Nuclear Valence Shell

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Abstract

The study proves that the outer protons of the atomic nucleus form a shell. It determines the chemical properties of an atom because it shields the electric field of internal protons. Therefore, it can be called a Nuclear Valence Shell (NVS). The full NVS contains 8 protons. This corresponds to a 4-dimensional space inside nucleus with 2 protons in each dimension and explain Octet rule of periodic table of elements.

Keywords: physics, chemistry, octet rule, space, atom, nucleus, Periodic table of elements, electron, proton, shell model of nucleus

PACS Classification codes:

01.55.+b General physics; 31.10.+z Theory of electronic structure, electronic transitions, and chemical binding; 21.60.-n Nuclear structure models and methods; 12.10.-g Unified field theories and models

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Introduction

The properties of chemical elements are mainly determined by the shell of the valence electrons. In each period, the valence shell begins with 1 electron (alkali metals) and ends with a full 8 electron shell (noble gases). The elements of the main groups form the valence shell. There are 8 elements in each period (Fig. 1) that make up the 8 main groups from IA to VIIIA.

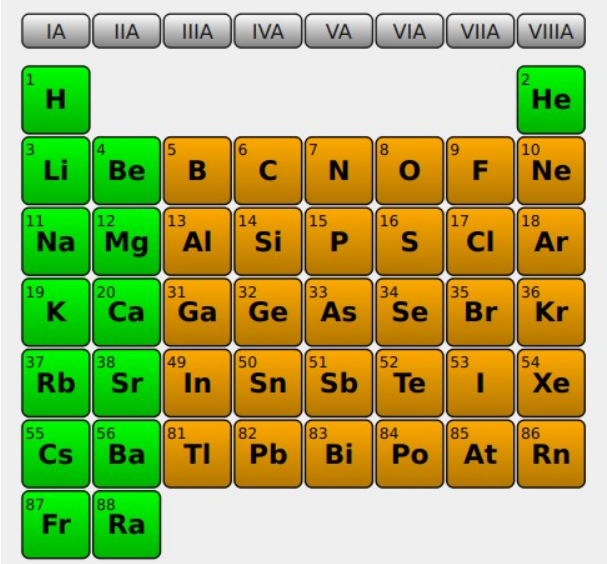

Fig. 1. Short periodic table.
Elements with outer *s* (green) and outer *p* orbitales (dark yellow).

The geometrical properties of these elements are summarized in Table 1. The table uses data on the most common isotopes in nature. Various unstable, exotic and only artificially obtainable isotopes are not considered.

The largest radius [2] in each period is for alkali metals, the smallest - for noble gases. This also applies to transition metals (Fig. 2).

Atomic nuclei behave very differently [3], their radius increasing as the number of nuclones in the nucleus increases (Fig. 2).

