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The Periodic Table of Elements and Other Materials for the Final Chemistry Exam; Students' Opinion

Introduction

The 150th anniversary of the discovery of the Periodic Table by Dmitri Mendeleev (a Russian chemist and inventor) was celebrated in 2019. That is why the year was announced by the ONZ General Assembly an International Year of the Periodic Table of Chemical Elements 2019 – IYPT2019. The celebration has been arranged and coordinated by: UNESCO, International Union of Pure and Applied Chemistry – IUPAC, European Association for Chemical and Molecular Science – EuCheMS, International Science Council – ISC, International Astronomical Union – IAU, International Union of Pure and Applied Physics – IUPAP and International Union of History and Philosophy of Science and Technology – IUHPST¹.

After 150 years of its usage, we now understand much better how properties are affected by the position of elements within the periodic table. A synergy between proper understanding of the periodic table and our understanding of different chemical materials was created.

The context and purpose of the framework

Science school education is based on the periodic table of elements. There is no core curriculum for chemistry that does not contain specific content on the Periodic Table of the Elements. Some specific requirements for chemistry at a primary school level are presented in Table 1 and for chemistry at the upper secondary school level are presented in Table 2.

¹ From: <https://iypt2019.org/>

Table 1. Some specific requirements for chemistry at a primary school level²

Main teaching content	Teaching content – specific requirements
II. Internal structure of matter. School students:	2. describes the composition of the atom (nucleus: protons and neutrons, electrons); based on the position of the element in the periodic system, determines the number of electron shells for elements groups 1 and 2 and 13–18; determines position of the element in the periodic system (group number, period number);
	6. reads basic information from the periodic table about the elements (symbol, name, atomic number, atomic mass, type of element – metal or non-metal)
	7. explains the relationship between the similarity of properties of elements belonging to the same group of periodic system and the gradual change of properties of the elements lying in the same period (metals – non-metals) and the structure of atoms;
	13. determines, on the basis of periodic system, the value (relative to hydrogen and maximum relative to oxygen) for the elements of groups 1; 2; 13; 14; 15; 16 and 17.

Table 2. Some specific requirements for chemistry at an upper secondary school level³

Main teaching content	Teaching content – specific requirements
II. Structure of the atom and the periodic table of elements. School students:	1. applies the terms: shell, subshell; writes electron configurations of atoms of elements up to Z=20 and ions with a given charge, taking into account the affiliation of electrons to subshells (records of configurations: full, abbreviated);
	2. determines belonging of the elements to the configuration blocks: s, p of the periodic table based on the electron configuration;
	3. indicates the relationship between electron structure of the atom and the position of the element in the periodic table and its physical (e. g. atomic radius, ionization energy) and chemical properties.
X. Metals, non-metals and their compounds. School students:	1. describes similarities in properties of elements in groups of periodic system and variability of properties in periods;

We cannot imagine chemistry lessons without periodic table of elements. A good periodic table is a great tool for solving chemistry problems.

The periodic table of elements is included in the school chemistry textbooks at all levels of education. In 2017, a very interesting article covering this area appeared (Chrzanowski, Buczek, Musialik, Ostrowska, 2017). The authors wrote:

² <https://podstawaprogramowa.pl/Szkola-podstawowa-IV-VIII/Chemia>

³ <https://podstawaprogramowa.pl/Liceum-technikum/Chemia>

We analysed all the series of chemistry textbooks for junior high schools, which have been approved for use in schools by the Ministry of Education since 2009. The study results indicate that the content of all series of textbooks contains the periodic table of elements along with the materials helpful in forming the skills of reading data from such source of information. The most authors of textbooks also took care of that the periodic table of elements was present in every part of the series, which should help students in consolidating the ability to use this tool.

The periodic table of the elements is also included in the additional materials devoted to students that they use during the mature exam in chemistry. This material prepared by the Central Examining Board was called: "*Selected formulas and physico-chemical constants for the mature exam in biology, chemistry and physics.*" These materials are designed to help those taking the exam to solve the tasks set for them (Krzeczowska, Krajewska, 2016). What can be found in these materials? From the chemistry point of view, such material includes many important information, as follows:

- Periodic table of elements
- Selected organic acids
- Selected amino acids
- Solubility of salts and hydroxides in water at 25 °C
- Dissociation constants of selected acids in aqueous solutions at 25 °C
- Dissociation constants of selected bases in aqueous solutions at 25 °C
- Electrochemical series of selected metals
- Logarithms
- Square equations
- Prefixes
- Constants and physical and chemical units

On page 6 we can additionally find formula for the law of common gravitation, on page 7 – formula for density, the equation for the state of perfect gas (Clapeyron's), a table entitled "*Contemporary physics*" and also on page 8 – formula for Coulomb's law.

