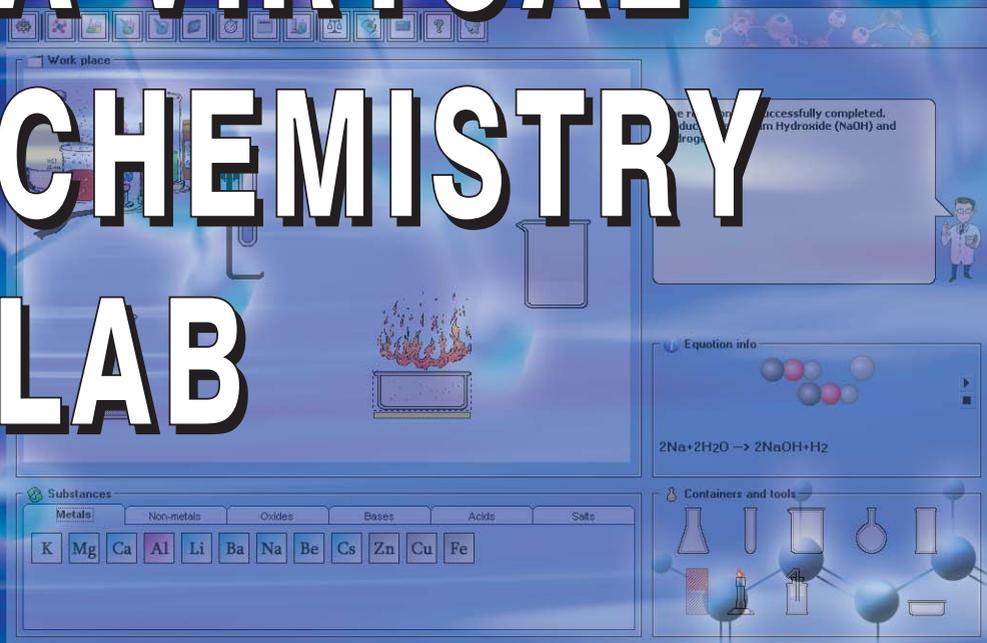


 **17th**
European
Union Contest
for Young Scientists



A VIRTUAL CHEMISTRY LAB



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The project is a virtual chemistry laboratory. It is created for students who study chemistry for the first year and for their teachers. The program is consistent with the study program in the 7th grade when the students have to study this subject for the first time. If they learn the most important parts of chemistry in this first year they will be able to learn new things more easily after that. So my program aims to help young learners to do this. It can help them to test different reactions and solve different problems. The program can be used both at school and at home. It is very useful for disabled children who can't study like the ordinary ones. The program can help them learn chemistry and develop their skills very quickly. In the future, the program will use an on-line database. Scientists from all over the world will be able to update the database and let other users view new reactions.

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SUMMARY

The high school I study in, as probably lots of other schools, does not have its own laboratory facilities, which hinders the normal learning process in Chemistry. For many students Chemistry would be much easier if they had the opportunity to conduct virtual lab experiments on their computers at school or at home. The aim of this project is to create a virtual Chemistry laboratory to help students in their first year of studying Chemistry and their teachers, as well. It is based on the subject material in Chemistry for the seventh grade which covers the basis of this subject and the good understanding of it at this point is a prerequisite for dealing successfully with the subject in upper grades. The product is designed for the students in the seventh grade and perhaps their teachers, but certain components of it, due to their universal nature, can be of use to students in upper grades, as well.

There are already some online helpers and virtual labs developed in the Internet. But most of them are restricted to visualizing a particular reaction or a separate process and the universal ones are developed for university students of chemistry and are extremely hard to use. What's more, most of those applications are shareware and require licensing, which is not affordable for most schools and students. The project is aimed at a specific group of users, which makes it far better for its purpose than universal laboratories; it has an easy-to-use interface, a help file, a manual and is completely free.

The program is very useful for disabled children, who cannot study the way the other children do. Using the program they can understand Chemistry and play with it. They can use the program both at school and at home. The program is very easy and they can easily improve their skills.

The product has a myriad of functions and is indeed a useful tool for teachers as well as for students and for those who are interested in Chemistry. The program is very intuitive – there is a

virtual worktable and two panels – for lab instruments and for substances respectively. To perform a reaction the user just has to put the necessary containers on the worktable and put the needed substances in them. The program has a database of reactions and it can visualize those, which are studied in the seventh grade. For example, if you fill a lab glass with water and put sodium in it, you will see an animation not only of how the reaction goes but how the molecules of the two substances interact to produce the final result of the chemical reaction. In general, the way experiments are conducted is very simple and reminds of actual lab work. The program also includes an assistant which notifies of all the changes within the program. The program offers plenty of tools including the periodic table, the solubility table, the oxidizing and relative activity table and even a glossary. Should those not suffice, there is an additional number of tools – an equation editor and a unit converter. There is also a self-test, a scientific calculator, lab exercises/tasks and a lab log (in order to prepare reports of the experiments).

