The size of the Electron.

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Abstract:

The structure of the atom is analyzed using the results of established experiments on ionization energies and spectral emissions. Ionization energy levels - when electrons are energized to escape from the Potential Energy Well of the atom – show distinct patterns. The depth of the Potential Energy Well is directly proportional to the number of protons in the nucleus, but is not dependent on the number of neutrons. The ionization energies, and therefore the electron depths, are similar to those of a "multi-layered ball" of electrons, as if they simply fill the three-dimensional Potential Energy Well around the nucleus. The electrons appear to be loosely-packed for the lighter elements, and more tightly-packed for the heavier elements. The electrons appear to be much larger than we presently imagine.

Introduction:

Simple physics experiments have been conducted over the centuries with numerous theories to explain the observations. Certain theories have become dominant and, in the modern era, these fundamental beliefs generally go unchallenged. This paper re-examines some basic observations in physics and proposes an alternative explanation for the structure of the atom.

Einstein's General Theory of Relativity proposes the distortion of the fabric of space by an object, creating a Potential Energy Well. Ionization energies and spectral emissions suggest the atom is a Potential Energy Well having a small nucleus at the centre with numerous electrons surrounding the nucleus. Bohr's model proposes fixed electron orbits whilst Quantum theory proposes probability functions. Neither theory satisfactorily explains the detailed nature of ionization energies and spectral emissions.

Method:

Using datasets for electron ionization, we analyse the ionization energies required to **remove** the "deepest" electron from the atom in the first six elements. The numbers are taken from the Compendium of Chemical Terminology **[1]**. (An example of the dataset is shown in **Annex 1.**)

Element	H	He	Li	Be	B	C
No of protons	1	2	3	4	5	6
energy to remove an electron (eV)	**-13.60**	-24.60	-5.39	-9.30	-8.30	-11.26
		-54.40	-75.60	-18.21	-25.15	-24.38
			-122.45	-153.90	-37.93	-47.89
				-217.70	-259.40	-64.49
					-340.20	-392.08
						-489.98

Figure 1a. IONIZATION: Table of energies to remove electrons.

We can see that the Ionization Energy of the deepest electron is proportional to the square of the number of protons in the nucleus. In diagrammatic form:

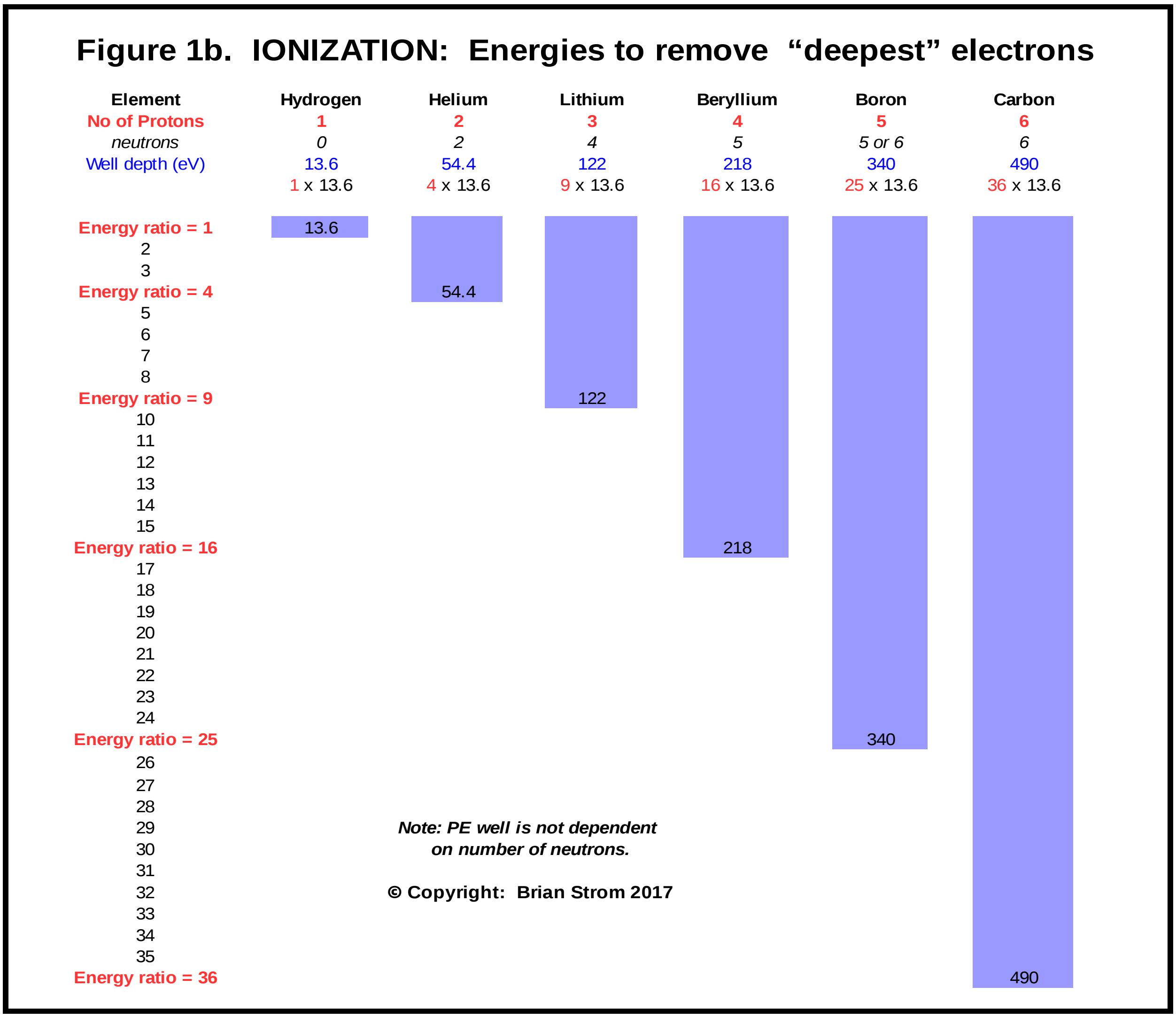

Figure 1b. IONIZATION: Histogram of energies to remove “deepest” electrons.

