Title: NANOTECHNOLOGY: Making a Fullerene Model

Topics: NANOTECHNOLOGY: Making a Fullerene Model	**Time**: 90 minutes (2 lessons)	**Age**: 10 class 15 – 16 years old pupils

Differentiation:

- Students that are more able are asked to calculate the necessary parameters.
- With the more able students, fullerene molecule's geometrical structure parameters are discussed.
- Students who complete the work quickly are asked to work on the extension tasks provided.

Guidelines, ICT support etc.:

- Students are presented with a consistent workflow. An explanation of how to make a fullerene model is given.
- Students are asked to complete the activity work sheets individually or in groups of 2-3 students.
- Every group is asked to find and to organize the information about fullerenes in a certain aspect and to present the collected information.

Equipment needed for this activity:

- Two printed copies of appendix 1
- One printed copy of appendix 2.
- Scissors for cutting paper.
- Sticky tape (better transparent)
- Activity sheet.

Required knowledge:

- Concepts of atom, Carbon atom.
- Types of polygon; polygon angle sum

Health and Safety:

Safe handling of scissors.

Learning outcomes for this activity:

<u>All</u>

- Will know the newest technology examples around us.
- Will be acquainted with the beginning of nanotechnologies – fullerenes.
- Will be able to make fullerene molecule's model.
- Will be able to recognise fullerene's geometrical structure.

<u>Most</u>

- Will be able to find, systemize and present information about fullerenes.
- Will be able to describe fullerene's geometrical structure.

<u>Some</u>

- Will be able to calculate fullerene molecule's geometrical parametres.
- Will know and will be able to describe the application of fullerenes now and in future.

Main Activity

Pupils begin work on **NANOTECHNOLOGY: MAKING A FULLERENE MODEL** worksheet.

Fullerene – a molecule, consisting entirely from carbon atoms, able to be of a form of a hollow ball, ellipsoid or a tube (nanotube). By its structure it is similar to graphite, but it can also have pentagonal or octagonal eyes. The name is derived from the name of an engineer *Buckminster Fuller*, who designed similarly looking geodesic constructions.

Fullerenes are the third carbon modification found after graphite and diamond. These are molecules, formed entirely from carbon (the number of atoms has to be not smaller than twenty and by all means even, having the hollow sphere, of an ellipsoid or a tube form, or flat. Spherical fullerenes are also referred to as „buckyballs“, and of a cylinder form are referred to as carbon nanotubes or „buckytubes“. - See more at: http://fulerenai.tikra.info/teorija/kas-yra-fulerenai/#sthash.d0gd7pp4.dpuf

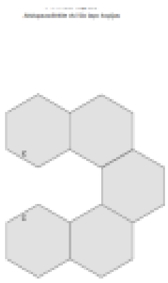
An explanation of practical is given. **How to make a fullerene model**

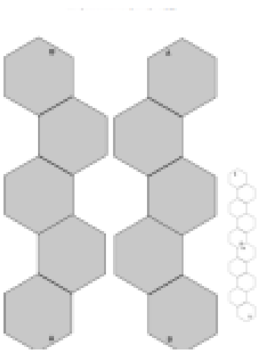

Fullerene C_{60} molecule is distributed in the same form as it is a soccer ball.

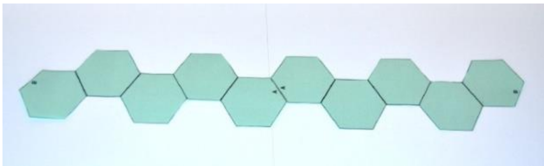
It has 32 surfaces, from which 20 are simple hexagons and 12 pentagons. These surfaces are linked in between by 60 points (peaks). In fullerenes, on each of these peaks, there is a carbon atom.

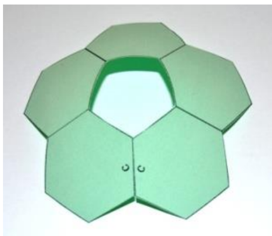
C_{60} fullerene paper model one can easily make in a classroom or at home. It will consist of 20 hexagons linked so, that 12 pentagonal form gaps are left.

