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ISOMERES AND ISOTOPES OF CARBON

Alexander I. Melker

St. Petersburg Academy of Sciences on Strength Problems, Peter the Great St. Petersburg Polytechnic University

Polytekhnicheskaya 29, 195251, St. Petersburg, Russian Federation

e-mail: ndtcs@inbox.ru

Abstract. The nuclear geometry has been developed by analogy with the fullerene geometry. On the base of this geometric approach, the structure of carbon isomers and isotopes, which can be obtained by means of nuclear synthesis, has been designed. The mechanisms of possible nuclear reaction are discussed. Carbon is an unusual element. It has four isomers of different symmetry: three-fold, six-fold and tetrahedral ones, two being stable and one half-stable. The isotopes of carbon inherit the structure of the isomers.
Keywords: carbon, graph representation, isomer, isotope, nuclear electron, nuclear geometry, nuclear reaction, nuclear synthesis

1. Introduction

Nucleus models. There are various models of nuclear structure, but all the nuclear models play the role of more or less probable working hypotheses [1]. They are based on the identification of a nucleus with one of physical systems, which properties are well studied. Each model is grounded on experimental facts and allows explain only the properties considered. Although these models often contradict each other, usually they describe different features of a nucleus and therefore supplement each other.

In Ref. [2] possible ways of nuclear synthesis were suggested in the range from hydrogen to boron, the nuclear geometry for the nuclei obtained being designed. The starting point for the geometry of nuclei is the possible analogy between the smallest fullerene, tetrahedral C_4, and helium $_2He^4$. It was assumed that a nucleus of helium $_2He^4$ can have also the form of a regular tetrahedron, where:

1) All the four apices are equivalent and therefore they are protons,

2) Each neutron in a nucleus decomposes into a proton and three negatively charged particles (tertions) having the charge ⅓ of that of an electron; two neutrons creating six such particles for six edges,

3) Interaction of these particles produces a special electronic pattern, which symmetry does not coincide with that of proton cell, but determines its space structure.

Using the above postulates, the structure of other nuclei was designed by means of geometric modeling. For hydrogen, deuterium, tritium and helium 3, there obtained a point, a linear and a plane structure, respectively. Helium 4, as already noted, had a tetrahedral symmetry. Then one has rectangular, regular triangular prisms (lithium 6 and 7), quadrangular ones (beryllium 8, 9, 10) and pentagonal prisms (boron 10 and 11). The nuclear electron patterns are more complex; they are polyhedrons and resemble the electron pairs arrangement at the valence shells of molecules [3].

Isotopes. Once the geometric model of nuclei has been done, the next crucial point is the isotopy of nuclei. The term "isotope" (ισος− equal+ τοπος− place) was suggested by Frederick Soddy in 1910, who said that the isotopes are equal on the outside, but different in

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the interior. The isotopism consists in the existence of nuclei having an equal number of protons but different number of neutrons. The isotopes take one and the same place in the Mendeleyev periodic system of chemical elements and have identical structure of the electron shells of atoms. The geometric model of nuclei, developed by analogy with the fullerene geometry, allows explain why the nuclei have a definite number of stable isotopes as well as that of isotopes having a large half-decay period [2].

Isomerism of atomic nuclei. According to the Russian Physical Encyclopedic Dictionary [1] the notion "Isomerism of atomic nuclei" appeared in 1921, when Otto Hahn (1879-1968) discovered a new radioactive substance, uranium-Z, which has the same chemical properties and mass number A as the known substance, uranium-X_2. Later it was found that both substances are two states of one and the same nucleus, having both different energies and half-life periods. By analogy with the isomerism of molecules they were named nuclear isomers". Further we read: "Isomerism of atomic nuclei is conditioned by the peculiarities of nuclear structure". What is the nuclear structure, to say nothing of the peculiarities? Not a word.

Instead of this vague notion "nuclear isomerism", the clear notion accepted for molecules should be put to better use, i.e. to accept that *space isomerism of nuclei* is the phenomenon which consists in the existence of nuclei having an equal mass number but different positions of the nuclear constituents in the space, and therefore having different properties. To confirm this statement, one will lean upon the parallels between nuclei and fullerenes. There is, however, another side to this problem. It should be emphasized that the nuclear geometry is still in its infancy [2]. Although the fullerene geometry is older [4] than the nuclear geometry, the former is also under development [5-8]. One of the recent achievements of the fullerene geometry is the explanation of the space isomerism of fullerenes [8]. This brings up the question: How to use the fullerene space isomerism for obtaining space isomers of nuclei?

Nucleosynthesis. In the Russian Physical Encyclopedic Dictionary [1] we read: "Nucleosynthesis (from Latin nucleus and Greek συνθεσις − combination) − a chain of nuclear reactions leading to creation of heavy atomic nuclei from other, lighter ones". In particular, "α-process is an assemblage of thermonuclear reactions owing to which three nuclei of helium create a nucleus of carbon ^{12}C; this carbon can react with helium giving oxygen, $^{12}C + ^{4}He \rightarrow ^{16}O$, oxygen with helium $^{16}O + ^{4}He \rightarrow ^{20}Ne$ and so on, up to silicon ^{28}Si".

There is no need for analyzing this "arithmetic approach" for the following reasons:

- It does not consider how the isotopes originate at all,
- Some of these reactions are highly unlikely because they are incompatible from the geometric standpoint [2].

Instead, in this contribution I submit the geometric approach which explains not only the generation of new elements but also that of their isotopes in the framework of one and the same unified modeling.

Carbon problem. In this contribution, the new approach developed early for nucleus study is applied to carbon. It's important draw an analogy between the structure of fullerene C_{12} and that of the carbon nuclei designed. The new geometric approach allows do thorough studying both the nucleus structure, as well as the nuclear synthesis of new elements, their isotopes, and in a new fashion to explain the isomerism of atomic nuclei. The results for the nuclei of carbon are submitted.

2. Reactions of deuteron with boron nucleus

2.1. Reaction $d + {}_5B^{10} \rightarrow {}_6C^{12}$**.** Previously [2] the nuclear reactions $d + {}_3Li^6 \rightarrow {}_4Be^8$ and $d + {}_4Be^8 \rightarrow {}_5B^{10}$ were successfully used for modeling this nucleosynthesis. Let us continue this row, i.e. consider now reaction $d + {}_5B^{10} \rightarrow {}_6C^{12}$. It is illustrated in Figure 1, from which it follows that deuteron is almost completely dissolved in the carbon structure formed. As for boron, only four protons (from ten) and two tertions (from fifteen) take part actually in the reaction. The reacting particles are specially marked in the figure; the protons are light pink balls, the tertions are small grey-green balls, the new proton-proton bonds are lilac, the old bonds, which have to be destroyed, are shown using red dot lines. The proton cell and the tertion net, as well as their graphs, are presented separately in Fig. 2.

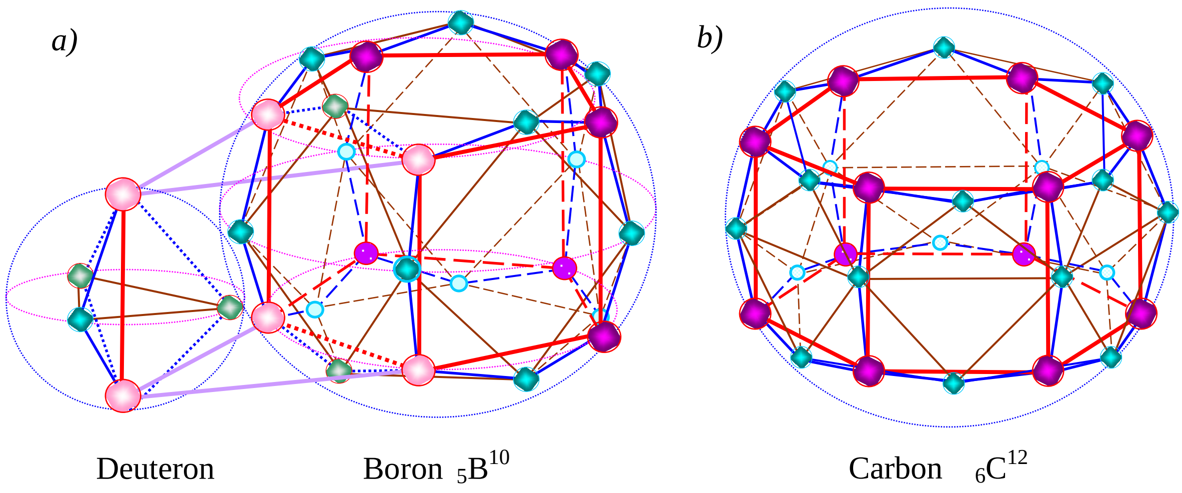

Fig. 1. Formation of carbon ${}_6C^{12}$: a) fusion of deuteron and boron ${}_5B^{10}$; b) carbon nucleus after relaxation. Here: protons (light and dark pink balls); tertions (small turquoise and grey-green balls); heavy red and thin brown lines are proton-proton and cotertiary bonds, respectively; heavy and dash blue lines are tertion-proton bonds; lilac lines are new proton-proton bonds; dot red lines are old destroyed bonds; dot blue lines are old destroyed tertion-proton bonds

