Glasnik hemičara i tehnologa Bosne i Hercegovine

*Bulletin of the Chemists and Technologists of Bosnia and Herzegovina*

2017

*49*

49-52

Print ISSN: 0367-4444
Online ISSN: 2232-7266

UDC: _____

*Technical Paper*

# Incorporation of astronomy topics in the chemistry curriculum at Gymnasiums in Canton Sarajevo

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**Article info**
Received: 14/10/2017
Accepted: 12/12/2017

**Keywords:**
Gymnasium
Astronomy topics
Education in chemistry
Curriculum of chemistry
Astrochemistry

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**Abstract:** Astronomy, like no other scientific discipline, combines elements from almost the whole spectrum of research, from high energy physics to philosophy and psychology. It is expected that chemistry, as one of the fundamental sciences, finds significant place in this ever increasing field of frontier research. Astronomy topics in gymnasiums in Canton Sarajevo are, at present time, part of physics and geography programs. This paper explains how study of astronomy can be progressed by its incorporation in gymnasium subject such as chemistry. Topics can be chemical composition of celestial bodies, organic molecules present in gas clouds and exotic types of matter not found on Earth. The benefit of this incorporation does not hold only at purely educational level but expands on the goal of bringing somewhat abstract and fascinating ideas of reality beyond the tangible borders of Earth with the aim of increasing the interest of students in the subject of chemistry.

## INTRODUCTION

Probably one of the earliest memories of any individual are those of the landscapes and night sky. The celestial phenomena have fascinated humanity from the inception of human civilization, regardless of age. Indeed, the prospects of great beyond had marked our lives in ways we can hardly quantify. It was in no small part to these that science and civilization have progressed side by side to reach the heights of today.

Research in astronomy is conducted observation and experimentation as is the case with all natural sciences. The observation comes from studying light sources and their interaction with outer spare materials and objects and experimentation by analyzing samples obtained by the manned mission and robotic probes. This has lead to vast application of chemistry principles and methods, such as the analysis of emission and absorption spectra of light originating from objects in space (Sun, other stars, nebulae…), content determination of samples of soil from Mars, asteroids and comets by robotic laboratories located on unmanned probes and so forth. This has also lead to the rise of the field of astrochemistry and cosmochemistry. (Muminovic, 2014)

In educational systems of Bosnia and Herzegovina gymnasiums represent the continuation of general education after elementary schools without clear vocational direction, with the exception of a mild increase in certain groups of subjects in higher years depending on students choice. As astronomy is in general one of the most fascinating subjects for students in general, this study aims to explain ways how it can be incorporated in chemistry curriculum with the aim

of increasing the student interest in chemistry as well as natural sciences in general.
The current chemistry curriculum for gymnasiums contains a wide range of topics with the aim of familiarising students with basic facts from all areas of chemistry. As chemistry is significantly interconnected with other natural sciences it is possible to make connections with them in certain lessons and same goes for other natural sciences. This movement has gained ground in recent years and is now commonly referred to as STEM (science, technology, engineering and mathematics). This paper aims to show how that integration can be achieved in case of chemistry and astronomy on level of gymnasiums.

## INCORPORATION SEGMENTS

This part aims to elaborate on the specific astronomy themes that can be incorporated at different class years in accordance with present curriculum:

First year

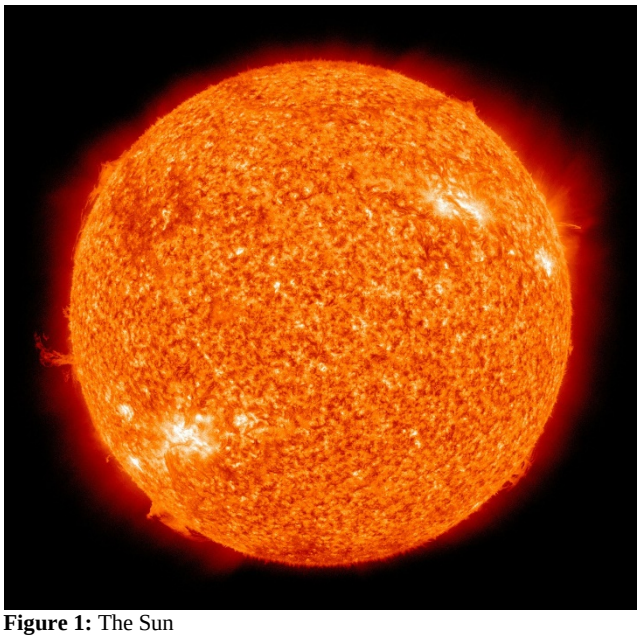

**Figure 1:** The Sun

The first year chemistry gives the main emphasis on the basic chemistry laws and principles and gives an introduction to chemical elements and their basic properties.While discussing gases and their characteristics added segments would be the composition of atmospheres on different planets and interplanetary bodies as opposed to Earth and gas cloud called nebulae. In addition to basic properties and aggregate states, this paper suggests incorporation of exotic state of hydrogen called “metallic hydrogen” that exists in systems of high pressure where hydrogen is compressed enough to become a solid electrical conductor.

