygen**	0.660714
Indium	1.464286	**Astatine**	1.107143	**Argon**	0.553571
Calcium	1.446429	**Tellurium**	1.089286	**Fluorine**	0.535714
Sodium	1.428571	**Arsenic**	1.071429	**Neon**	0.410714
Livermorium	1.375	**Silicon**	1.053571	**Helium**	0.267857
Bismuth	1.357143	**Boron**	1.035714		

From the Table 2, the biggest atomic size is Francium with special number equal 2, on the other hand the lowest atomic size is Helium with S = 0.267857. So we can realize the position of these two elements directly, and have a priority idea about others elements position in the periodic table. From the table we can compare between the elements, for example take the Lead with S = 1.482143, this number give the Lead a special atomic size, if we take any value less than this that means the elements with that value has smaller atomic size and the opposite if we take larger than a number of lead. Now, the effective nuclear charge can be known also in the same way of the atomic size, apply the equation and arrange the result of the number of elements to have the data appears in the next table.

Table 3. Arranging the elements with respect to their Effective nuclear charge (which has the biggest number is the largest Effective nuclear charge), by applying equation 1

Element	S	Element	S	Element	S
Francium	2	**Tin**	1.339286	**Radon**	0.982143
Radium	1.875	**Gallium**	1.321429	**Iodine**	0.964286
Cesium	1.857143	**Magnesium**	1.303571	**Selenium**	0.946429
Ununtrium	1.75	**Lithium**	1.285714	**Phosphorus**	0.928571
Barium	1.732143	**Ununseptium**	1.25	**Carbon**	0.910714
Rubidium	1.714286	**Polonium**	1.232143	**Xenon**	0.839286
Flerovium	1.625	**Antimony**	1.214286	**Bromine**	0.821429
Thallium	1.607143	**Germanium**	1.196429	**Sulfur**	0.803571
Strontium	1.589286	**Aluminium**	1.178571	**Nitrogen**	0.785714
Potassium	1.571429	**Beryllium**	1.160714	**Krypton**	0.696429
Ununpentium	1.5	**Hydrogen**	1.142857	**Chlorine**	0.678571
Lead	1.482143	**Ununoctium**	1.125	**Oxygen**	0.660714
Indium	1.464286	**Astatine**	1.107143	**Argon**	0.553571
Calcium	1.446429	**Tellurium**	1.089286	**Fluorine**	0.535714
Sodium	1.428571	**Arsenic**	1.071429	**Neon**	0.410714
Livermorium	1.375	**Silicon**	1.053571	**Helium**	0.267857
Bismuth	1.357143	**Boron**	1.035714		

From the Table 3, the element which has the biggest Effective nuclear charge is Francium, also the lowest is Helium, and the comparing between elements can be done easy. Also arrangement of elements due to the ionization energy obtain using Eq.1 , and the result is in the Table 4.

Table 4. Arranging the ionization energy of the elements (which has the biggest number is the lowest ionization energy) using equation 1

Element	S	Element	S	Element	S
Helium	0.267857	**Silicon**	1.053571	**Livermorium**	1.375
Neon	0.410714	**Arsenic**	1.071429	**Sodium**	1.428571
Fluorine	0.535714	**Tellurium**	1.089286	**Calcium**	1.446429
Argon	0.553571	**Astatine**	1.107143	**Indium**	1.464286
Oxygen	0.660714	**Ununoctium**	1.125	**Lead**	1.482143
Chlorine	0.678571	**Hydrogen**	1.142857	**Ununpentium**	1.5
Krypton	0.696429	**Beryllium**	1.160714	**Potassium**	1.571429
Nitrogen	0.785714	**Aluminium**	1.178571	**Strontium**	1.589286
Sulfur	0.803571	**Germanium**	1.196429	**Thallium**	1.607143
Bromine	0.821429	**Antimony**	1.214286	**Flerovium**	1.625
Xenon	0.839286	**Polonium**	1.232143	**Rubidium**	1.714286
Carbon	0.910714	**Ununseptium**	1.25	**Barium**	1.732143
Phosphorus	0.928571	**Lithium**	1.285714	**Ununtrium**	1.75
Selenium	0.946429	**Magnesium**	1.303571	**Cesium**	1.857143
Iodine	0.964286	**Gallium**	1.321429	**Radium**	1.875
Radon	0.982143	**Tin**	1.339286	**Francium**	2
Boron	1.035714	**Bismuth**	1.357143		

From the Table 4, Helium has the highest ionization energy; conversely the Francium has the least ionization energy value. Using the data from the previous tables, we can express the values as shown in Table 5. If we compare between Table 3 and Table 4, it is clear they are the same and that fit with the natural of the elements on the periodic table, obtained by using equation (1) and have the value of the elements fit with there is position in the periodic Table 5.