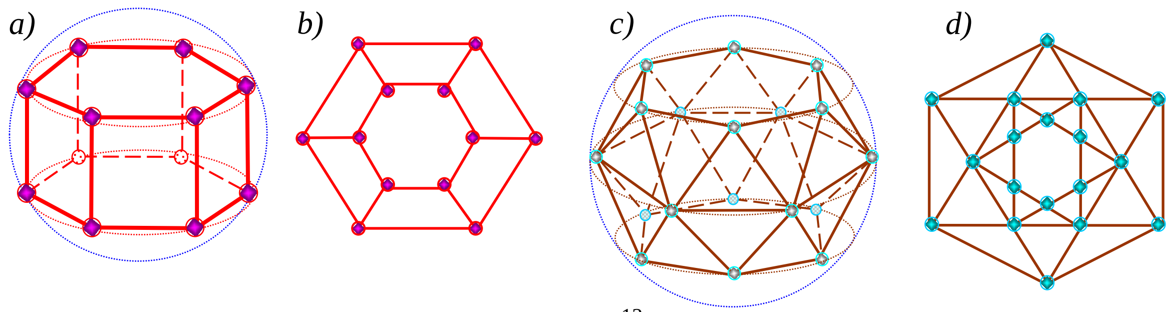

Fig. 2. Structure of six-fold symmetry carbon ${}_6C^{12}$: a) proton cell; b) graph of the proton cell; c) tertion net; d) graph of the tertion net

2.2. Reaction $d + {}_5B^{11} \rightarrow {}_6C^{13}$. Now consider this reaction shown in Fig. 3. From the figure it follows that the reacting particles are completely the same as in the previous case. However, the proton cell, the tertion net, and their graphs are quite different (Fig. 4).

One comment should be made. For boron 11, as was shown in Ref. [2], the intercell electric field is of five-fold symmetry. Because of the Stark-effect, each of two split components has a complex nature, consisting of one tertion and one semi-tertion. These particles are specially marked in the figure as small green balls. Such situation is transferred to carbon 13, which intercell electric field being of six-fold symmetry.

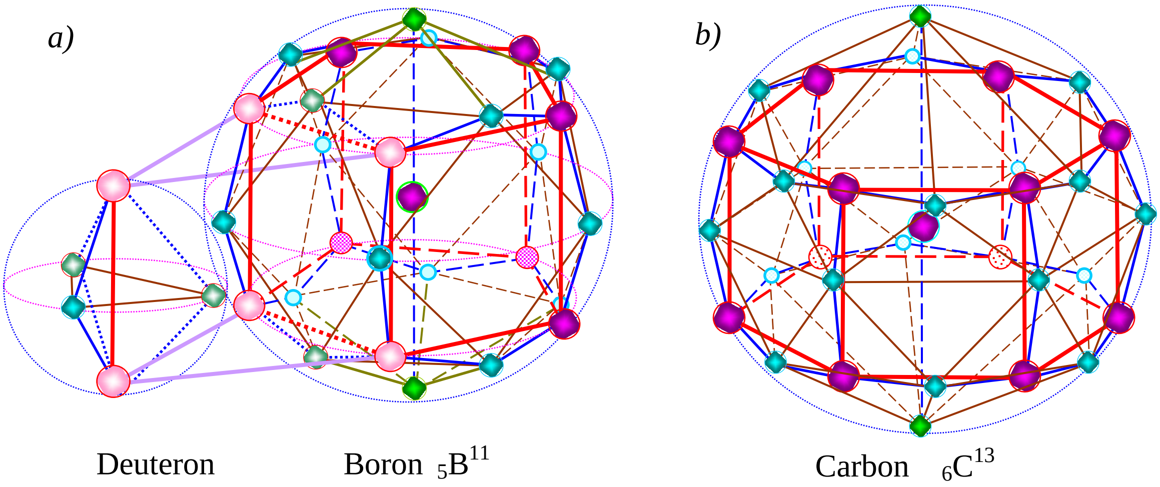

Fig. 3. Formation of carbon $_6C^{13}$: a) fusion of deuteron and boron $_5B^{11}$; b) carbon $_6C^{13}$

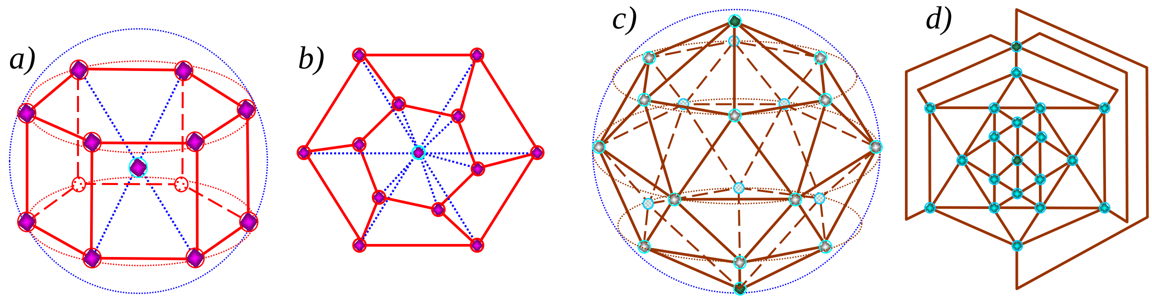

Fig. 4. Structure of carbon $_6C^{13}$: a) proton cell; b) graph of the proton cell; c) tertion net; d) graph of the tertion net

3. Neutron capture

It is known that in addition to the stable carbon isotopes considered, there exists isotope $_6C^{14}$ having a rather large half-decay period being equal to 5730 years. It can be incorporated into the scheme analogously to Ref. [2] by the following way. Suppose that a neutron has penetrated into the nucleus of $_6C^{13}$ (Fig. 5), where it decays into a proton and tertions. Here the new proton together with its own tertions interacts with the already exiting “core” proton and its tertions, forming a new tertion-proton configuration. Such procedure is thoroughly analyzed in Ref. [2] for beryllium 10. Similar to beryllium 10, carbon 14 has two protons and six tertions for reconstructing the core structure. It should be emphasized that the reconstruction has no concern with the outer structure of carbon 12; the latter is supposed to be stable. As a consequence, we have two "electronic" isomers of beryllium 10 which are presented in Fig. 6. Here the old tertions of the external net are marked in turquoise, the new tertions in green, and the old semi-tertions in brown-green. The proton cell, the tertion net, as well as their graphs, of carbon 14 is presented separately in Fig. 7. It is worth noting that the tertion nets of the electronic isomers vary only in the particles lying on the sixfold-symmetry axis (vertical axis in the figure). For the isomer shown in Fig. 6a, it is a semi-tertion, for the isomer of Fig. 6 is a tertion.