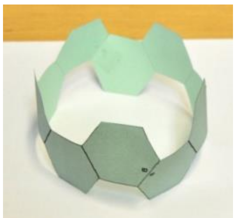
Work procedure











1. Make the copies of pages (two copies of the Appendix 1, one of the Appendix 2).
2. Cut one form from the first page.
3. Using a sticky tape, join together the edges marked by the letter “C”.
4. Pay attention, that you get five hexagons surrounding pentagon form space.
5. Repeat the same action with the second copy of the page.
6. Cut the form from the second page. You should get two homogenous strips (each of them is made of five hexagons).
7. Using sticky tape, join the edge of one strip marked by the letter “A”

with the same edge of another strip.

8. Stick the edge, marked by the letter “B” with the other edge, marked by the same letter.
9. Join the parts from the first page to the part which has just been made. Stick the free hexagon edges by sticky tape as it is shown.
10. Overturn the constructed figure and stick another part from the first page in the same way.
11. That is all. C60 model is in your hands.

<u>Work sheet activity</u>

Pupils are asked to complete the activity work sheets individually, pupils are asked to answer the questions.

More able pupils may be asked to calculate the necessary parameters.

<u>Extension activity</u>

Pupils who complete the work quickly are asked to work on the extension tasks provided (**NANOTECHNOLOGY: Making a Fullerene Model**).

<u>Plenary</u>

Pupils are asked about the procedure carried out; they are asked to discuss the answers to presented questions.

With the more gifted pupils, fullerene molecule’s geometrical structure parameters are discussed.

NANOTECHNOLOGY: FULLERENES

The aim of the lesson. To get acquainted with the beginning of nanotechnologies - fullerenes. To get acquainted with fullerene C60 structure, producing fullerene molecule's model.

Nanotechnology is an interdisciplinary and one of the fastest growing fields of science. This science and advancing technology opens up new possibilities for developing new materials and devices; no one of which previously could not even be imagined. Unfortunately, very few people know that the discovery of fullerenes in 1985 gave rise to nanotechnology, not only opened up this new field of science, but also strongly affected the physics, chemistry and many other scientific fields (ACS to Honor Discovery of Fullerenes. Azo Nanotechnology, http://www.azonano.com/news.asp?newsID=19,861).

Fullerenes discovery was so important that in 1996 was awarded the Nobel Prize.

This discovery had a very great importance in physics, chemistry, computer science and other fields of science.

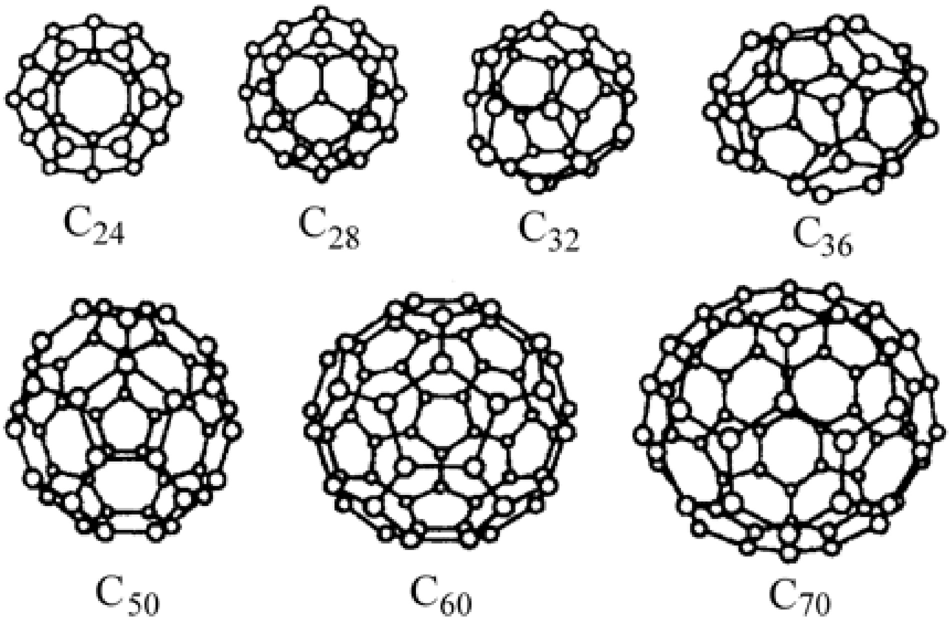
Fullerenes is the third found carbon allotropic modification after graphite and diamond. These are molecules, composed entirely of carbon (the number of atoms has to be not smaller than twenty and necessarily even), having a hollow sphere, ellipsoid of a tube form, or flat. Spherical fullerenes are also called „buckyballs“, and having a form of a cylinder are referred to as carbon nanotubes or „buckytubes“.