Table 5. Applying the Equation 1 to elements within the periodic table

IA							**VIIIA**
H 1.142857	**IIA**	**IIIA**	**IVA**	**VA**	**VIA**	**VIIA**	He 0.267857
Li 1.285714	Be 1.160714	B 1.035714	C 0.910714	N 0.785714	O 0.660714	F 0.535714	Ne 0.410714
Na	Mg	Al	Si	P	S	Cl	Ar

1.428571	1.303571	1.178571	1.053571	0.928571	0.803571	0.678571	0.553571
K	Ca	Ga	Ge	As	Se	Br	Kr
1.571429	1.446429	1.321429	1.196429	1.071429	0.946429	0.821429	0.696429
Rb	Sr	In	Sn	Sb	Te	I	Xe
1.714286	1.589286	1.464286	1.339286	1.214286	1.089286	0.964286	0.839286
Cs	Ba	Ti	Pb	Bi	Po	At	Rn
1.857143	1.732143	1.607143	1.482143	1.357143	1.232143	1.107143	0.982143
Fr	Ra	Uut	Fi	Uup	Lv	Uus	Uuo
2	1.875	1.75	1.625	1.5	1.375	1.25	1.125

4. Discussion

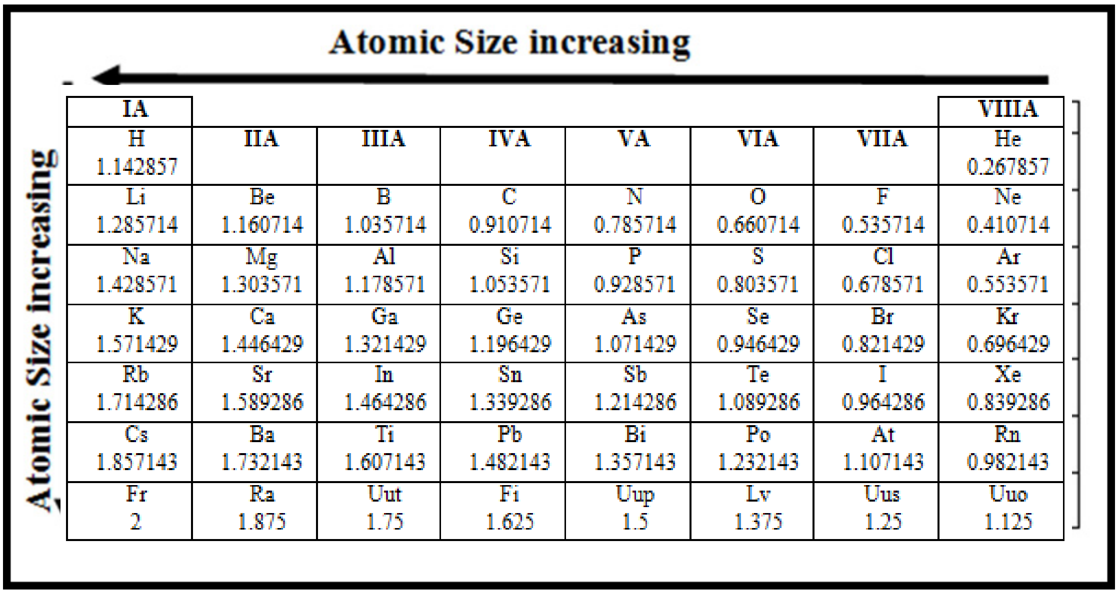
The periodic table element trends are detailed arrangements in the periodic table that demonstrate various aspects of a given element, including its size and electronic properties. They also provide a tool for predicting the properties of an element. These trends are found and exist because of the similar atomic structure of the elements within their respective families of groups or periods and because of the periodic nature of the elements. The main trends of the periodic table include: electronegativity, ionization energy, electronic affinity, atomic radius, melting Point and metallic character.