Note: There is no mathematical pattern for electron ionization energies in relation to the supposed number of neutrons in the atom. This suggests that neutrons – whatever their properties - do not reside in the nucleus, where their mass would contribute to the nature of the nuclear Potential Energy Well.

We continue by analysing the differing ionization energies for each “level” of electrons for the first twelve elements, where the electrons are ejected one-by-one: *(The main excitation levels for Hydrogen and Helium are also shown.)*

Element	H	He	Li	Be	B	C	N	O	Fl	Ne	Na	Mg
No of protons	1	2	3	4	5	6	7	8	9	10	11	12
	-1.51											
	-3.40	-4.60										
Energy (eV)	-13.60	-24.60	-5.39	-9.30	-8.30	-11.26	-14.53	-13.62	-17.42	-21.56	-5.14	-7.65
		-54.40	-75.60	-18.21	-25.15	-24.38	-29.60	-35.12	-34.97	-40.96	-47.29	-15.04
			-122.45	-153.90	-37.93	-47.89	-47.45	-54.93	-62.71	-63.45	-71.64	-80.14
				-217.70	-259.40	-64.49	-77.47	-77.41	-87.14	-97.11	-98.91	-109.24
					-340.20	-392.08	-97.89	-113.90	-114.20	-126.20	-138.40	-141.26
						-489.98	-552.10	-138.10	-157.20	-157.90	-172.20	-186.50
							-667.03	-739.30	-185.20	-207.30	-208.50	-224.94
								-871.40	-953.90	-239.10	-264.20	-265.90
									-1103.00	-1196.00	-299.90	-327.95
										-1362.14	-1465.00	-367.53
											-1648.66	-1761.80
												-1962.61

Figure 2a. IONIZATION - Table of energies to remove electrons.

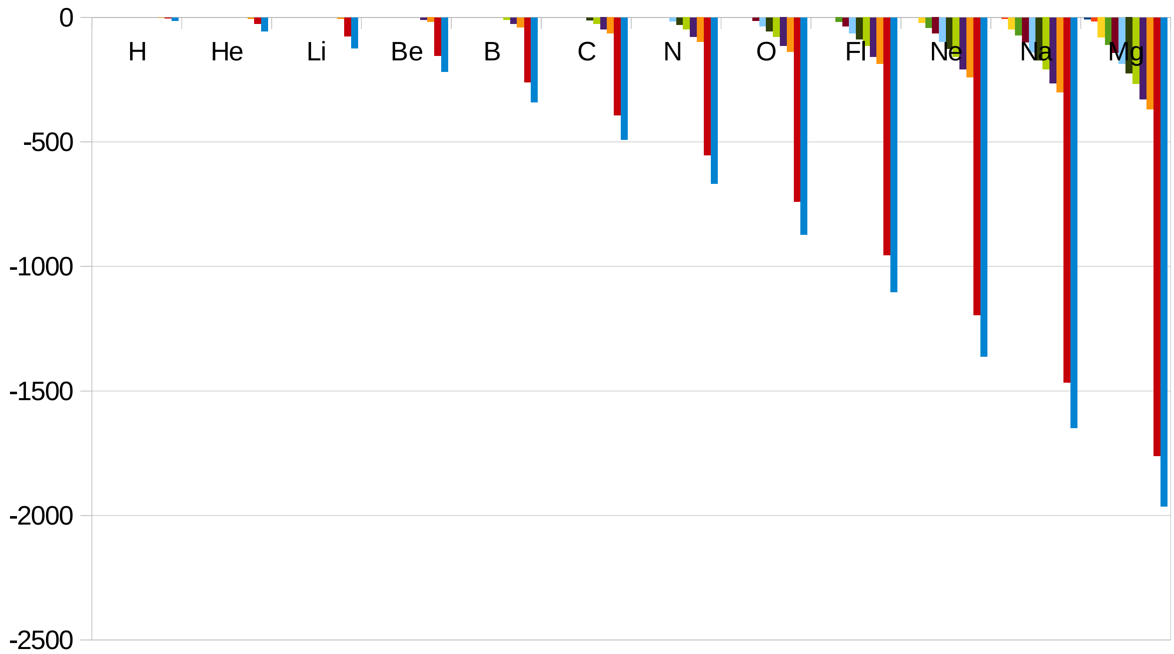

Figure 2b. IONIZATION - Histogram of energies to remove electrons.

We use the mathematical relationship that the **“depth”** of an electron in the atomic Potential Energy Well is proportional to the square root of the energy required to remove the electron:

Element	H	He	Li	Be	B	C	N	O	Fl	Ne	Na	Mg
	-1.23											
	-1.84	-2.14										
depth proportional to	-3.69	-4.96	-2.32	-3.05	-2.88	-3.36	-3.81	-3.69	-4.17	-4.64	-2.27	-2.77
square root of energy		-7.38	-8.69	-4.27	-5.01	-4.94	-5.44	-5.93	-5.91	-6.40	-6.88	-3.88
			-11.07	-12.41	-6.16	-6.92	-6.89	-7.41	-7.92	-7.97	-8.46	-8.95
				-14.75	-16.11	-8.03	-8.80	-8.80	-9.33	-9.85	-9.95	-10.45
					-18.44	-19.80	-9.89	-10.67	-10.69	-11.23	-11.76	-11.89
						-22.14	-23.50	-11.75	-12.54	-12.57	-13.12	-13.66
							-25.83	-27.19	-13.61	-14.40	-14.44	-15.00
								-29.52	-30.89	-15.46	-16.25	-16.31
									-33.21	-34.58	-17.32	-18.11
										-36.91	-38.28	-19.17
											-40.60	-41.97
												-44.30

Figure 3a. IONIZATION – Table of electron “depths” (∝ square root of energy)