With the discussion of quantum physics and work of Max Planck, the example of black body radiation can be based on the spectrum of Sun and how that has allowed astronomers to determine its composition and temperature. It would also include the nucleosynthesis of elements in the Big Bang explosion and in subsequent synthesis during bombardments of atoms with cosmic rays, fusion in stars and supernova explosions as part of studying the periodic table of elements. This also enables establishing astrochemistry and cosmochemistry distinct disciplines that bridge chemistry and astronomy and cosmology respectively (Muminovic, 2014).

Second year

The second year chemistry deals with organic and biochemistry topics. Here it is suggested that topics would include the presence of basic organic molecules in atmospheres of different objects and gas clouds with a comparison between different compositions, as well as examples of biomolecules such as amino acids. As many astronomical photographs are made in IR spectra this could be correlated with the tendency of organic molecules to be excitable while subjected to IR light.
(Muminovic, 2014; Cameron, P.J. (1968)

**Figure 2:** Orion nebula imaged in IR spectrum; credit: ESO/H. Drass et al.

Third year

The third-year curriculum includes discussion of inorganic chemistry that would be an opportunity to include information about diversification of elements in Earth's crust in comparison to other objects in space, as well as universe in general, with the emphasis on rare elements on Earth that are abundant in space with example of these being presence of hydrogen and helium u Earth’s atmosphere in comparison to the Sun. Space probes can be discussed in the topics of analytical chemistry as small robotic laboratories applying instrumental analytical methods. (Muminovic, 2014; Richter, N.B., 1963; Bizony, P. 1998)

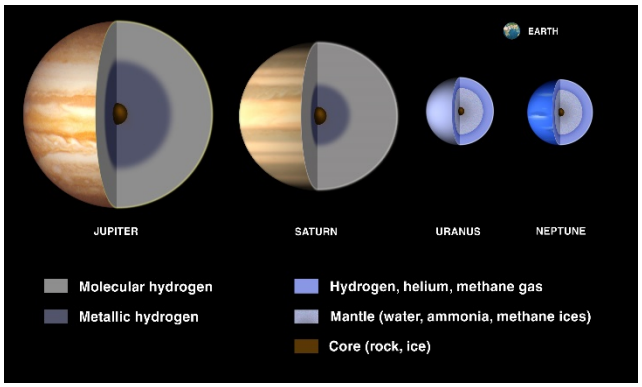


**Figure 3:** Comparison of chemical composition of Jovian planets; source: Lunar and Planetary Institute

Fourth year

The fourth year includes the student projects in ecochemistry and it is suggested to add a project that explores the influence of solar cycles and space debris on Earth. (Muminovic, 2014)

## TEACHING TOOLS

As the aim of incorporation of astronomy is in opening new horizons to students it is suggested to make significant use of multimedia, simulations and digital photographs from different past and ongoing missions from space as well from Earth-based observatories. These include European Southern Observatory, Hubble Space Telescope, different National Aeronautics and Space Administration (NASA) and European Space Agency (ESA) missions and so forth. The multimedia and simulations provide a new dimension to teaching in addition to benefits provided by astronomy subjects in terms of providing teaching benefits. Also with the rising popularity of citizen science undertakings, students could be actively engaged with the aim of encouraging scientific initiative. This can include interactive web application Galaxy Zoo that enables participants to classify galaxies from image library and therefore engage in scientific astronomy firsthand. Another interactive experience would be the use of online simulation such as http://astro.unl.edu/.

## CONCLUSION

By analyzing the current chemistry curriculum it has been determined that suggested additions can be made without requiring significant restructuring of lessons and textbooks, as these can be incorporated as additional materials presented within currently planned lessons. With the addition of multimedia and interactive materials, these could also serve a purpose as giving new insights and view on chemistry from angles of another natural science.

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**Summary/Sažetak**

Astronomija, kao nijedna druga naučna disciplina, kombinuje elemente iz skoro cijelog spektra načnih istraživanja, od fizike visokih energija do filozofije i psihologije. Za očekivati je da hemija, kao jedna od fundamentalnih prirodnih nauka, nalazi značajno mjesto u ovom polju vrhunskih istraživanja koje se konstantno širi. Tematika astronomije u gimnazijama u Kantonu Sarajevo je, u ovom trenutku, dio programa fizike i geografije. Ovaj rad objašnjava kako učenje o astronomiji može napredovati uz njegovu inkorporaciju u okviru gimnazijskih predmeta poput hemije. Teme mogu biti hemijski sastav nebeskih tijela, organske molekule pristune u oblacima gasa i egzotični tipovi materije koji se ne mogu naći na Zemlji. Prednost ove inkorporacije se ne ogleda samo na čisto edukacijskom nivou, već što radi dalje na cilju donošenja donekle apstraktnih i fascinantnih ideja realnosti izvan dodirnih tačaka Zemlje sa ciljem povećanja interesa učenika za predmet hemije.