4.1 Atomic Size Trends

Atom size can be measured by knowing the atomic radius, which is half the distance between the nuclei of two atoms (similar to a radius half the diameter of a circle), but because it is difficult to measure the size of the elements (radius also) there is a possibility to calculate the atomic radii with the functions of quantum mechanics. The fact that the radial values obtained by such calculations are not identical to any of the experimentally measured sets of values offers a possibility to compare the intrinsic sizes of all elements and to clearly show that the atomic size varies at regular intervals, thus it is easier to compare the size using equation 1.

The atomic size gradually decreases from left to right within the same period of elements. This is because electrons are added to the same shell over a period or family of elements. The effect of increasing the number of protons is greater than that of increasing the number of electrons; hence there is a greater nuclear pull; This means that the nucleus attracts electrons with greater force and brings the shell of the atoms closer to the nucleus. The valence electrons stay closer to the nucleus of the atom. The atomic radius decreases as shown in Table 6.

Table 6. Periodic table showing Atomic size trend



Atomic Size increasing

Atomic Size increasing

IA							VIIIA
H 1.142857	IIA	IIIA	IVA	VA	VIA	VIIA	He 0.267857
Li 1.285714	Be 1.160714	B 1.035714	C 0.910714	N 0.785714	O 0.660714	F 0.535714	Ne 0.410714
Na 1.428571	Mg 1.303571	Al 1.178571	Si 1.053571	P 0.928571	S 0.803571	Cl 0.678571	Ar 0.553571
K 1.571429	Ca 1.446429	Ga 1.321429	Ge 1.196429	As 1.071429	Se 0.946429	Br 0.821429	Kr 0.696429
Rb 1.714286	Sr 1.589286	In 1.464286	Sn 1.339286	Sb 1.214286	Te 1.089286	I 0.964286	Xe 0.839286
Cs 1.857143	Ba 1.732143	Ti 1.607143	Pb 1.482143	Bi 1.357143	Po 1.232143	At 1.107143	Rn 0.982143
Fr 2	Ra 1.875	Uut 1.75	Fi 1.625	Uup 1.5	Lv 1.375	Uus 1.25	Uuo 1.125

In the periodic table, atomic size increase from right to left across a row and increase from top to bottom down a column. Because of these two trends, the largest atoms are found in the lower left corner of the periodic table, and the smallest are found in the upper right corner. Plotting the special number (S) obtain from equation (1) with the atomic number for the main group elements from 1A to 8A, the plotting will be as show in Figure 1 (note that figure 1 is pure calculations based on equation 1). Also Figure 2 shows the actual and real periodic variation of atomic size with atomic number. comparing these two plots there is a similarity to the plot of atomic size versus atomic number.

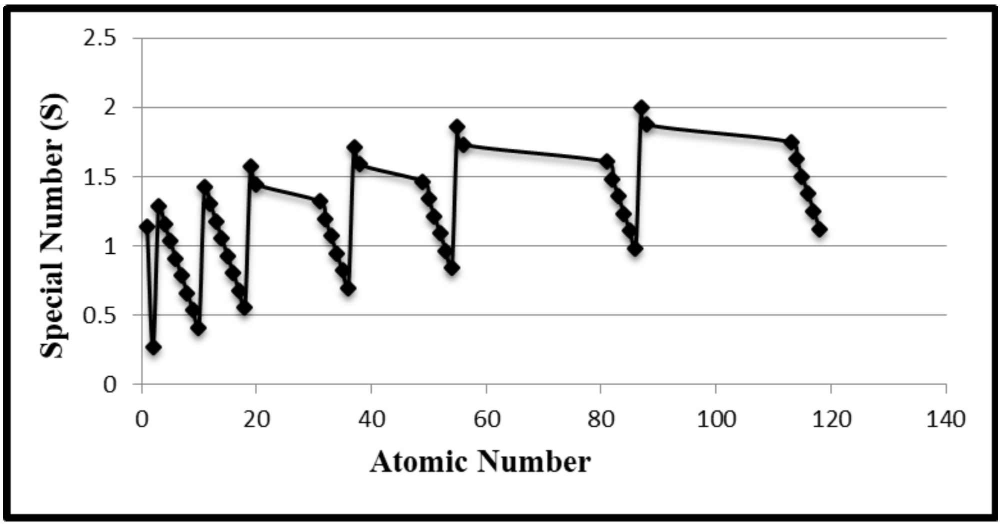


Figure 1. A plot of atomic number with the special number of elements (S).