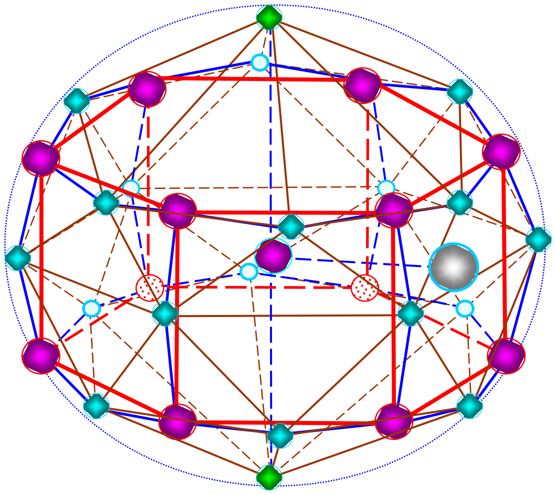

Fig. 5. Neutron (large grey ball) inside carbon $_6C^{13}$

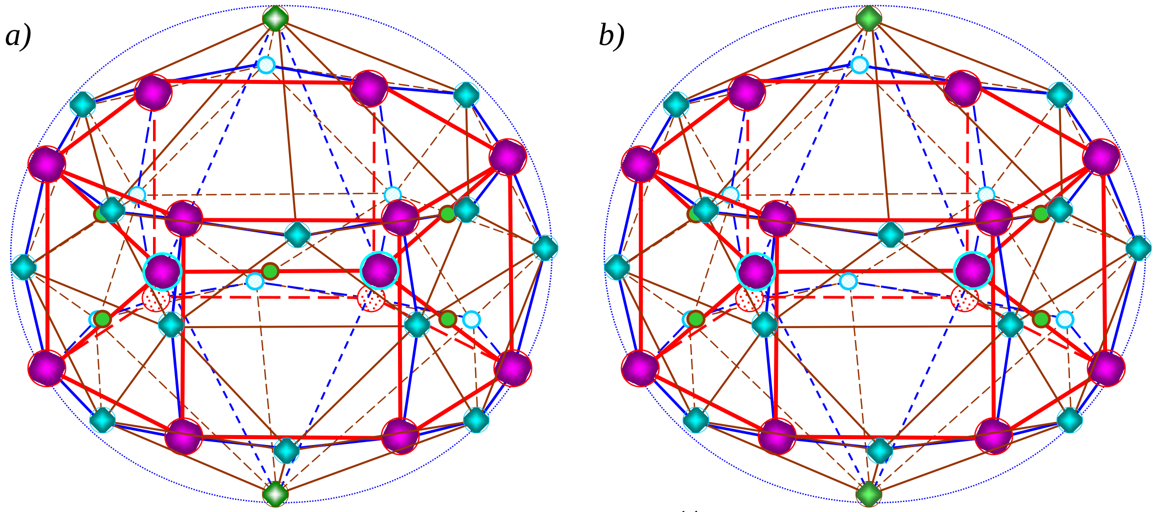

Fig. 6. Hexagonal-prism shape of carbon $_6C^{14}$: two 'electronic' isomers

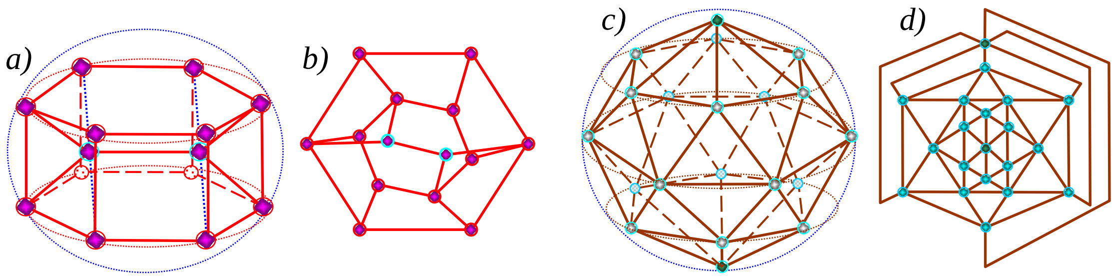

Fig. 7. Structure of carbon $_6C^{14}$: a) proton cell; b) graph of the proton cell; c) tertion net; d) graph of the tertion net

4. Fusion of lithium nuclei

Using arithmetic approach, one can write down three nuclear reactions:

$$^{6}Li + {}^{6}Li \rightarrow {}^{12}C, \quad {}^{6}Li + {}^{7}Li \rightarrow {}^{13}C, \quad {}^{7}Li + {}^{7}Li \rightarrow {}^{14}C,$$

which formally describe the formation of carbon isotopes. As discussed above, this approach has scholastic character and does not explain how the process is going on. For this reason the geometric approach will be used.

4.1. Joining two triangular prisms lying on one and the same plane. The first fusion reaction, ${}^{6}Li + {}^{6}Li \rightarrow {}^{12}C$, is illustrated in Figure 8. Here the both prisms are lithium 6, and one obtains carbon 12. If one of two prisms is lithium 7, the second reaction, ${}^{6}Li + {}^{7}Li \rightarrow {}^{13}C$, takes place, and one has carbon 13. If both prisms are lithium 7, there occurs the third reaction, ${}^{7}Li + {}^{7}Li \rightarrow {}^{14}C$, and one receives carbon 14. Therefore no new isotopes were obtained by comparison with the reactions of deuteron with boron nucleus.

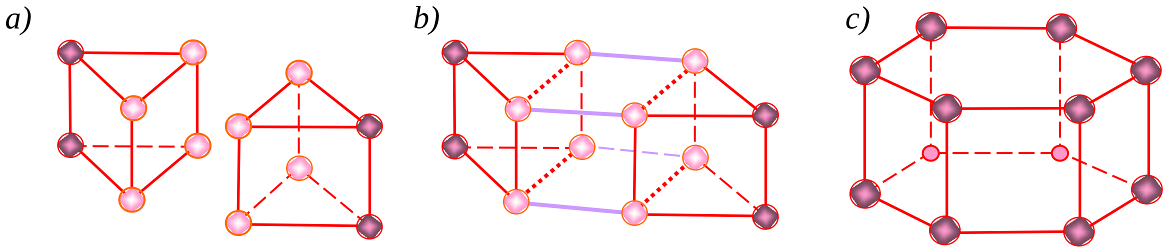

Fig. 8. Joining two parallel triangular prisms: (*a*) separated objects; (*b*) intermediate compound; (*c*) hexagonal prism. Pale pink and pink balls are reacting and neutral atoms, respectively; red lines are proton bonds; lilac lines are new proton bonds; dot red lines are old destroyed bonds

4.2. Joining two triangular prisms lying along one and the same axis. Consider at first more simple reaction ${}^{6}Li + {}^{6}Li \rightarrow {}^{12}C$. It is illustrated in Fig. 9. The obtained structure of carbon 12 resembles a triangular barrel; its graph has twelve vertices and eighteen edges. According to our assumption, six neutrons of carbon 12 decompose into six protons and eighteen tertions, each tertion being placed on a geodesic line connecting two nearest protons. These lines are approximated by the proton-proton bonds in Fig. 9c and by the graph edges in Fig. 9f. The number of the bonds and the edges is equal to 18. Therefore physics and geometry do not contradict each other.

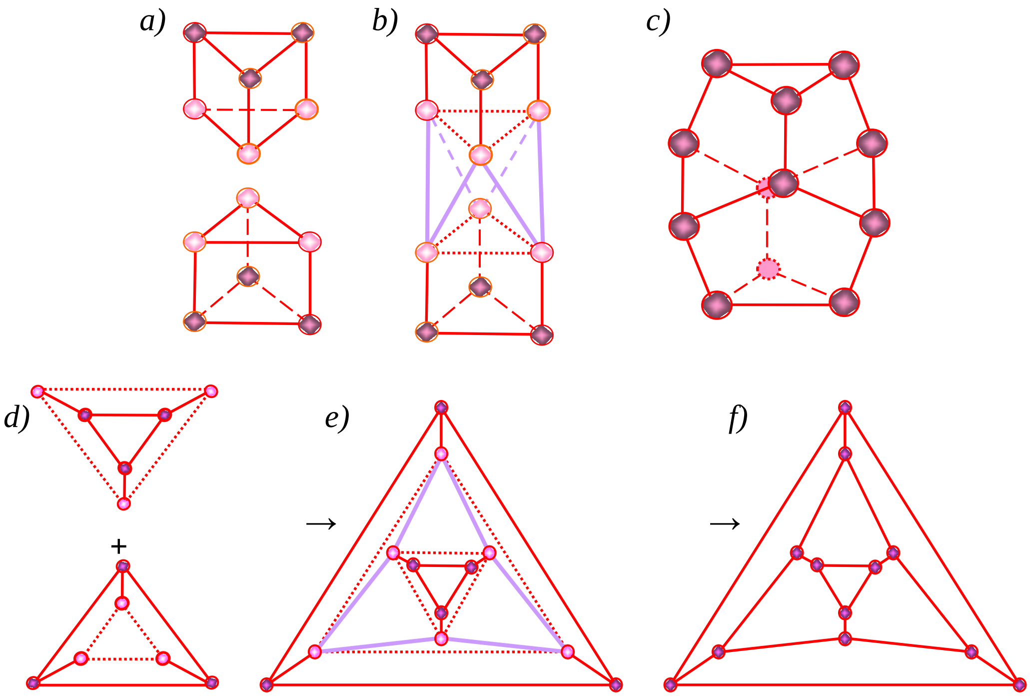

Fig. 9. Rotation-reflection-symmetry joining two triangular prisms (${}^{6}Li + {}^{6}Li$) into a triangular barrel (${}^{12}C$) above; graph representation of this fusion reaction below; *a, d*) separate prisms; *b, e*) intermediate compound; *c, f*) triangular barrel

To get a comprehensive idea of the fusion, one need to construct a tertion net and its graph. Since graph designing is simpler, begin with it. There is no need to construct the graph of the tertion net *ab ovo*. One can take as a basis the graph of the proton cell and put on its edges the tertions, and then to connect them (Fig. 10a). Removing the base, one receives the graph of the tertion net (Fig. 10b). Having this graph and the proton cell obtained before (Fig. 9c), designing the tertion net becomes easier (Fig. 10c).

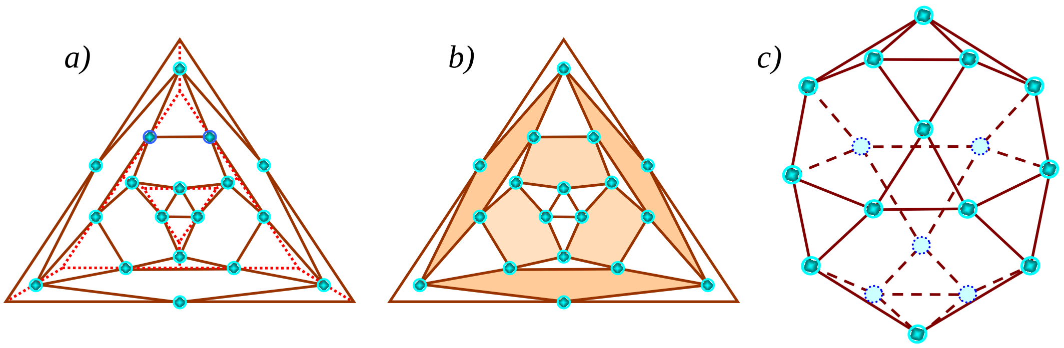

Fig. 10. Structure of carbon $_6C^{12}$: *a*) graph of tertion net being constructed on the basis of the proton-cell graph denoted by dot red lines; *b*) graph of tertion net; *c*) tertion net

Now consider reaction $^6Li + ^7Li \rightarrow ^{13}C$ shown in Figure 11. Compared to the previous case, here the change affect only a half the nucleus. This half becomes a body centered one (Fig. 11b). The main difference is connected with the tertion net, a half of it becoming denser. Let's transfer to reaction $^7Li + ^7Li \rightarrow ^{14}C$, which is illustrated in Fig. 12. The reaction leads to a homogeneous structure of both proton cell and tertion net.