It is obvious that students should know what is in these materials and what this information can be used for. Developing these skills during chemistry classes is very important and helpful while using them during the exam, where stress occurs and finding the right part, a proper issue can be time consuming.

It was assumed that students should use these materials during chemistry study. Every day, each student should be practicing this particular skill, which makes him better prepared for the final exam.

Based on the long-term experiences of the author who conducts chemistry lessons at school with extended program and due to the special revision course for school students before mature exam, her observations and reflections, the following hypothesis can be formulated: "Not all students use these materials in every chemistry class".

The main aim of my study was to collect the students' opinion on this kind of materials.

Research methodology

To acquire and evaluate the opinions of school and university students a special form of a questionnaire was created as the research tool.

The research sample included – a) students of the first year of chemistry and medical chemistry study and b) school students at upper secondary school level. Age for boys and girls did not differ significantly. The oldest participant was 20 years, the youngest 17 years old. The research was conducted at the beginning of the 2019–2020 school and academic year. Student participation was voluntary and anonymous.

Responders answered in a written form to the questions:

Q.1. How often do you use these additional materials for final exams during chemistry lessons? An answer was on a 5-point Likert scale.

Q.2. Do you use a periodic table of elements during chemistry classes?

Q.3. Do you use a table of solubility of salts and hydroxides in water at 25 °C during chemistry classes?

Q.4. Do you use an electrochemical series of selected metals during chemistry classes?

Q.5. Do you use a table of dissociation constants of selected acids and selected bases in aqueous solutions at 25 °C during chemistry lessons?

Q.6. Has the teacher shown what other additional information can be found there or in what other situations it is worth using?

Short characteristics of respondents is given in Table 3.

Table 3. Characteristics of respondents (survey).

	University students (first year) N = 159	School students Penultimate class N = 62	School students Last class N = 57
Gender	F: 22% M: 28%	F: 82% M: 18%	F: 82% M: 18%
Age in Years	19 years: 79% 20 years: 8% 21 years: 13%	17 years: 50% 18 years: 50%	17 years: 16% 18 years: 81% 19 years: 3%
Higher education (before an academic year with survey)	Yes: 13% No: 87%	–	–
Town/city	Krakow	Krakow Rzeszów Ostrowiec Świętokrzyski	Krakow Rzeszów Ostrowiec Świętokrzyski
The number of classes	1 – chemistry study 1 – medical chemistry study	3	3

Gender and age of the respondents were not an unimportant variable. I assumed that an important variable for university students is the fact of previous study.

It is quite clear that out of the total respondents (N = 278) investigated for this study, overwhelming majority (76 per cent) of them were females whereas about 24 per cent were found to be males.

Results and discussion

The answers obtained from all surveyed students were added up and converted into percentage. The obtained data are presented in the form of graph with some commentary.

For all graphs, individual symbols A, B and C were used to differentiate groups of responders:

A – school students (penultimate class)

B – school students (last class)

C – university student

Q.1 – The results are presented in Figure 1.

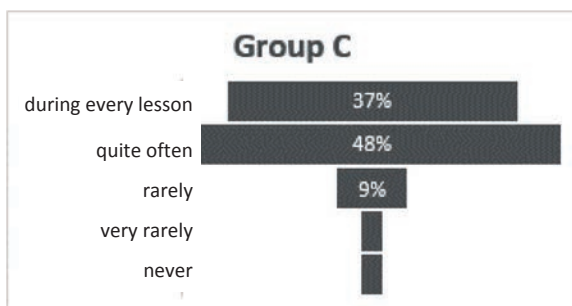
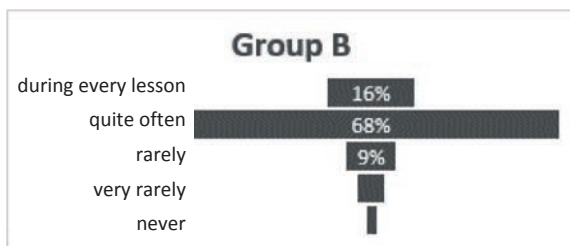
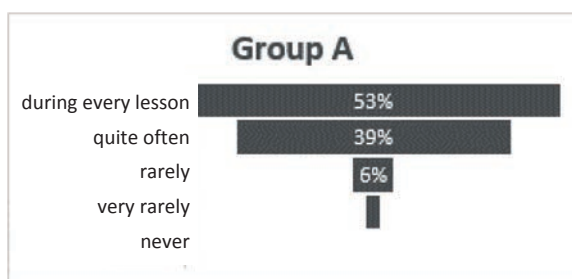


Figure 1. The results for question no. 1 in each group of respondents.