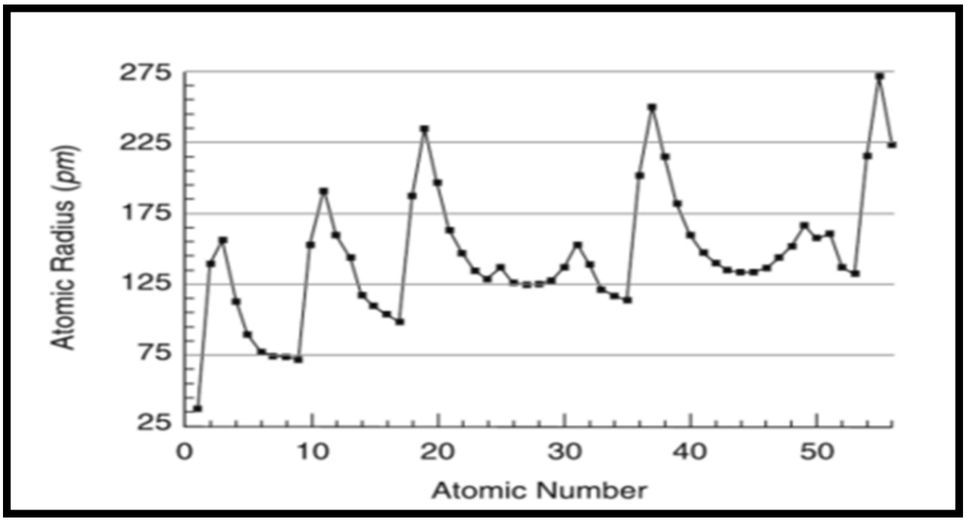


Figure 2. Atomic radius against atomic number

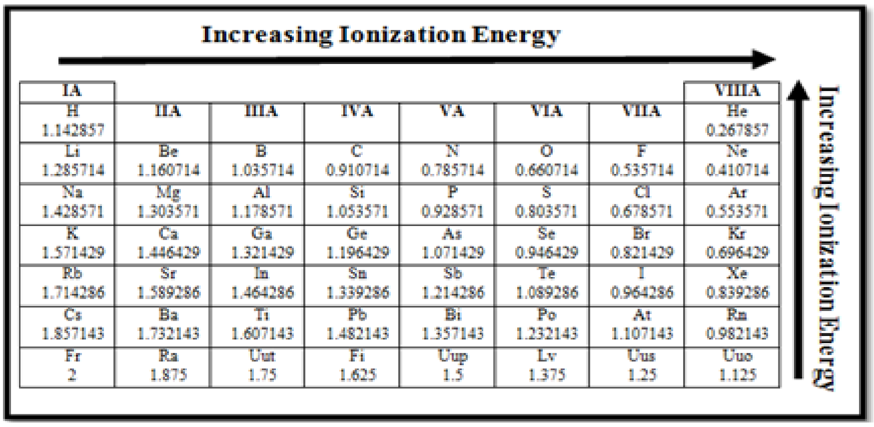
As shown in Figure 1, it is clear that at the first 20 elements the relation is leaner that confirm the result of equation (1). There is a striking resemblances and similarities between figure 1 data (obtained from equation 1) and figure 2 data (represents the real and actual values)

4.2 Ionization Energy Trends

Another factor that affects ionization energy is electron shielding. Electron shielding describes the ability of an atom's inner electrons to shield its positively-charged nucleus from its valence electrons. Ionization energy is the energy required to remove an electron from a neutral atom in its gaseous phase.