Fullerenes resemble to a graphite by their structure, another allotropic carbon modification, which is formed of a pile of sheet, in which hexagonal rings are joined, but also inside should have pentagonal (sometimes heptagonal) rings, that prevent the sheet from being planar. Hydrogen and iron atoms can join the fullerenes, forming big, complicated molecules.

Fullerenes are one of the main nanomaterial spheres together with nanocomposites, nanoparticles, ceramics, carbon nanotubes and thin layers.

Fullerene molecule‘s structure is interesting, that inside every carbon „ball“ a hollow sphere forms, into which, owing to capillary properties, one can insert atoms and molecules of the other substances. There are synthesized and researched fullerene molecules, consisting of various amounts of carbon atoms – from 36 to 540.

- See more at: http://fulerenai.tikra.info/teorija/kas-yra-fulerenai/#sthash.d0gd7pp4.dpuf



C60

The first found, mostly known and mostly researched fullerene. This is the most rounded and the most symmetrical molecule, found up to now. It consists of 60 carbon atoms, each of them are arranged in the molecule in the joining peaks of two hexagons and one pentagon.

In C60 molecule the number of hexagons is 20, and pentagons – 12. Each pentagon is adjacent only to hexagons, and each hexagon has three common walls with hexagons and three – with pentagons. The same structure has a European soccer ball.

- This molecule is approximately 7-15 Å diameter and one carbon atom thick.
- It is very stable from chemical and physical point of view (does not start to dissociate up to 1000 °C).
- Has a bigger stretching power limit, than any known two-dimensional structure or element.
- The biggest packing density of all known structures.
- Under normal conditions it is not passable for all elements. Even for helium atom with 5eV energy.
- Hydrogen and iron atoms can join it, forming big complicated molecules.
- Comparatively small critical temperature (33 K), therefore it has superconductors' properties.
- C60 forms yellow crystals, but when dissolved changes colour to violet.

- See more at: http://fulerenai.tikra.info/teorija/fulerenu-rusys/c60/#sthash.dPRalqVm.dpuf

Task for the next lesson

Find and systemize the information from the internet about fullerenes according to these aspects:

- ***How Fullerenes were discovered*** – the history of the discovery of fullerenes;
- ***Discoverers*** – scientists who discovered fullerenes (Harold W. Kroto, Robert F. Curl, Richard E. Smalley);
- ***Nobel Prize*** – when, who and for what received the award;
- ***Second Nobel Prize*** - another major award, which is associated with Fullerenes - the graphene, its discovery and the possibility of its use;
- ***Significance of the Discovery*** – what are the benefits of the discovery of fullerenes to science and humanity, what new possibilities it opened up;
- ***What are the Fullerenes*** – theory, definition, examples and illustrations;
- ***The Origin of the Term*** – where and why came such a name of newly discovered substance;
- ***Applications*** – what are the applications of fullerenes now and what are the possibilities of application in the future;
- ***Types of Fullerenes*** – a description of the existing types of fullerenes.

NANOTECHNOLOGY: Making a Fullerene Model

Answer sheet

- From what atoms is Fullerene composed? From carbon (C)

………

- How many atoms comprise Fullerene C60 molecule? 60 carbon atoms

………

- What other substances do you know composed from carbon atoms? Graphite, diamond, graphene.

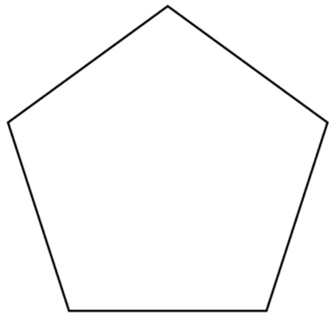
………

- How many and what geometrical figures form Fullerene C60? 20 – Hexagons and 12 pentagons.

………

Polygon angle sum

s = (n - 2) · 180, n – number of sides or angles.



- Using polygon angle sum formula, calculate sum of interior angles of a pentagon.

    ……………………………………………………………………………………………

- What is the measure of one interior angle of a pentagon?

    ……………………………………………………………………………………………

- Using polygon angle sum formula, calculate sum of interior angles of a hexagon.

    ……………………………………………………………………………………………

- What is the measure of one interior angle of a hexagon?