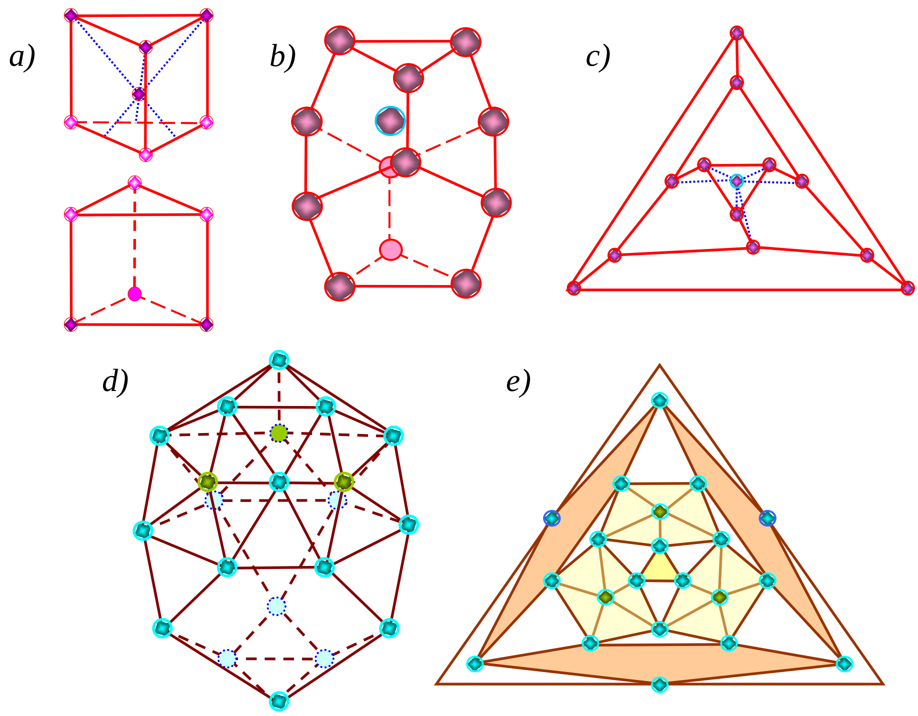

Fig. 11. Rotation-reflection-symmetry joining two triangular prisms ($^7Li + ^6Li$) into a triangular barrel (^{13}C) and graph representation of this fusion reaction: *a*) separate prisms; *b*) triangular barrel; *c*) graph of the proton cell: *d*) tertion net *e*) graph of the tertion net

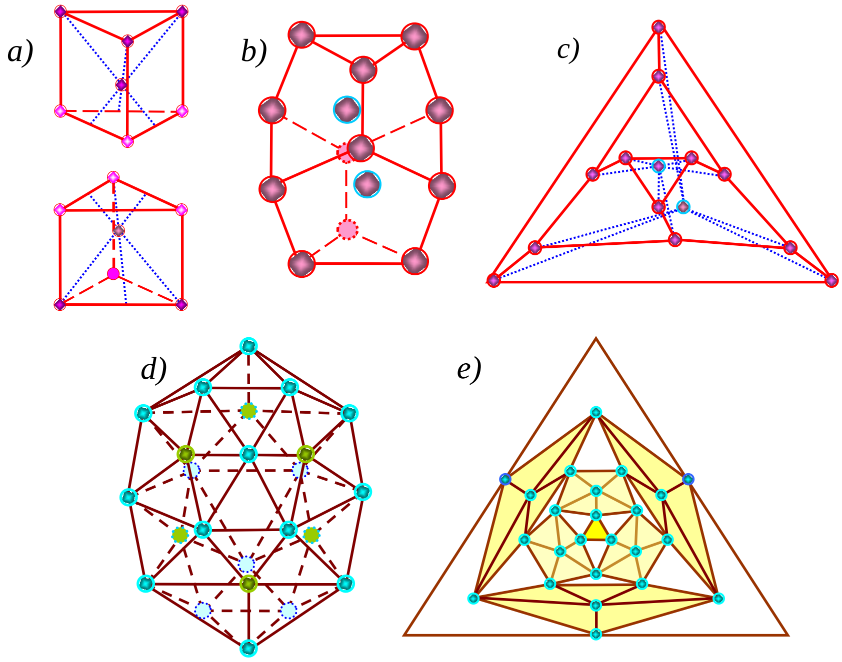

Fig. 12. Rotation-reflection-symmetry joining two triangular prisms ($^{7}Li + ^{7}Li$) into a triangular barrel (^{14}C) and graph representation of this fusion reaction: *a*) separate prisms; *b*) triangular barrel; *c*) graph of proton cell: *d*) tertion net *e*) graph of tertion net

4.3. Two crossed triangular prisms combined. There are two extremal paths of fusion, both being depended on the position of proton bonds conserved and destroyed. As a result, there appear two different configurations: a truncated tetrahedron and a tetra-penta octahedron.

4.3.1. Truncated tetrahedron. If the both prisms are lithium 6, (reaction $^{6}Li + ^{6}Li \rightarrow {}^{12}C$), one has an isomer of carbon 12. The reaction is shown in Figs. 13 and 14. The transfer to reaction $^{6}Li + ^{7}Li \rightarrow {}^{13}C$ is illustrated in Fig. 15. The main difference is connected with the tertion net, it becoming denser. There is no need to consider reaction $^{7}Li + ^{7}Li \rightarrow {}^{14}C$, because there is not enough room for two protons inside the truncated tetrahedron.

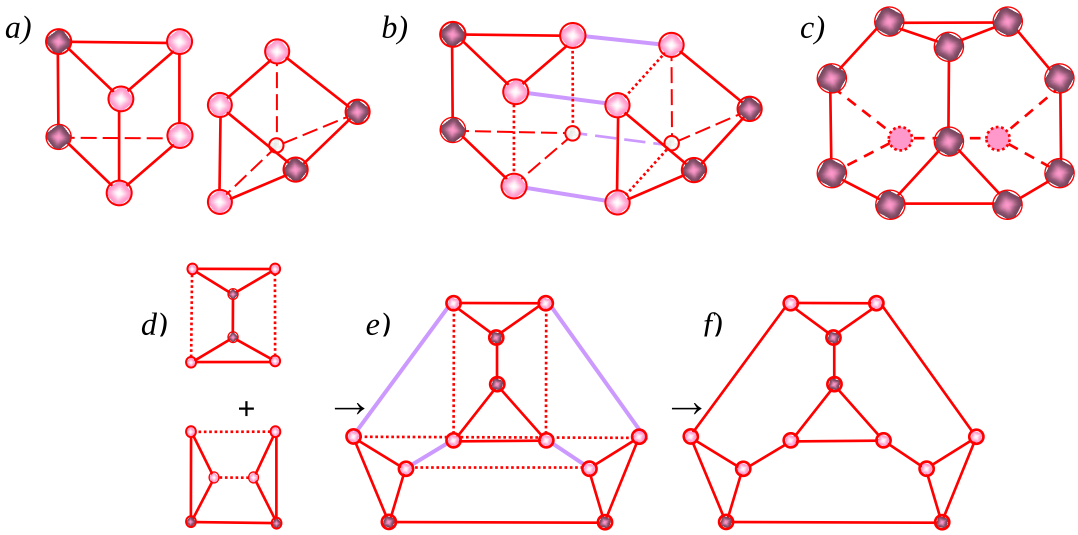

Fig. 13. Joining two crossed triangular prisms ($^{6}Li + ^{6}Li$) into a truncated tetrahedron (^{12}C) above, graph representation of this fusion reaction below;
a, *d*) separate prisms; *b*, *e*) intermediate compound; *c*, *f*) truncated tetrahedron

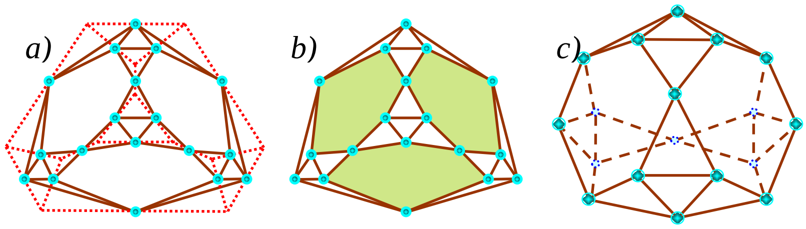

Fig. 14. Structure of carbon truncated tetrahedron $_6C^{12}$: *a*) graph of the tertion net being constructed on the basis of the proton-cell graph denoted by dot red lines; *b*) graph of the tertion net; *c*) tertion net