In the majority of surveyed students, these additional materials were used for final exams during every chemistry lesson or quite often. In fact, 3% of the university students and 2% of school students never used such help. This is, perhaps because school teachers never encouraged them to do so. All university students before the academic year with survey (students who have previously studied somewhere) fell into 37% of the respondents (group C) who chose “during every lesson”.

The next four questions (Q.2 – Q.5) concerned detailed information contained in the materials.

The obtained results are shown in Figure 2.

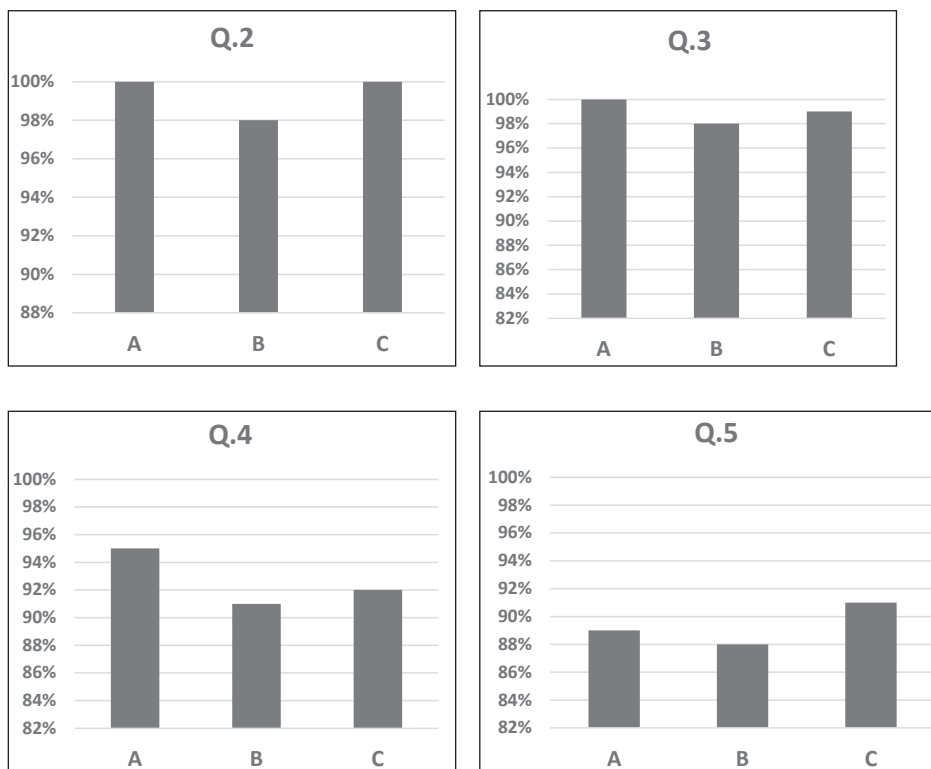


Figure 2. The results for questions no. 2 to no. 5 in each group of respondents.

The results indicate that among elements: a periodic table of elements, a table of solubility, an electrochemical series of selected metals, and a table of dissociation constants, a periodic table of elements had most affirmative answers “yes” and a table of dissociation constants had least answer “yes”. The comparison of A group with B group results indicated that slightly more answers “yes” appeared in group A, perhaps because in the last class (B group), organic chemistry is usually discussed and the use of these materials is less frequent.

Q.6 – Among the upper secondary school students, more than 88 % answered “yes” for question 6, but only 66% university students marked “yes”. Another worrisome phenomenon is the fact that not all teachers demonstrated the usefulness of these materials.

Maybe teachers do not pay attention to the most important content and skills that should be mastered by students.

Based on the obtained data, it can be concluded that students used different elements of these materials. It could be anticipated that we do not know whether students use the proper way.

It is obvious that the proper way of using the reference literature chemistry materials, helps students to be better prepared for the final exam.

In the future, it will be interesting to continue this research by using a special test that will allow me to check students’ problem solving skills based on a proper usage of these materials.

Thanks to the participants of the survey.

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Abstract

All school chemistry teachers, along with their students, realize that the periodic table of elements (and some other reference literature chemistry materials) is one of the most fundamental sources of information in chemistry. School and university students were surveyed in order to collect their opinions on the frequency of use of these materials in the class, together with their judgement on which elements were used. I would also like to know: Do teachers at school teach how to use the reference literature chemistry materials?

Keywords: chemistry, final exam, additional material

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