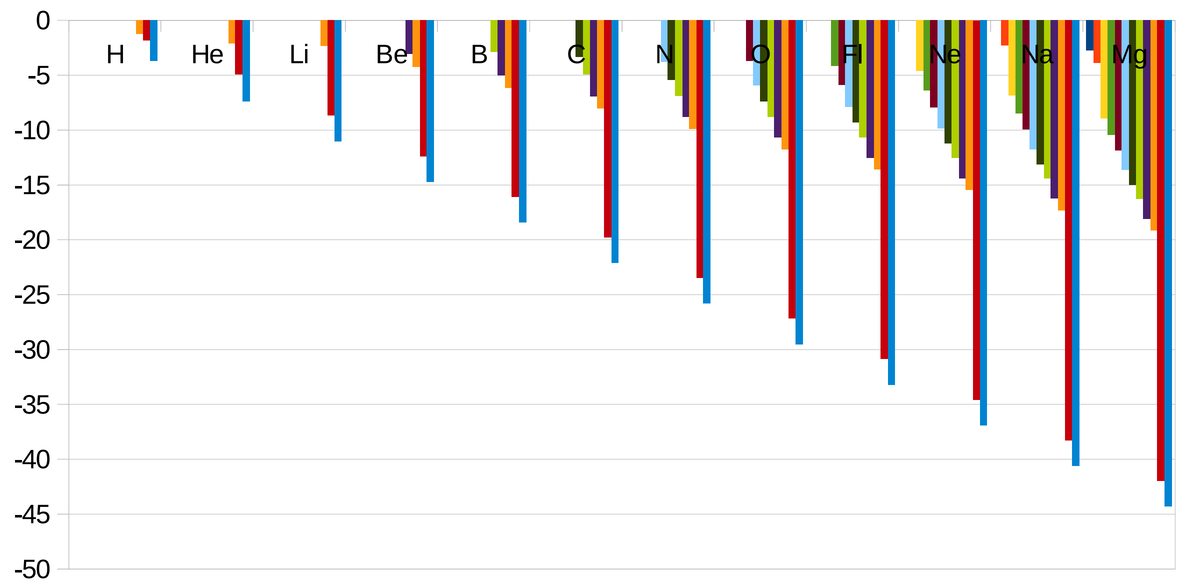

Figure 3b. IONIZATION – Histogram of electron “depths” (∝ square root of energy)

We observe that the depth of the atomic Potential Energy Well is directly proportional to the number of protons in the nucleus. Dividing the electron depths by the number of protons in the nucleus, we can see the comparative depths, as though each nucleus contained one proton only:

Element	H	He	Li	Be	B	C	N	O	Fl	Ne	Na	Mg
	-1.23											
	-1.84	-1.07										
depth of electron	-3.69	-2.48	-0.77	-0.76	-0.58	-0.56	-0.54	-0.46	-0.46	-0.46	-0.21	-0.23
(per proton)		-3.69	-2.90	-1.07	-1.00	-0.82	-0.78	-0.74	-0.66	-0.64	-0.63	-0.32
			-3.69	-3.10	-1.23	-1.15	-0.98	-0.93	-0.88	-0.80	-0.77	-0.75
				-3.69	-3.22	-1.34	-1.26	-1.10	-1.04	-0.99	-0.90	-0.87
					-3.69	-3.30	-1.41	-1.33	-1.19	-1.12	-1.07	-0.99
						-3.69	-3.36	-1.47	-1.39	-1.26	-1.19	-1.14
							-3.69	-3.40	-1.51	-1.44	-1.31	-1.25
								-3.69	-3.43	-1.55	-1.48	-1.36
									-3.69	-3.46	-1.57	-1.51
										-3.69	-3.48	-1.60
											-3.69	-3.50
												-3.69

Figure 4a. IONIZATION: Table of electron depths per proton.

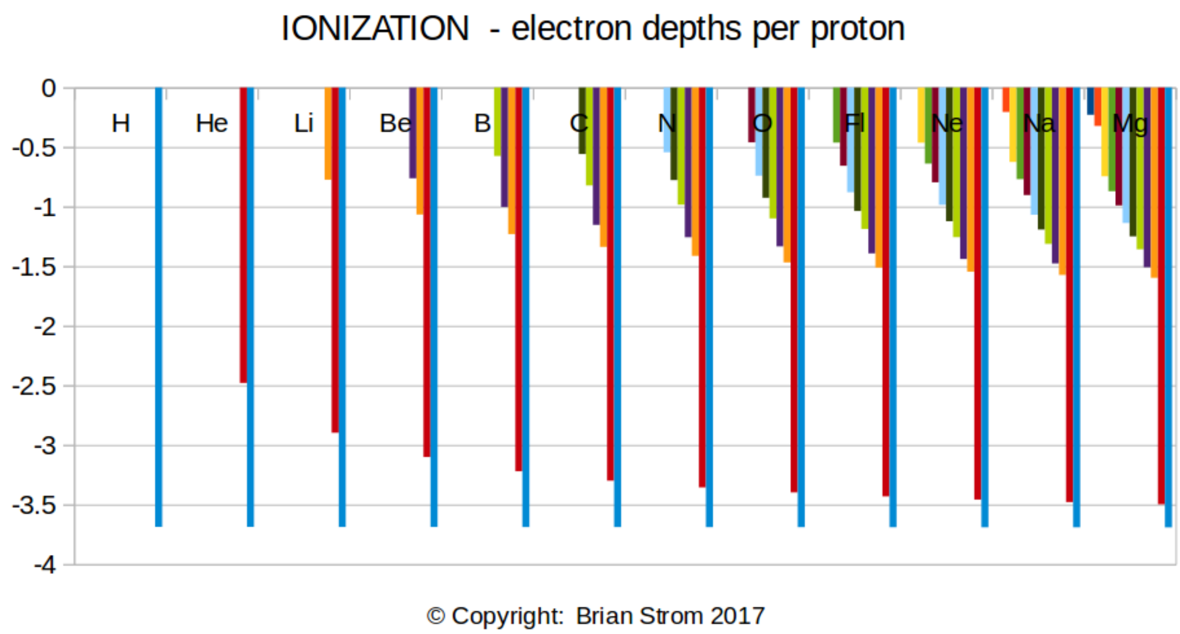

Figure 4b. IONIZATION: Histogram of electron depths per proton.