Table 1

Radii of atoms and their nuclei

Group	Element	Protons count	Neutrons count	Nucleons total	Nuclear Radius fm	Radius increase* fm	Atomic Radii Å
I	H	1	0	1	0.8783		0.5292
VIII	**He**	**2**	**2**	**4**	**1.6755**	**0.7972**	**0.3113**
I	Li	3	6	9	2.245	0.5695	1.6282
II	Be	4	6	10	2.355	0.11	1.0855
III	B	5	6	11	2.406	0.051	0.8141
IV	C	6	7	13	2.4614	0.0554	0.6513
V	N	7	7	14	2.5582	0.0968	0.5427
VI	O	8	9	17	2.6932	0.135	0.4652
VII	F	9	10	19	2.8976	0.2044	0.4071
VIII	**Ne**	**10**	**14**	**24**	**2.9007**	**0.0031**	**0.3618**
I	Na	11	9	20	2.9718	0.0711	2.1649
II	Mg	12	13	25	3.0284	0.0566	1.6711
III	Al	13	14	27	3.061	0.0326	1.3607
IV	Si	14	15	29	3.1176	0.0566	1.1476
V	P	15	16	31	3.1889	0.0713	0.9922
VI	S	16	16	32	3.2611	0.0722	0.8738
VII	Cl	17	18	35	3.3654	0.1043	0.7807
VIII	**Ar**	**18**	**16**	**34**	**3.3654**	**0**	**0.7056**
I	K	19	19	38	3.4264	0.061	3.5598
II	Ca	20	19	39	3.4595	0.0331	2.7479
III	Ga	31	38	69	3.9308	0.0025	1.5663
IV	Ge	32	38	70	4.0414	0.1106	1.3862
V	As	33	42	75	4.0968	0.0554	1.2431
VI	Se	34	42	76	4.1395	0.0427	1.1269
VII	Br	35	44	79	4.1629	0.0234	1.0305
VIII	**Kr**	**36**	**36**	**72**	**4.1635**	**0.0006**	**0.9493**
I	Rb	37	50	87	4.1989	0.0354	4.8106
II	Sr	38	50	88	4.224	0.0251	3.7135
III	In	49	55	104	4.5184	0.0062	2.1167
IV	Sn	50	58	108	4.5605	0.0421	1.8732
V	Sb	51	70	121	4.6802	0.1197	1.6799
VI	Te	52	64	116	4.6847	0.0045	1.5228
VII	I	53	74	127	4.75	0.0653	1.3926
VIII	**Xe**	**54**	**66**	**120**	**4.7509**	**0.0009**	**1.2828**
I	Cs	55	63	118	4.7832	0.0323	6.0615
II	Ba	56	64	120	4.8092	0.026	4.6788
III	Tl	81	107	188	5.4017	0.0184	2.667
IV	Pb	82	107	189	5.4177	0.016	2.3603
V	Bi	83	108	191	5.484	0.0663	2.1167
VI	Po	84	113	197	5.5112	0.0272	1.9187
VII	At	85	115	200	5.552	0.0408	1.7546
VIII	**Rn**	**86**	**116**	**202**	**5.5521**	**0.0001**	**1.6164**
I	Fr	87	116	203	5.556	0.0039	7.2404
II	Ra	88	120	208	5.585	0.029	5.5887

* Increase of nuclear radius versus atomic number.

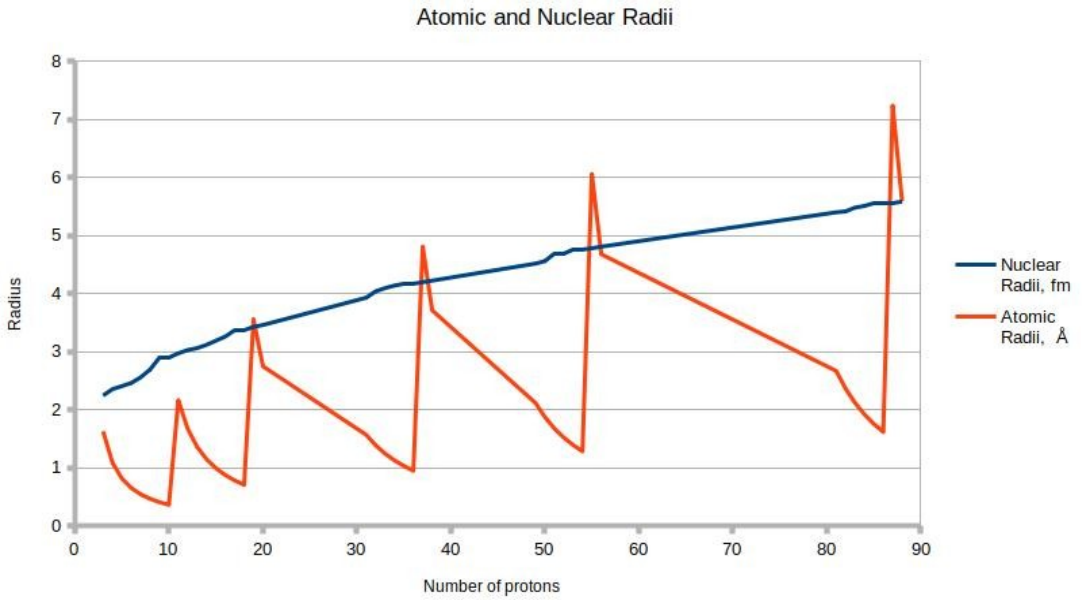

Fig. 2. Comparision of Atomic (Å) and Nuclear (fm) radii versus number of protons in the chemical element.