Generally, elements on the right side of the periodic table have a higher ionization energy because their valence shell is nearly filled, on the other hand, elements on the left side of the periodic table have low ionization energy because of their predisposition to lose electrons and become cations. So, ionization energy increases from left to right on the periodic. From table 6 and 7, Ionization energies decrease as atomic size increase.

Table 7. Periodic table showing ionization energy trend



Increasing Ionization Energy

IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
H 1.142857							He 0.267857
Li 1.285714	Be 1.160714	B 1.035714	C 0.910714	N 0.785714	O 0.660714	F 0.535714	Ne 0.410714
Na 1.428571	Mg 1.303571	Al 1.178571	Si 1.053571	P 0.928571	S 0.803571	Cl 0.678571	Ar 0.553571
K 1.571429	Ca 1.446429	Ga 1.321429	Ge 1.196429	As 1.071429	Se 0.946429	Br 0.821429	Kr 0.696429
Rb 1.714286	Sr 1.589286	In 1.464286	Sn 1.339286	Sb 1.214286	Te 1.089286	I 0.964286	Xe 0.839286
Cs 1.857143	Ba 1.732143	Ti 1.607143	Pb 1.482143	Bi 1.357143	Po 1.232143	At 1.107143	Rn 0.982143
Fr 2	Ra 1.875	Uut 1.75	Fi 1.625	Uup 1.5	Lv 1.375	Uus 1.25	Uuo 1.125

Increasing Ionization Energy

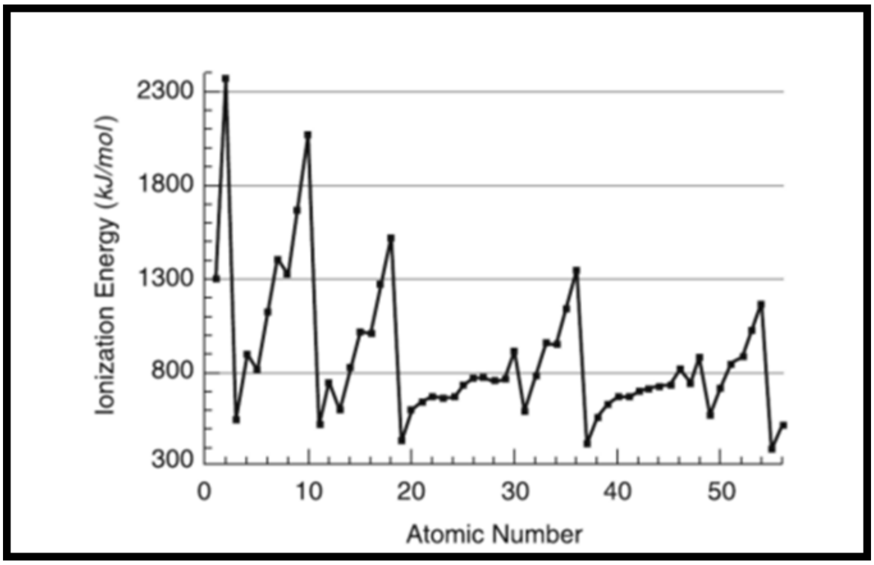


Figure 3. Ionization energy plotted against atomic number[10]

Table 4 show that successive ionization energies for an element increase steadily; removing the first electron reduces the repulsive forces among the remaining electrons, so the attraction of the remaining electrons to the nucleus is stronger.