Normalizing the electron depths to give a unitary comparison:

Element	H	He	Li	Be	B	C	N	O	Fl	Ne	Na	Mg
	-0.33											
	-0.50	-0.29										
Electron depths	-1.00	-0.67	-0.21	-0.21	-0.16	-0.15	-0.15	-0.13	-0.13	-0.13	-0.06	-0.06
per proton		-1.00	-0.79	-0.29	-0.27	-0.22	-0.21	-0.20	-0.18	-0.17	-0.17	-0.09
(normalized)			-1.00	-0.84	-0.33	-0.31	-0.27	-0.25	-0.24	-0.22	-0.21	-0.20
				-1.00	-0.87	-0.36	-0.34	-0.30	-0.28	-0.27	-0.25	-0.24
					-1.00	-0.89	-0.38	-0.36	-0.32	-0.30	-0.29	-0.27
						-1.00	-0.91	-0.40	-0.38	-0.34	-0.32	-0.31
							-1.00	-0.92	-0.41	-0.39	-0.36	-0.34
								-1.00	-0.93	-0.42	-0.40	-0.37
									-1.00	-0.94	-0.43	-0.41
										-1.00	-0.94	-0.43
											-1.00	-0.95
												-1.00

Figure 5a. IONIZATION: Table of electron depths per proton – normalized.

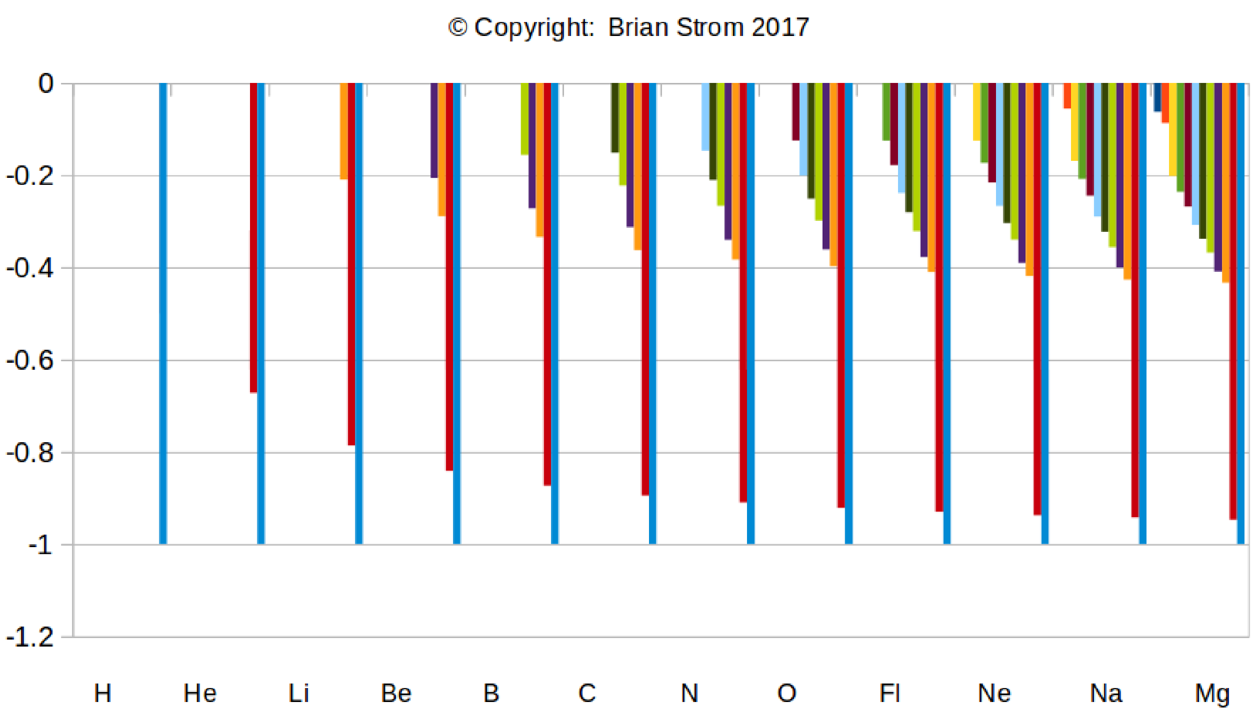

Figure 5b. IONIZATION: Histogram of electron depths per proton – normalized.

ATOMIC SPECTRA:

We use the experimentally observed spectral emission line wavelengths from the official data published by the National Institute of Standards and Technology [2]. (An example of the Dataset is shown in Annex 2.)

We believe these spectral emission lines occur when electrons **fall** into the atom, collide with another electron, and emit photons. The frequency (and energy) of the spectral emission is inversely proportional to the emission wavelength.

We analyze the spectral lines for the first 12 elements, plus Uranium:

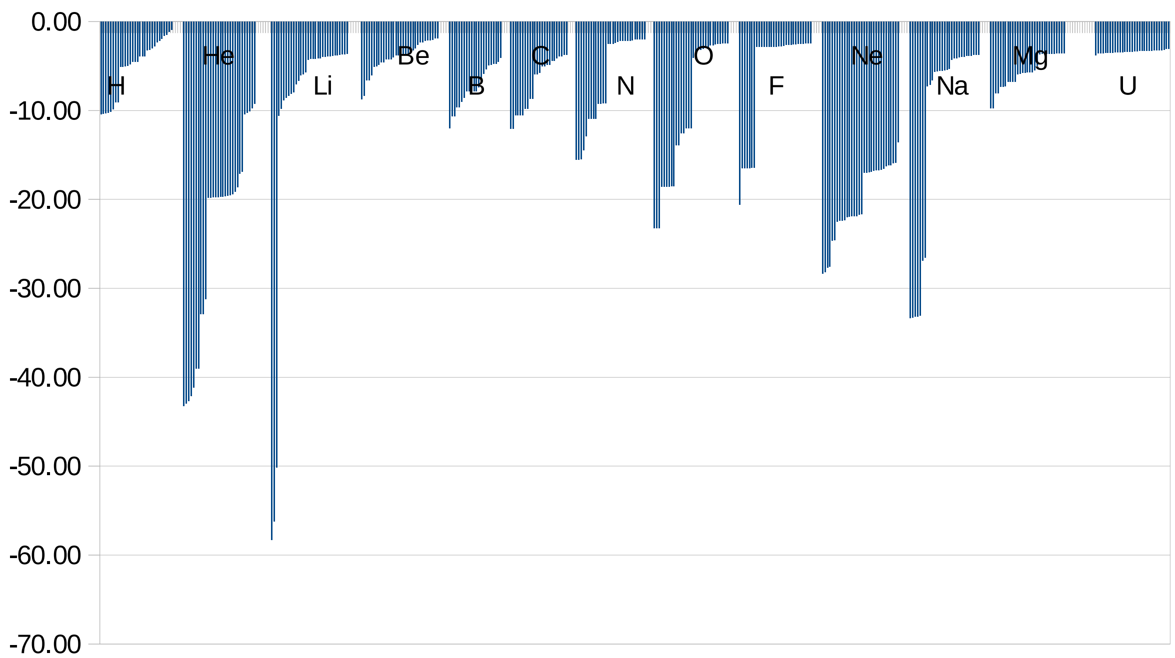

Figure 6a. SPECTRA: energy of electron fall.