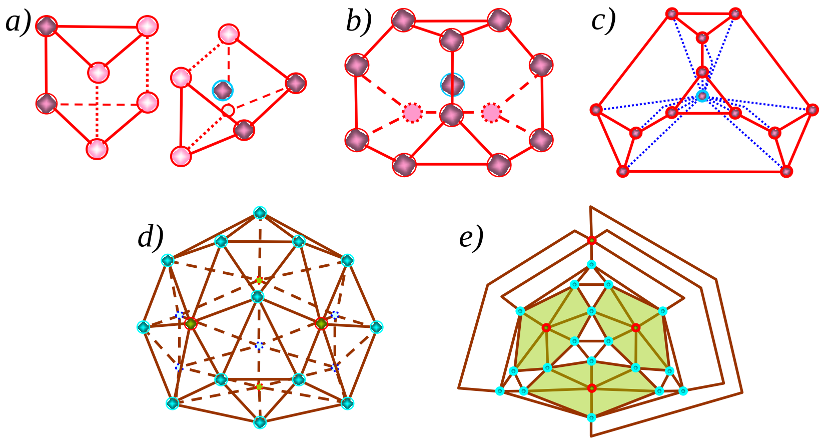

Fig. 15. Joining two crossed triangular prisms ($^6Li + ^7Li$) into a truncated tetrahedron (^{13}C) and graph representation of this fusion reaction: *a*) separate prisms; *b*) truncated tetrahedron; *c*) graph of the proton cell: *d*) tertion net *e*) graph of the tertion net

4.3.2. Tetra-penta octahedron. Similar to the previous case, if the both prisms are lithium 6, (reaction $^6Li + ^6Li \rightarrow ^{12}C$), one has another isomer of carbon 12, which is shown in Figs. 16 and 17. The transfer to reaction $^6Li + ^7Li \rightarrow ^{13}C$ is illustrated in Fig. 18. The main difference is connected with the tertion net, it becoming denser. As before the reaction $^7Li + ^7Li \rightarrow ^{14}C$ is not considered, because there is also not enough room for two protons inside the tetra-penta octahedron having tetrahedral symmetry.

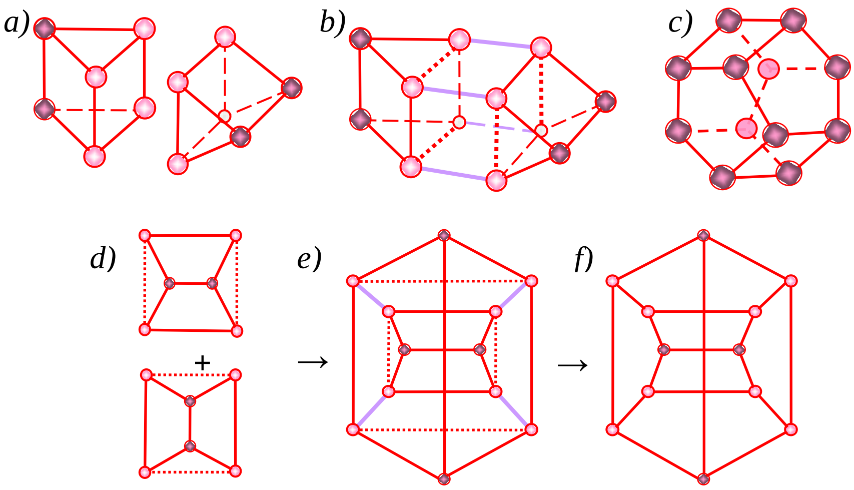

Fig. 16. Joining two crossed triangular prisms ($^6Li + ^6Li$) into a tetra-penta octahedron (^{12}C) above, graph representation of this fusion reaction below; *a*, *d*) separate prisms; *b*, *e*) intermediate compound; *c*, *f*) tetra-penta octahedron

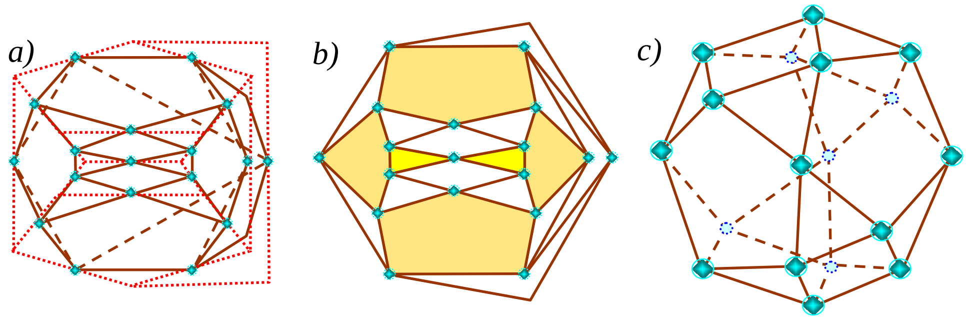

Fig. 17. Structure of carbon tetra-penta octahedron $_6C^{12}$: *a*) graph of the tertion net being constructed on the basis of the proton-cell graph denoted by dot red lines; *b*) graph of the tertion net; *c*) tertion net

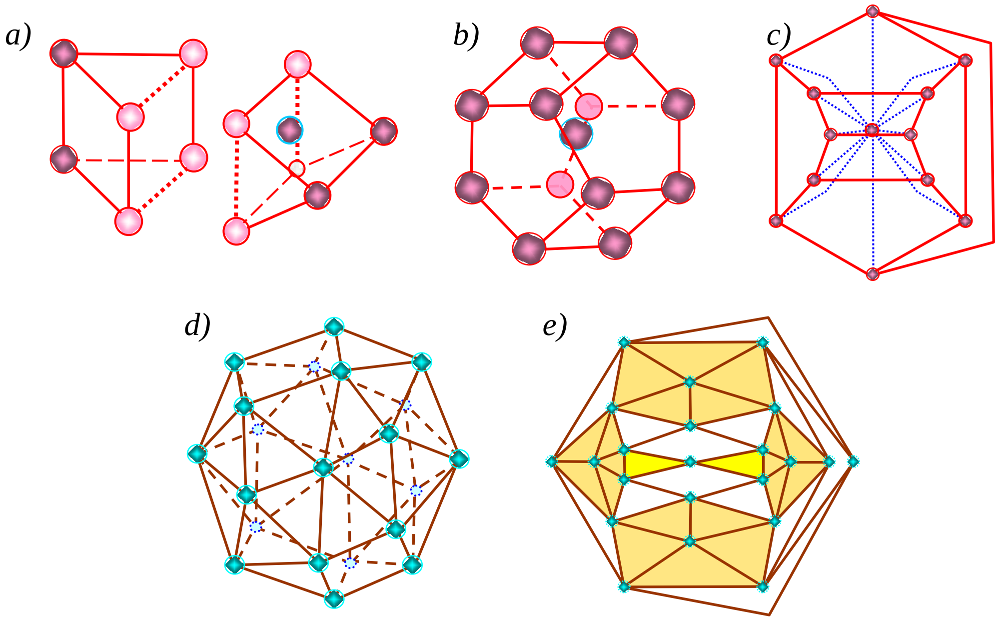

Fig. 18. Joining two crossed triangular prisms (^6Li + ^7Li) into a tetra-penta octahedron (^{13}C) and graph representation of this fusion reaction: *a*) separate prisms; *b*) tTetra-penta octahedron; *c*) graph of the proton cell: *d*) tertion net *e*) graph of the tertion net

5. Reaction Be^9 (α, n) C^{12}

Reactions (α, n) brought to the discovery of a neutron [9]. For the most part, the reactions are endothermic ones, i.e. heat-absorbing reactions. However, among the light nuclei there are such for which irradiation leads to exothermic reactions, i.e. to heat-producing processes. The most important is reaction Be^9 (α, n) C^{12}. The final nucleus C^{12} is stable. Moreover, it is suggested that it is one of the "fastest packed nuclei" [9]. However, what does it mean, nothing is said.

Let's try to use the geometric approach for clarifying this phenomenon. The structures of the reacting components were obtained in Ref. [2]. Let's consider them in greater detail adding intermediate components which are important for understanding the process. The structure of α-particle is presented in Fig. 19, the structure of beryllium 8 in Fig. 20, and the structure of beryllium 9 in Fig. 21.