The increase in nuclear radius with increasing number of protons is summarized in Table 2.

Table 2

Increase of nuclear radius (fm)

Group	2. period	3. period	4. period	5. period	6. period
I		0,0711	0,0610	0,0354	0,0323
II	0,1100	0,0566	0,0331	0,0251	0,0260
III	0,0510	0,0326	0,1106	0,0062	0,0184
IV	0,0554	0,0566	0,1106	0,0421	0,0160
V	0,0968	0,0713	0,0554	0,1197	0,0663
VI	0,1350	0,0722	0,0427	0,0045	0,0272
VII	0,2044	0,1043	0,0234	0,0653	0,0408
VIII	0,0031	0,00001	0,0006	0,0009	0,0001

The increase in radius depending on the number of protons in each period is relatively constant (Fig. 3). The exception is noble gases, for which growth tends to zero.

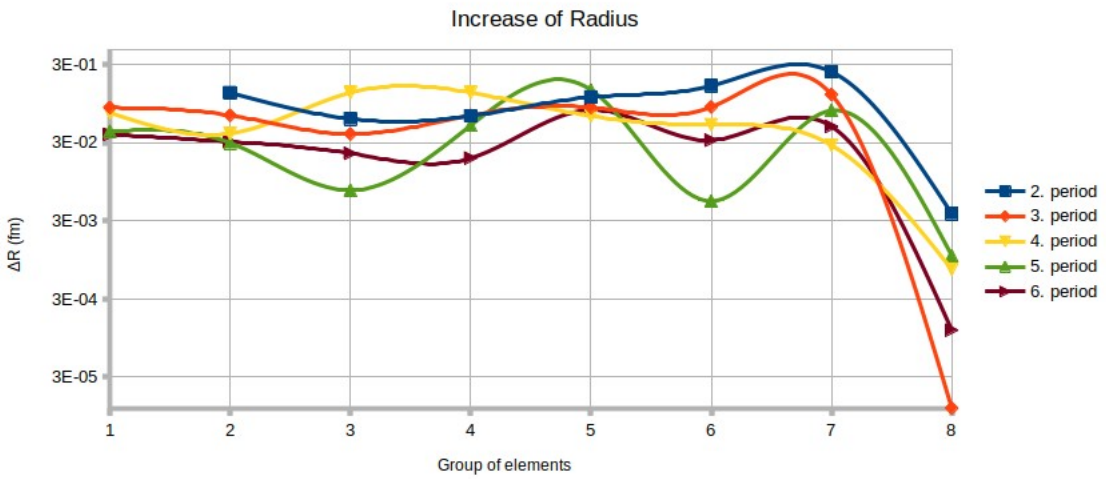

Fig. 3. An increase in the radius of the nucleus with an increase in the number of protons in the nucleus.
Group 1 is alkali metals,
Group 8 is noble gases.

Conclusions

Each period begins with a sharp increase in radius. For 7 elements in a row, the radius increase is practically constant. At the eighth element (noble gases) the radius increases around zero. This is the case for all periods.

From this it can be concluded that the protons in the nucleus are arranged in shells and there may be only 8 protons in the outer shell of the atomic nucleus. This corresponds to a 4-dimensional space inside nucleus [4, 5, 6] in which each dimension can have 2 protons. The protons of the outer shell shield the inner proton field, so their effect on the properties of the atom is negligible. Therefore, the outer shell of the nucleus should be called a Nuclear Valence Shell (NVS). It determines the valence of the atom and explains the cause [7] of the Octet Rule.

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