The "depths" the electrons fall into the atomic Potential Energy Well are proportional to the square root of the emission energies:

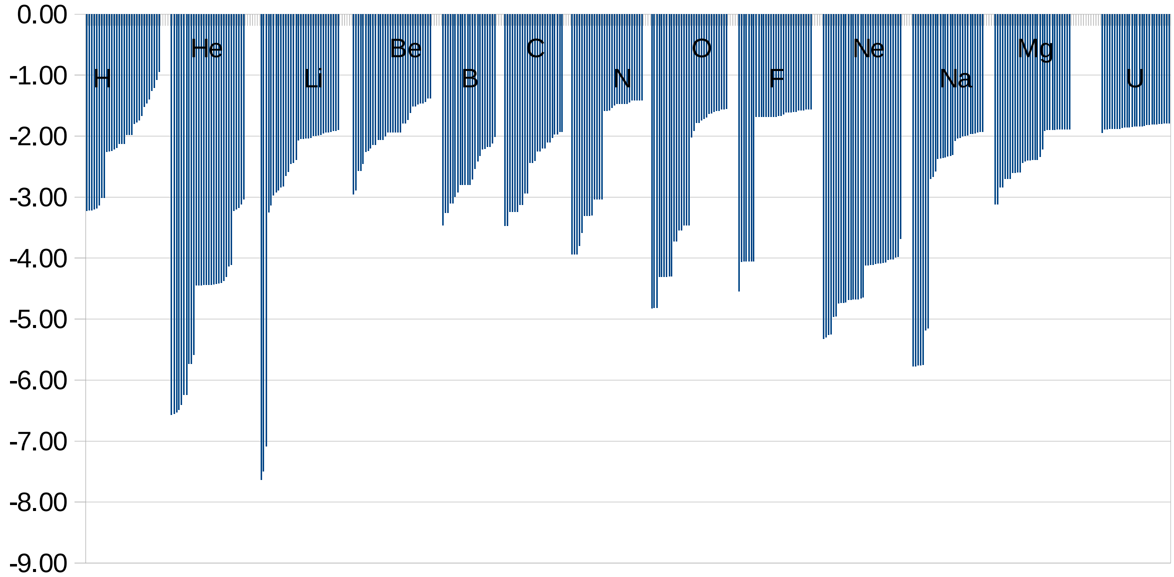

Figure 6b. SPECTRA: "depth" of electron fall.

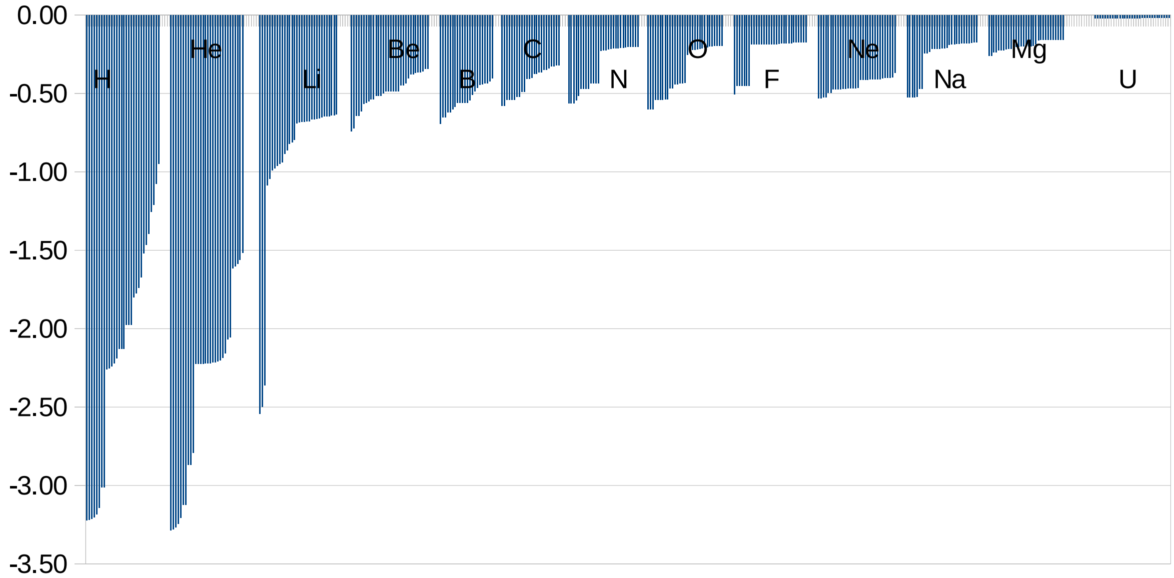

Figure 6c. SPECTRA: depth of electron fall - per proton.

ANALYSIS:

We analyze the dataset of ionization energies for electrons being ejected from the atom, and conclude that the "depth" of the three-dimensional atomic Potential Energy Well is dependent on the number of protons in the atom. As proton numbers increase, the depth of the Potential Energy Well increases in direct proportion.

Note: At least for the lighter elements, the characteristics of the atomic Potential Energy Well do not appear to be dependent on the number of neutrons in the atom.

For the spectral emissions dataset, we envision electrons "falling" into the three-dimensional Potential Energy Well of the atom. The further an electron falls, the more energetic is its spectral emission.

Both the ionization energy, and the spectral emission energy, are proportional to the square of the depth of the electron in the Potential Energy Well.