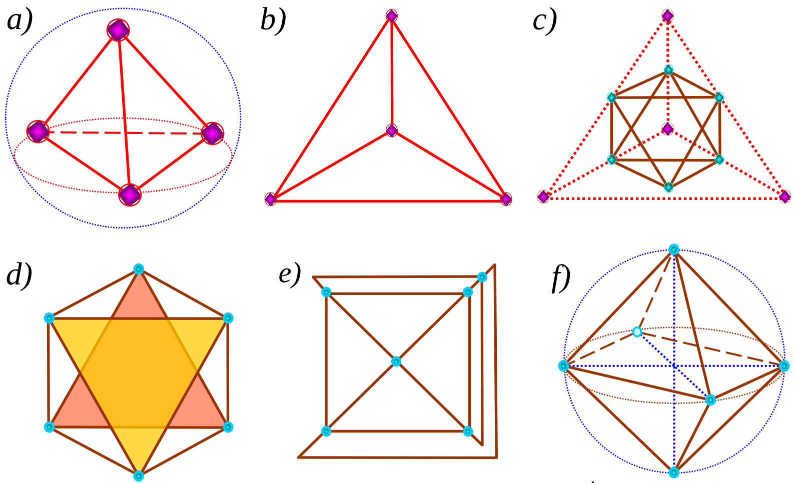

Fig. 19. Structure of α-particle: a) proton cell of helium $_2He^4$; b) its graph; c) graph of the proton cell in combination with a planar graph of the tertion net; d) planar graph of the tertion net; e) packing of the tertion-net planar graph (plane graph); f) spatial arrangement of tertions

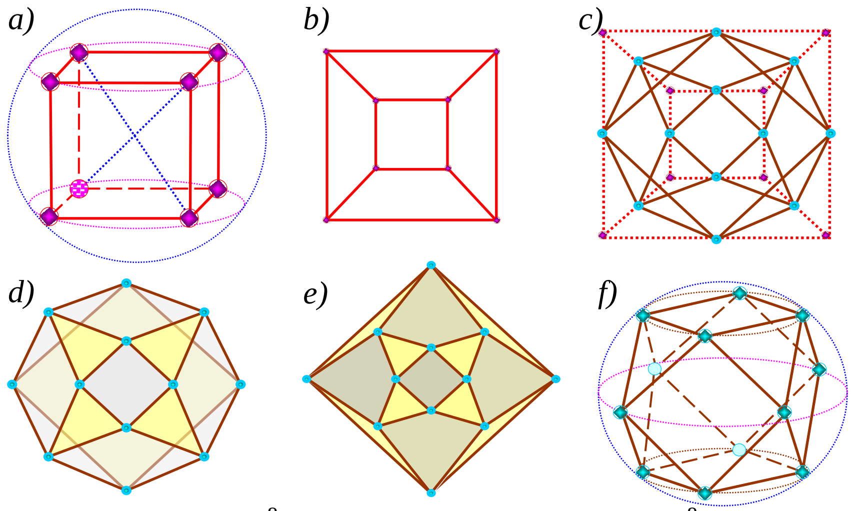

Fig. 20. Structure of beryllium $_4Be^8$: a) proton cell of beryllium $_4Be^8$; b) its graph; c) graph of the proton cell in combination with a planar graph of the tertion net; d) planar graph of the tertion net; e) plane graph; f) spatial arrangement of tertions

Now one has all the necessary input data. In what it follows, the analogy with radiation solid state physics will be used. According to it, during relaxation of a system of electrons and ions the following relation takes place [10, p. 223]

$$\tau_{ee} : \tau_{ii} : \tau_{ei} \sim 1 : \sqrt{M/m} : M/m \, .$$

Here m, M is the electron mass and the mass of an ion; $\tau_{ee}, \tau_{ii}, \tau_{ei}$ are the times of relaxation for setting electron-electron, ion-ion and electron-ion equilibrium, respectively. We assume that the analogous relation is valid for the system of tertions and protons. So thinking over a collision of alpha-particle with beryllium, one may take into consideration only protons.

The nuclear reaction may be thought of as shown in Fig. 22. The bombarding particle collides with the core proton and knocks out it from the proton cell (a). The process is going on so fast that other protons have no time to displace. If after the collision the alpha-particle remains in the cell center, there produces "so called" replacement (b) [10, p. 112]. The structure obtained is in a compressed unstable state, since there is no enough room for the incorporated particle. The system is compelled to relax. A possible mechanism of relaxation is presented below.

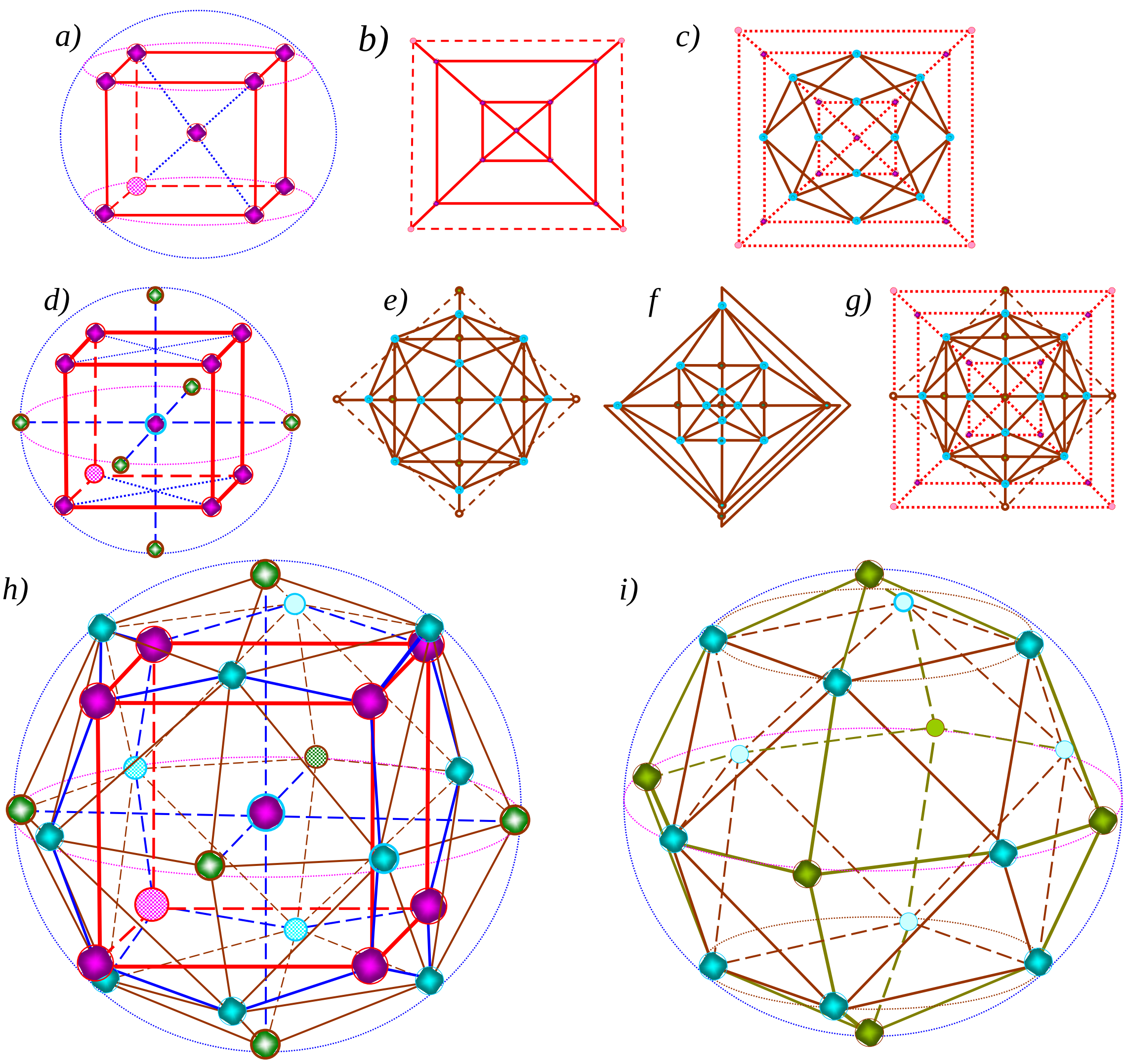

Fig. 21. Structure of beryllium $_4Be^9$: a) proton cell of beryllium $_4Be^9$; b) its plane graph; c) plane graph of $_4Be^9$ proton cell in combination with a planar graph of $_4Be^8$ tertion net; d) proton cell of beryllium $_4Be^9$ together with tertions of a core proton; e) planar graph of $_4Be^9$ tertion net; f) plane graph of $_4Be^9$ tertion net; g) plane graph of $_4Be^9$ proton cell combined with a planar graph of its tertion net; h) space structure of beryllium 9; f) spatial arrangement of tertions of $_4Be^9$

From the standpoint of mechanics [11], one has structural instability in the form of folding catastrophe (Fig. 22c). For relaxation it is necessary to remove the catastrophe. It can be done by breaking and stretching the bonds shown by dot lines (4 bonds from 6 of alpha-particle and 4 bonds from 12 of beryllium). During this process four square beryllium planes parallel to the linear momentum of the alpha-particle transform into pentagon planes (d), and two square planes, normal to the linear momentum, conserve their shape, but change the location (e). As for the alpha-particle, it is completely dissolved in a new structure (f). As a result, we have the compact shape of carbon (g), which is identical to obtained earlier (Fig. 16 c).

It should be mentioned that the knock-out core proton is tightly connected with its tertions as shown in Fig. 21d. It is believed that, leaving the nucleus, the proton takes them away. Out of the nucleus, they transform at first into an electron and then it collapses transforming the proton into a neutron.