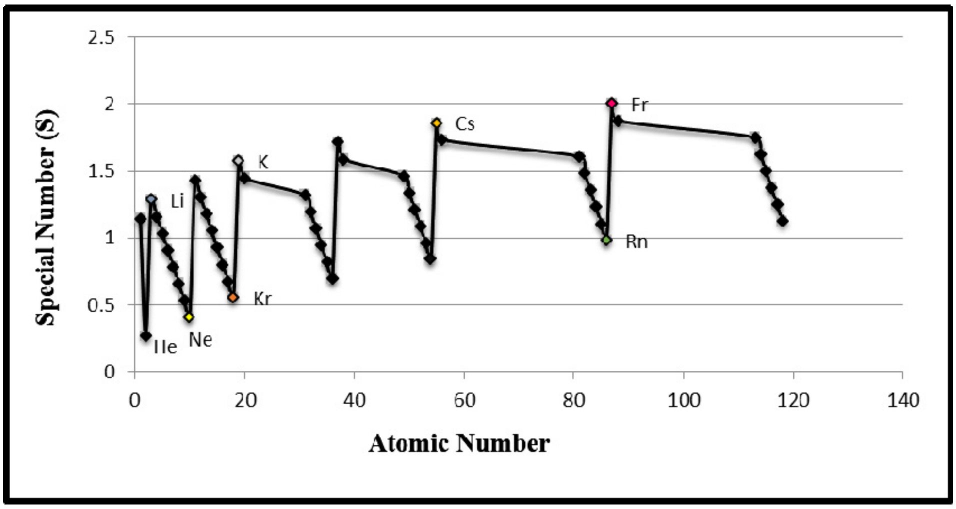


Figure 4. Special number (S) from table 4 plotted against atomic number

Plots 3 and 4 illustrate three important trends:

1. The changes seen in the second (Li to Ne), third (Na to Ar), fifth (Rb to Xe), and sixth (Cs to Rn) rows of the s and p blocks follow a pattern similar to the pattern described for the third row of the periodic table.
2. First ionization energies generally decrease down a column with increasing principal quantum number (n).
3. Filled inner shells are effective at screening the valence electrons, so there is a relatively small increase in the effective nuclear charge. Consequently, the atoms become larger as they

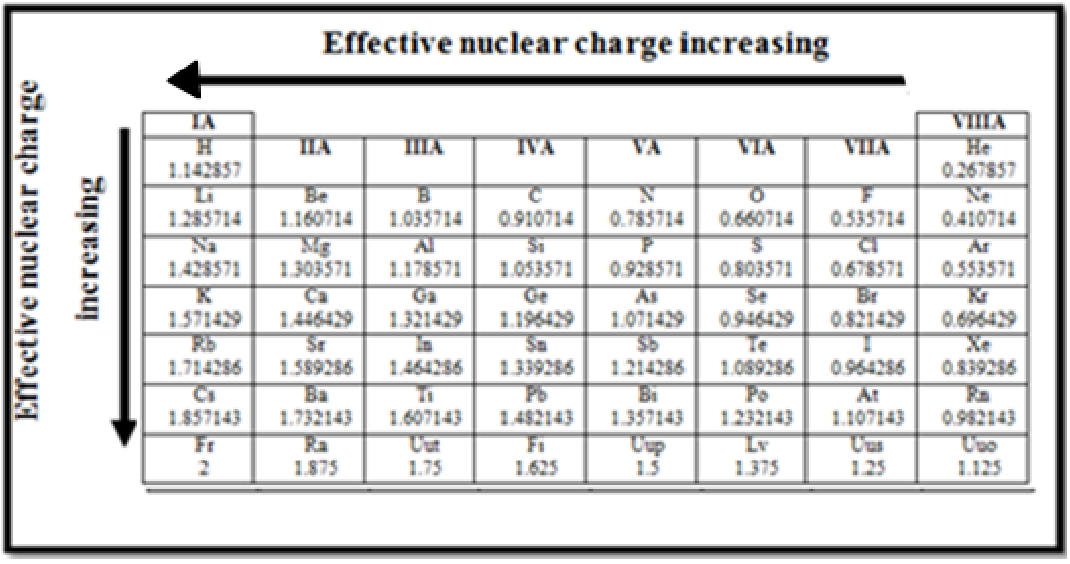
acquire electrons. Valence electrons that are farther from the nucleus are less tightly bound, making them easier to remove, which causes ionization energies to decrease. A larger radius corresponds to a lower ionization energy.

4. Because of the first two trends, the elements that form positive ions most easily (have the lowest ionization energies) lie in the lower left corner of the periodic table, whereas those that are hardest to ionize lie in the upper right corner of the periodic table. Consequently, ionization energies generally increase diagonally from lower left (Fr) to upper right (He).