Comparison with multi-layered ball:

We consider the energy levels for a "multi-layered ball" of spherical objects in a 3-dimensional Potential Energy Well:

The closest a sphere can sit next to the centre of the Potential Energy Well is adjacent to the centre, at sphere radius r.

For 2 spheres sitting side-by-side, the distance from their centres to the centre of the Potential Energy Well will also be sphere radius 1r.

For 3 identical spheres in a flat plane, the equilibrium position for each sphere will be for its centre to be 1.155 r from the centre of the Potential Energy Well (Figure 7).

We consider the numerous energy levels as more spheres are added. The energy steps become smaller as the number of spheres increases.

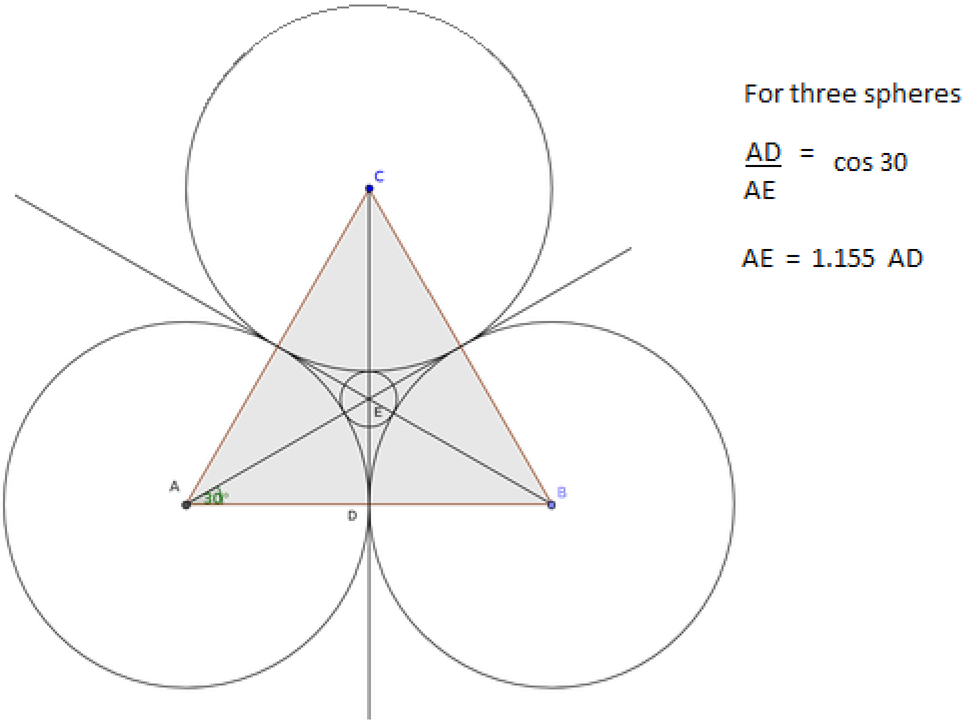

Figure 7. Dimensions for three close-packed electrons.

Identification of patterns:

We compare the ionization electron depths and the mathematics for spheres in a Potential Energy Well and identify the similarities. We conclude that electrons simply fill the three-dimensional atomic Potential Energy Well around the nucleus, layer by layer.

Dividing the electron depths by the number of protons in the nucleus shows the normalized depths the electrons fall. This suggest we can place electron centres at each position. (Figure 8.)

For the lighter elements, the electrons appear to be loosely-packed. For Hydrogen, it is relatively easy for an incoming electron to fall through the loosely-packed electrons to the lower levels in the atom, even to the lowest level alongside the nucleus.

For the heavier atoms, the electrons are more tightly-packed, so electrons falling into the Potential Energy Well will travel through fewer layers of electrons before colliding with one of them.

For the elements with more protons and a deeper Potential Energy Well, the second layer electron energy level is seen to become asymptotically closer to the 1.155 r position.

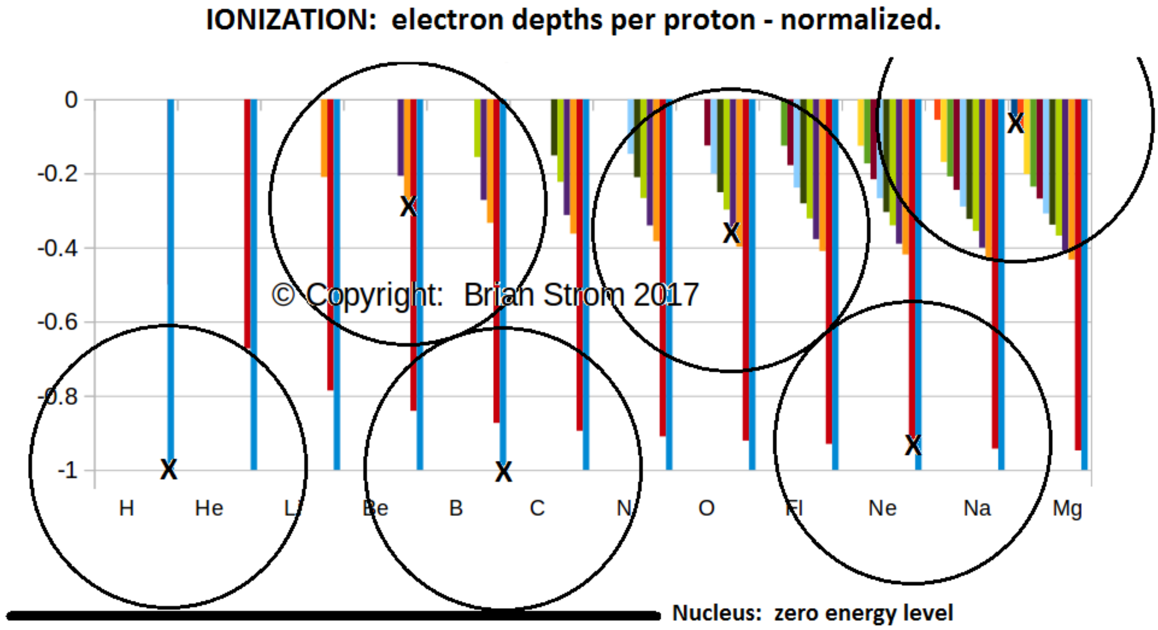

Figure 8. The AI envisions electrons at each energy point.