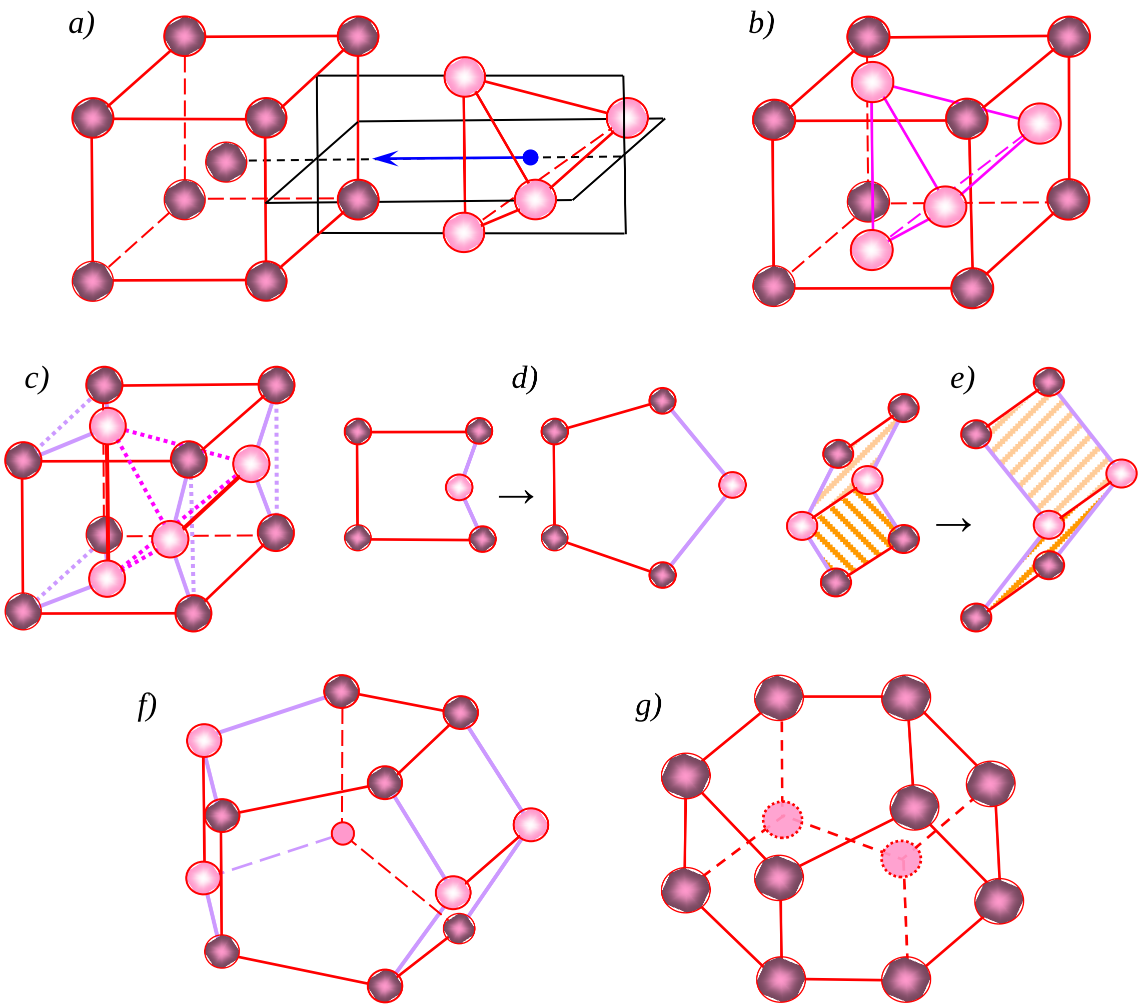

Fig. 22. Generation of $_6C^{12}$: a) collision of α-particle with $_4Be^9$: b) intermediate compound; c) bond making and breaking; d) and e) decompression jump; f) and g) new and old structure

6. Reaction $3He^4 \rightarrow C^{12}$

The reaction is considered to be the main reaction of the helium cycle of nucleosynthesis [1]. It is assumed that the process is two-stage one going through an intermediate nucleus beryllium 8. However, to write a "chemical" symbol, it doesn't mean to show the mechanism. Besides, the reaction $Be^8 + He^4 \rightarrow C^{12}$ is incompatible from the geometric standpoint [2]. Really, the nucleus of beryllium 8 is a cube, whereas the nucleus of helium 4 is a tetrahedron. How to combine the reacting faces, a square and a triangle, nobody knows.

Instead of the above mentioned rather artificial interpretation, here the geometric scheme of the process is proposed, according to which three helium nuclei may make up one carbon nucleus without any moderator. The model is developed by analogy with protein biosynthesis [12]. The structure of α-particle is presented in Fig. 19. The nuclear reaction may be thought of as shown in Fig. 23. Similar to the previous reaction, we take into consideration only protons. The reacting particles are specially marked in the figure; the protons are light pink balls, the new proton-proton bonds are lilac, the old bonds, which have to be destroyed, are shown using red dot lines.

At first, two alpha-particles combine forming a dimer (a). Then the dimer combines with another alpha-particle forming a linear trimer with one proton which is slightly connected with the trimer through the use of only one bond (b). This structure can fold up in three dimensions (c). During the process some inter-proton bonds are destroyed and there appear two additional protons slightly connected with the structure formed (d). Similar to the interactions of electronic and atomic degrees of freedom [13,14], the interaction of tertions (they are not shown in the figure) and protons leads to internal rotation [15] of the slightly connected protons, which stabilize the chain folding occurred (e). Relaxation of the structure obtained creates the carbon nucleus having the symmetry of a truncated tetrahedron (f), which is identical to obtained earlier (Fig. 15b).

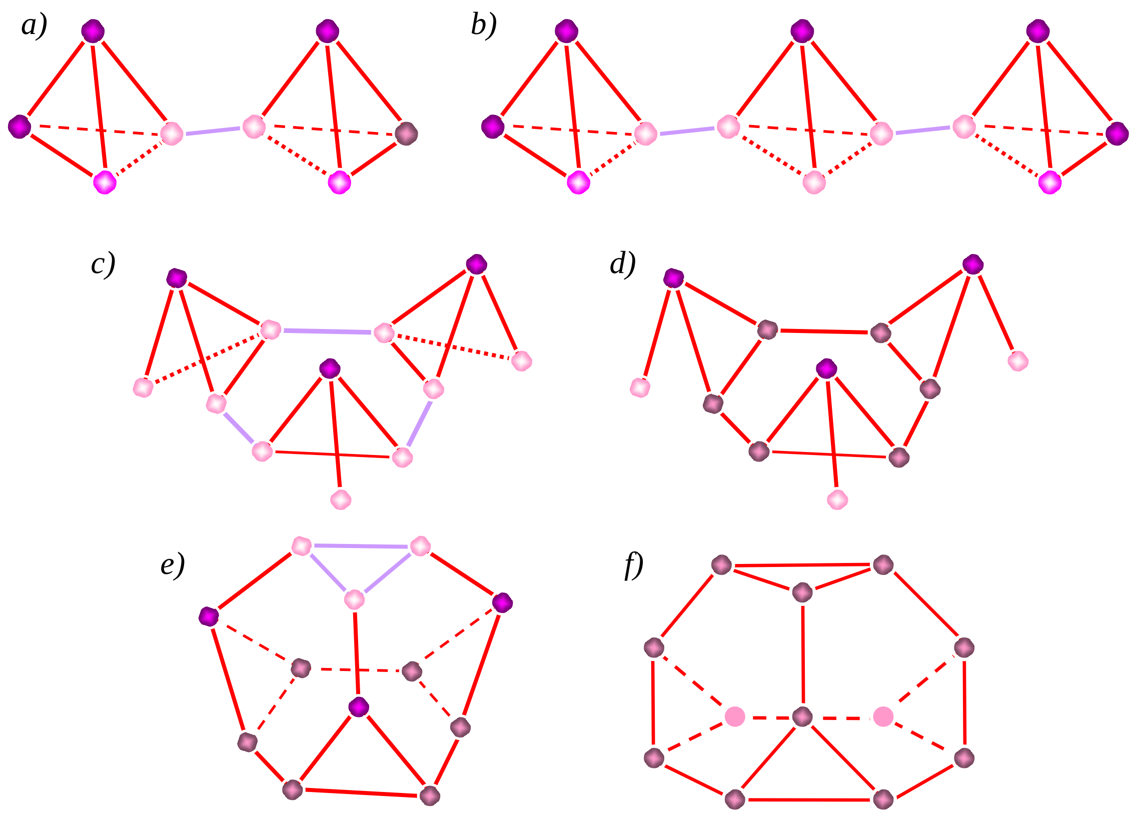

Fig. 23. Generation of $_6C^{12}$: a) dimer formation, b) trimer formation with one slightly connected proton, c) folding, d) appearance of two additional slightly connected protons, e) internal rotation of three protons and their combination, f) structure obtained after relaxation

7. Discussion

Carbon is a remarkable element showing a variety of stable forms ranging from 3D semi-conducting diamond to 2D semi-metallic graphite to 1D conducting and semi-conducting carbon nanotubes to 0D fullerenes [16]. Carbon is the sixth element of the periodic table and has the lowest atomic number of any element in column IV of the table. Each carbon atom has six electrons which occupy $1s^2$, $2s^2$, and $2p^2$ atomic orbitals. The $1s^2$ orbital contains two strongly bound core electrons. Four more weakly bound electrons occupy $2s^2 2p^6$ valence orbitals. In the crystalline phase, the valence electrons give rise to 2s, $2p_x$, $2p_y$, and $2p_z$ orbitals which form covalent bonds in carbon compounds. The energy difference between the upper 2p energy levels and the lower 2s level is small compared with the binding energy of the chemical bonds. So the electronic wave functions of these four electrons can mix with each other giving rise to hybridization [17-19]. The various bonding states are connected with certain structural arrangements. The mixing of a single 2s electron with one, two, or three 2p electrons creates sp, sp^2, and sp^3 hybridizations, which in their turn produce chain, planar and tetrahedral structures.