    ……………………………………………………………………………………………

- **In the pictures are presented the examples of regular pentagons, found in nature. Give more examples of regular pentagons, found in nature.**

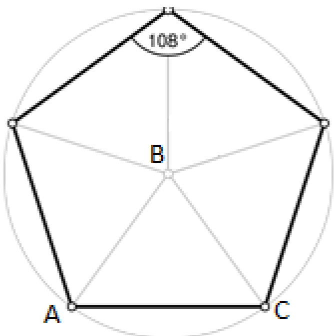
Morning Glory flower

Okra sliced

Sea star or Starfish

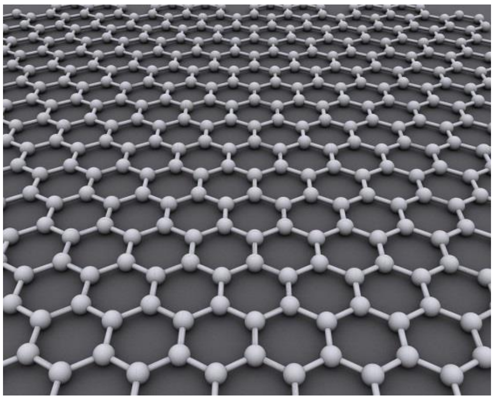
Pentagon – USA defence department

- Knowing the value of one interior angle of a pentagon, calculate the interior angle values of a triangle.



- **In the pictures are presented the examples of regular hexagons, found in nature. Give more examples of regular hexagons, found in nature.**

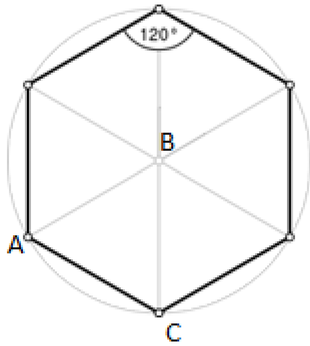

Korys (Honeycomb)



The ideal chrystaline structure of graphene (carbon atoms)

Chinese pavilion

- Knowing the value of one interior angle of a hexagon, calculate interior angle values of a triangle ABC.



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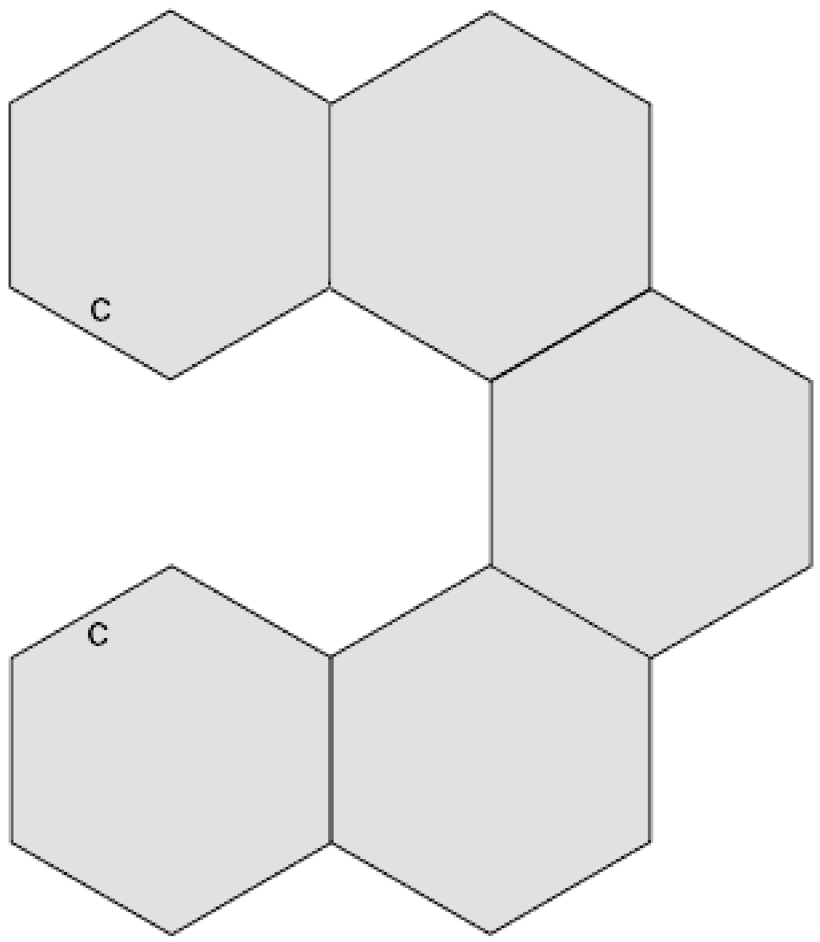

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