Symmetry:

The underlying structure and symmetry of the nucleus will be different for each element, depending on the number of protons. Consequently, the symmetry of the "ball" of electrons surrounding the nucleus will be slightly different for each element.

For heavier atoms with more protons, there will be more layers of electrons. For an atom with a nucleus having a symmetrical arrangement of protons, as in the noble gases, the electron layers also appear to be more symmetrical, requiring higher ionization energies to remove electrons.

The force on the falling electron will be much greater for the heavier elements with more protons in the nucleus, but the distance the electron falls is shorter in the heavier atoms because the existing electrons are more tightly-packed.

CONCLUSIONS:

The analysis of electron ionization and emission data indicates that the depth of the atomic Potential Energy Well is dependent on the number of protons in the atom.

At least for the lighter elements, the characteristics of the atomic Potential Energy Well do not appear to be dependent on the number of neutrons in the atom.

We propose that electrons simply fill the three-dimensional Potential Energy Well around the atomic nucleus, layer by layer, without the need for unexplained electron orbits as required for the Bohr atomic model.

We envision that electrons are larger than we presently imagine.

The image of the Hydrogen atom is a small cluster of electrons surrounding a nucleus of one proton:

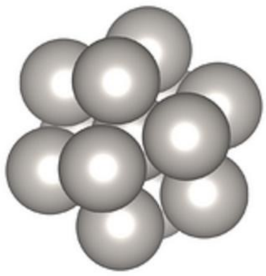

Figure 9. Hydrogen atom.

The image of the Carbon atom is a larger cluster of electrons surrounding a nucleus of 6 protons. The volume of the three-dimensional atomic Potential Energy Well is larger than for Hydrogen and, therefore, the number of electrons sitting in the Potential Energy Well is greater.

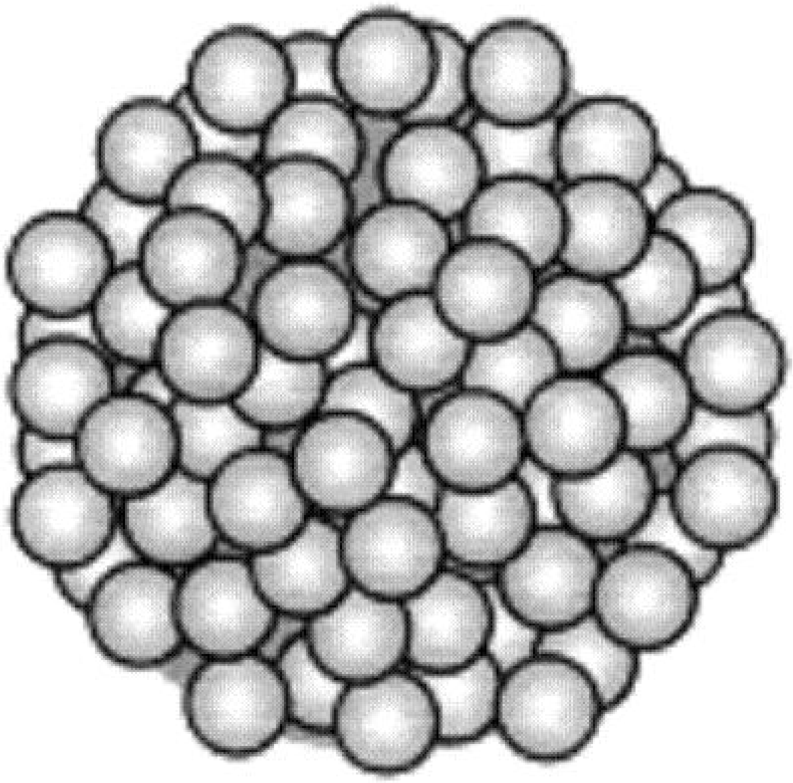

Figure 10. Carbon atom.

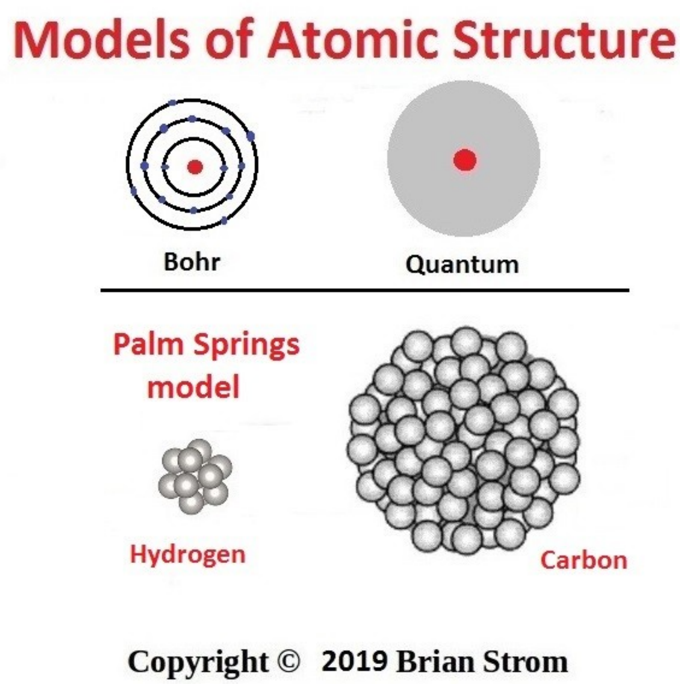

Figure 11. Models of Atomic Structure.

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REFERENCES

[1] Compendium of Chemical Terminology, 2nd ed. Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997).