4.3 Effective Nuclear Charge Trend

Trends in atomic size result from differences in the effective nuclear charges, for all elements except H, the effective nuclear charge is always less than the actual nuclear charge because of shielding effects. The greater the effective nuclear charge, the more strongly the outermost electrons are attracted to the nucleus and the smaller the atomic radius. The atoms in the second row of the periodic table (Li through Ne) illustrate the effect of electron shielding.

Table 8. Periodic table showing effective nuclear charge trend



IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA
H 1.142857							He 0.267857
Li 1.285714	Be 1.160714	B 1.035714	C 0.910714	N 0.785714	O 0.660714	F 0.535714	Ne 0.410714
Na 1.428571	Mg 1.303571	Al 1.178571	Si 1.053571	P 0.928571	S 0.803571	Cl 0.678571	Ar 0.553571
K 1.571429	Ca 1.446429	Ga 1.321429	Ge 1.196429	As 1.071429	Se 0.946429	Br 0.821429	Kr 0.696429
Rb 1.714286	Sr 1.589286	In 1.464286	Sn 1.339286	Sb 1.214286	Te 1.089286	I 0.964286	Xe 0.839286
Cs 1.857143	Ba 1.732143	Tl 1.607143	Pb 1.482143	Bi 1.357143	Po 1.232143	At 1.107143	Rn 0.982143
Fr 2	Ra 1.875	Uut 1.75	Fl 1.625	Uup 1.5	Lv 1.375	Uus 1.25	Uuo 1.125

From Table 8, the atoms in the second row of the periodic table (Li through Ne) illustrate the effect of electron shielding, all have a filled $1s^2$ inner shell, but as we go from left to right across the row, the nuclear charge increases. Although electrons are being added to the 2s and 2p orbitals, electrons in the same principal shell are not very effective at shielding one another from the nuclear charge. Thus the single 2s electron in lithium experiences an effective nuclear charge of approximately +1 because the electrons in the filled 1s2 shell effectively neutralize two of the three positive charges in the nucleus. In contrast, the two 2s electrons in beryllium do not shield each other very well, although the filled $1s^2$ shell effectively neutralizes two of the four positive charges in the nucleus. This means that the effective nuclear charge experienced by the 2s electrons in beryllium is between +1 and +2. Consequently, beryllium is significantly smaller than lithium. Similarly, as we proceed across the row, the increasing nuclear charge is not effectively neutralized by the electrons being added to the 2s and 2p orbitals. The result is a steady increase in the effective nuclear charge and a steady decrease in atomic size.

In group 1, the size of the atoms increases substantially going down the column. It may at first seem reasonable to attribute this effect to the successive addition of electrons to ns orbitals with increasing values of n. However, it is important to remember that the radius of an orbital depends dramatically on the nuclear charge. As we go down the column of the group 1 elements, the principal quantum number n increases from 2 to 7, and the nuclear charge increases.

Also the atomic size trends in a similar way as the affective nuclear charge, depending on plot 1, the effective nuclear charge can be explained in terms of the atomic size.

5. Conclusions

Theoretical development of an equation for the periodic table from which several parameters can be extracted that fit with the actual periodic table trend. Also the linear relation appears in plotting with atomic number for each group and period in general. Theoretical development of an equation for the periodic table from which several parameters can be extracted that fit with the actual periodic

References

Daniel, R., Scott, G., & David, B. (2009). Cengage Learning.

Hans-Jürgen, Quadbeck-Seeger (2007). The Periodic Table Through History, Wiley

Lambert, M., Surhone, M. T., & Timpledon, S. (2010). Periodic Table: Periodic Table, Chemical Element, History of the Periodic Table, Dmitri Mendeleev, Atomic Number, Electron Configuration, Chemical Symbol, Atomic Mass, Electronegativity, Betascript Publishing.

N. V. Sidgwick. (1957). Atomic Structure and the Periodic Table, Murray.

Primo, L., & Raymond, P. (2012). The Periodic Table, Penguin.

Raymond, R. The Periodic Table, New York.

Rod, B., & Alan, J. (2003). Structure, Bonding and Main Group Chemistry, Nelson Thornes, 2003.

Roger, S., & Maureen, S. (2012). Cambridge Checkpoints VCE Chemistry Units 3 and 4, Cambridge University Press.

Suzanne, S. (2007). Elements and the Periodic Table, Rosen Classroom.

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