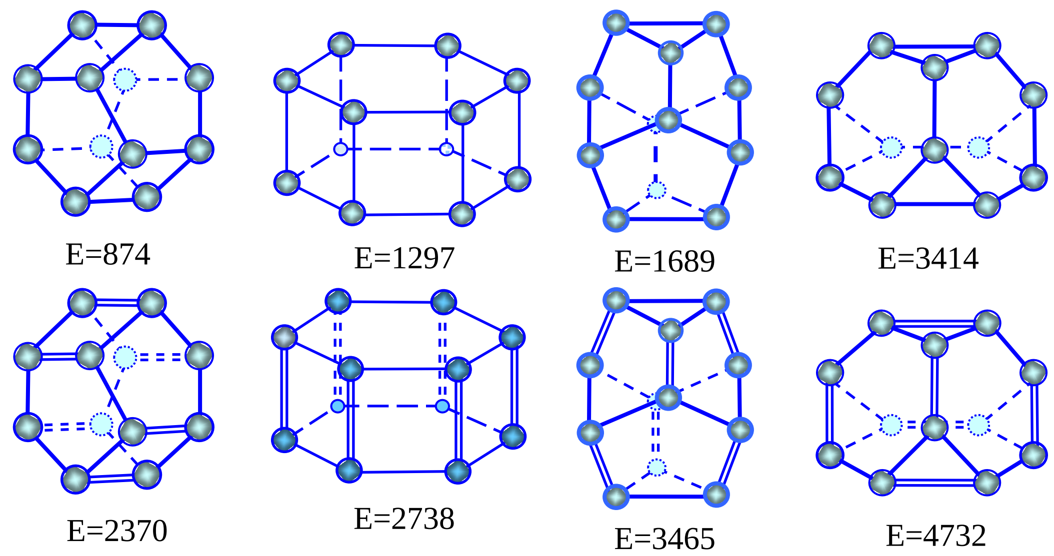

Fig. 24. Shape and energy of isomers of fullerene C_{12}: sp^2 hybridized atoms above and sp^3 hybridized atoms below

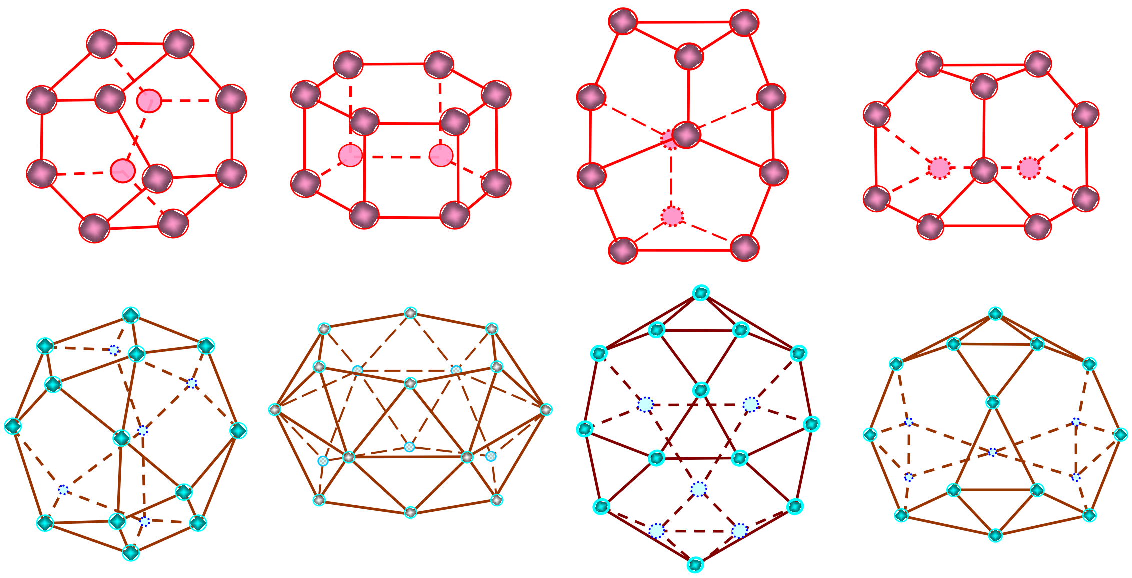

Fig. 25. Shape of isomers of nucleus ${}_6C^{12}$: proton cell above and tertion net below

For fullerenes, opinions vary and the evidence is not clear. It is widely believed that "classical fullerenes are cage-like, hollow molecules of pseudospherical symmetry consisting of pentagons and hexagons only, resulting in a trivalent (and in the most ideal case) convex polyhedron with exactly three edges (bonds) joining every vertex occupied by carbon, idealized as sp^2 hybridized atoms" [20]. Earlier the term "fullerene" was used in a broad sense as any convex shape inscribed into a spherical surface which can be composed of atoms, each atom having three nearest neighbors, as in classical fullerenes, whenever discussing hollow carbon clusters [5]. Such geometrical approach allowed obtaining possible forms of mini-fullerenes from C_4 and C_{20}. For the isomers of fullerene C_{12} the following energy series is obtained (Fig. 24). By analogy with fullerenes, the nuclear geometry was designed. On the basis of the similarity and resemblance of shapes, it is believed that an analogous series is valid for the isomers of nucleus $_6C^{12}$ (Fig. 25) as well as for the isomers of its isotopes.

Some other detail should be mentioned. In the previous study no distinction is done between the electrons forming a tertion coat of mail and the electrons of core neutrons. Now it is necessary to discriminate between them. In the first case the electrons disintegrate into tertions, each tertion having the charge equal to ⅓ electron charge. In the second case, the electrons of core neutrons disintegrate into particles which charge depends on the symmetry of a nucleus. By analogy with the valence theory [21], it is valid to say that formally each tertion gives rise to σ bonding between two protons of the proton cell of a nucleus, similar to an electron connecting two proton in a molecular ion of hydrogen H_2^+. Carbon atom has four valent electrons for occupying the many possible configurations of the electronic states induced by hybridization. Similar electronic states are created by the external proton cells for the core electrons of nuclear isotopes. However, the nuclei of the carbon isotopes have one or two core electrons produced by core neutrons. By virtue of symmetry the core electrons must occupy all the space equivalent hybridized states simultaneously. For this reason the effective charge of a core electron is fractional one, when it is integrated into a tertion net.

The first two isotopes shown in Fig. 25 are stable, the natural occurrence being 98.9 and 1.1%, respectively; the third is a relatively stable isotope, which has a rather large half-decay period being equal to 5730 years [22]. One excludes from consideration the fourth isotope supposing that its generation is highly unlikely (by analogy with fullerenes it can have a very high energy of formation). However the question of rather low stability of $_6C^{14}$ in comparison with that of $_4Be^{10}$ is still an open question (half-life period is 5730 and 1.6 10^{6} years respectively).

Assume that the reason is connected with the nucleus structure of both isotopes. In the case of beryllium 10, two core protons are tightly connected with the beryllium-8-proton cell [2, Fig. 19]. Just the similar proton configuration has hexagonal-prism carbon $_6C^{14}$, so we are compel to exclude the latter from further consideration. The only left isotope $_6C^{14}$ has the shape of a triangular barrel. From Fig. 12 it follows that both core protons, after delegating their electrons to the tertion net, have no electrons at all for creating a direct bond. However, as was mentioned before, the core protons are tightly connected with their own tertions.

It is felt that these charges as dynamic variables to some extent independent of its protons. It means that the vibration frequency of tertions is far beyond that of protons. In this case each group of tertions belonging to one proton plays the role of an external field with respect to another group, both groups polarizing each other. Such setting up of the problem is identical to developed early by us for solving the problem of molecule vibrations with regard to electronic degrees of freedom [13]. It was shown that covalent-bond charges can be treated as dynamic oscillators. What's more, there appears intra-molecular van der Waals attraction. From the mathematical point of view the both problems are identical. So we can set down that in the case of isotope $_6C^{14}$ there appears intra-nuclear van der Waals attraction of core protons. Van der Waals attraction in molecules creates a weak chemical bond [21]. Usually it is two orders of magnitude less than that of a valence bond [13,21]. It is interesting to note that the similar relation is valid between the life-time periods of $_6C^{14}$ and $_4Be^{10}$.

7. Summary

By analogy with fullerenes, the nuclear geometry has been designed. For hydrogen, deuterium, tritium and helium 3, earlier different structures were obtained; namely a point, a linear and a plane one respectively. Helium 4 has a tetrahedral symmetry. Three-fold symmetry prisms refer to lithium 6 and 7; four-fold ones correspond with beryllium 8, 9, and 10; and five-fold symmetry prisms with boron 10 and 11. Carbon is an unusual element. It has four isomers of different symmetry: three-fold, six-fold and tetrahedral ones. The two stable and one half-stable isotopes of carbon inherit the structure of these isomers.

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