[2] National Institute of Standards and Technology - Basic Atomic Spectroscopic Data: https://www.nist.gov/

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ANNEX 1. Ionization Energies in the Compendium of Chemical Terminology:

IONIZATION POTENTIALS[a]

Z Element	Spectrum																				
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
1 H	13.598																				
2 He	24.587	54.416																			
3 Li	5.392	75.638	122.451																		
4 Be	9.322	18.211	153.893	217.713																	
5 B	8.298	25.154	37.930	259.368	340.217																
6 C	11.260	24.383	47.887	64.492	392.077	489.981															
7 N	14.534	29.601	47.448	77.472	97.888	552.057	667.029														
8 O	13.618	35.116	54.934	77.412	113.896	138.116	739.315	871.387													
9 F	17.422	34.970	62.707	87.138	114.240	157.161	185.182	953.886	1103.089												
10 Ne	21.564	40.962	63.45	97.11	126.21	157.93	207.27	239.09	1195.797	1362.164											
11 Na	5.139	47.286	71.64	98.91	138.39	172.15	208.47	264.18	299.87	1465.091	1648.659										
12 Mg	7.646	15.035	80.143	109.24	141.26	186.50	224.94	265.90	327.95	367.53	1761.802	1962.613									
13 Al	5.986	18.828	28.447	119.99	153.71	190.47	241.43	284.59	330.21	398.57	442.07	2085.983	2304.080								
14 Si	8.151	16.345	33.492	45.141	166.77	205.05	246.52	303.17	351.10	401.43	476.06	523.50	2437.676	2673.108							
15 P	10.486	19.725	30.18	51.37	65.023	230.43	263.22	309.41	371.73	424.50	479.57	560.41	611.85	2816.943	3069.762						
16 S	10.360	23.33	34.83	47.30	72.68	88.049	280.93	328.23	379.10	447.09	504.78	564.65	651.63	707.14	3223.836	3494.099					
17 Cl	12.967	23.81	39.61	53.46	67.8	98.03	114.193	348.28	400.05	455.62	529.26	591.97	656.69	749.74	809.39	3658.425	3946.193				
18 Ar	15.759	27.629	40.74	59.81	75.02	91.007	124.319	143.456	422.44	478.68	538.95	618.24	686.09	755.73	854.75	918	4120.778	4426.114			
19 K	4.341	31.625	45.72	60.91	82.66	100.0	117.56	154.86	175.814	503.44	564.13	629.09	714.02	787.13	861.77	968	1034	4610.955	4933.931		
20 Ca	6.113	11.871	50.908	67.10	84.41	108.78	127.7	147.24	188.54	211.270	591.25	656.39	726.03	816.61	895.12	974	1087	1157	5129.045	5469.738	
21 Sc	6.54	12.80	24.76	73.47	91.66	111.1	138.0	158.7	180.02	225.32	249.832	685.89	755.47	829.79	926.00						
22 Ti	6.82	13.58	27.491	43.266	99.22	119.36	140.8	168.5	193.2	215.91	265.23	291.497	787.33	861.33	940.36						
23 V	6.74	14.65	29.310	46.707	65.23	128.12	150.17	173.7	205.8	230.5	255.04	308.25	336.267	895.58	974.02						
24 Cr	6.766	16.50	30.96	49.1	69.3	90.56	161.1	184.7	209.3	244.4	270.8	298.0	355	384.30	1010.64						
25 Mn	7.435	15.640	33.667	51.2	72.4	95	119.27	196.46	221.8	248.3	286.0	314.4	343.6	404	435.3	1136.2					
26 Fe	7.870	16.18	30.651	54.8	75.0	99	125	151.06	235.04	262.1	290.4	330.8	361.0	392.2	457	489.5	1266.1				
27 Co	7.86	17.06	33.50	51.3	79.5	102	129	157	186.13	276	305	336	379	411	444	512	546.8	1403.0			
28 Ni	7.635	18.168	35.17	54.9	75.5	108	133	162	193	224.5	321.2	352	384	430	464	499	571	607.2	1547		
29 Cu	7.726	20.292	36.83	55.2	79.9	103	139	166	199	232	266	368.8	401	435	484	520	557	633	671	1698	
30 Zn	9.394	17.964	39.722	59.4	82.6	108	134	174	203	238	274	310.8	419.7	454	490	542	579	619	698	738	1856
31 Ga	5.999	20.51	30.71	64																	
32 Ge	7.899	15.934	34.22	45.71	93.5																
33 As	9.81	18.633	28.351	50.13	62.63	127.6															
34 Se	9.752	21.19	30.820	42.944	68.3	81.70	155.4														
35 Br	11.814	21.8	36	47.3	59.7	88.6	103.0	192.8													
36 Kr	13.999	24.359	36.95	52.5	64.7	78.5	111.0	126	230.39												
37 Rb	4.177	27.28	40	52.6	71.0	84.4	99.2	136	150	277.1											
38 Sr	5.695	11.030	43.6	57	71.6	90.8	106	122.3	162	177	324.1										
39 Y	6.38	12.24	20.52	61.8	77.0	93.0	116	129	146.52	191	206	374.0									
40 Zr	6.84	13.13	22.99	34.34	81.5																
41 Nb	6.88	14.32	25.04	38.3	50.55	102.6	125														
42 Mo	7.099	16.15	27.16	46.4	61.2	68	126.8	153													
43 Te	7.28	15.26	29.54																		
44 Ru	7.37	16.76	28.47																		
45 Rh	7.46	18.08	31.06																		
46 Pd	8.34	19.43	32.93																		
47 Ag	7.576	21.49	34.83																		

Figure 11. Ionization: Compendium of Chemical Terminology

ANNEX 2. Spectral emission lines for Hydrogen in the National Institute of Standards and Technology - Basic Atomic Spectroscopic Data.

HYDROGEN Intensity	Spectral Wavelength	Spectral energy proportional to inverse of wavelength
15	926.2256	-10.39
20	930.7482	-10.37
30	937.8034	-10.33
50	949.743	-10.26
100	972.5367	-10.14
300	1025.7222	-9.87
1000	1215.66824	-9.07
500	1215.67364	-9.07
5	3835.384	-5.11
6	3889.049	-5.07
8	3970.072	-5.02
15	4101.74	-4.94
30	4340.462	-4.80
30	4861.2786	-4.54
10	4861.287	-4.54
60	4861.3615	-4.54
90	6562.711	-3.90
30	6562.7248	-3.90
180	6562.8518	-3.90
5	9545.97	-3.24
7	10049.4	-3.15
12	10938.1	-3.02
20	12818.07	-2.79
40	18751.01	-2.31
5	21655.3	-2.15
8	26251.5	-1.95
15	40511.6	-1.57
4	46525.1	-1.47
6	74578	-1.16
3	123685	-0.90

Figure 12. Spectral emission lines for Hydrogen.

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