Using this program, students acquire basic skills and knowledge for work in a laboratory without the risk of incidents in a real laboratory. Users have the option to check their skills and knowledge in an unconventional and entertaining way. As far as its further development is concerned, the program has the option for updating its database of the elements and their compounds.

1. INTRODUCTION

We live in the 21st century when education is no longer a privilege, but a duty for everyone. But what can the schools of today offer us? Everything or perhaps nearly everything. Elementary schools give us the foundations on which we can build up our knowledge. Afterwards, we begin developing ourselves in a specific area that we consider the most appropriate for ourselves. But it would be difficult to choose a direction to follow without the knowledge we acquire at school. The school becomes our second home. There we are taught not only Mathematics, Chemistry, Languages, Science and Biology but also how to be individuals as well. Even though we live in a modern world, some of our wishes cannot be fully fulfilled by our school. There are subjects, however, which require practice to be fully understood. Such subjects are Chemistry, Physics and others. And because we live in a world in which computers are an essential part of our life, I began working on a virtual laboratory. For many students Chem-



istry would be more understandable if they had the opportunity to conduct laboratory exercises on their home or school computer. At the beginning of the development process I wondered a lot where to begin from. Chemistry is a vast subject and it was not very easy for me. I consulted several teachers and I decided to begin from where the education in Chemistry begins – the seventh grade. In



that grade Chemistry is introduced for the first time in the curriculum. As with all other things, the first impression is very important. If the students get interested in Chemistry in the seventh grade, it will be a lot easier for them in the following years. Such a thing is unlikely to happen in schools, lacking laboratory facilities, which could provide students with the ability to experiment with substances such as sodium, sulphur, potassium and others. That is why I began

developing the project basing it on the subject material in the seventh grade. From various textbooks I picked up the most interesting and fascinating things which can make students like Chemistry. A subject should not be learned by force. If there is no attraction to the subject, a student can hardly learn anything. For students, a mere textual representation of a reaction would be of little interest. That was one of my aims – to make the program as much interesting and entertaining as possible. I had to find out the things that attract students. They want to have as many sources to obtain information from as possible and have fun at the same time.

2. PREPARATION

Before I began working on the project, I searched the Internet for something similar. I wanted to see what other developers have accentuated on. I was sure that I would find something and I really did. But did the things I found satisfy me? Another thing I

noticed is that only a small part of the programs I found contained a sufficient amount of material. Most of them were made to visualize only a particular reaction. There's nothing bad in that, but, as I already mentioned, students want as much information as possible. They wouldn't be satisfied with just a single reaction. The programs that included more information were made on an extremely high level and most of them weren't free. I'll remind the reader that the project is aimed at a more specific group of users, which makes it a lot more appropriate for the particular use than the universal laboratories. Besides it has an easy-to-use interface, a help file and is completely free.

3. PROBLEMS

And so, after lengthy research I began work on the project. I encountered no problems while developing the basics. But since I am not that good at Chemistry, I had some difficulty in the further development of the program. And this is where the Chemistry teacher helped me immensely – by gathering information and materials. I myself had to watch animated lab containers to develop their virtual counterparts instead of seeing them first-hand. I felt silly in this case and I can only imagine what the teachers feel like when they teach about sodium and cannot demonstrate at least one reaction so that the students can assimilate the new material more easily. Because a lot of information was gathered, the next step was to categorize it. It proved no easy feat as well but with a little help I managed to accomplish it. After a year and a half of hard work on the development of the project, it was finally completed.

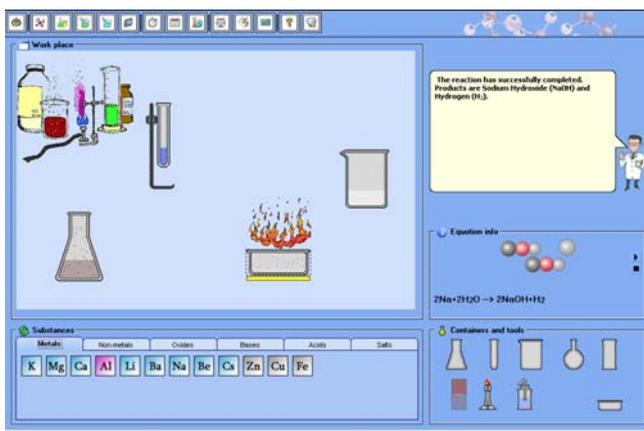


4. FUNCTIONALITY

The Virtual Laboratory of Chemistry provides: a way to visually conduct experiments with different substances, a model- and analysis-oriented view of the current reaction; an “assistant” to simplify the work with the program, valuable encyclopedic information regarding the elements; a glossary; self-test facilities; interactive lab exercises; a sophisticated unit converter; a lab log; a built-in calculator; an equation editor; a help file; an attractive interface and many other features. The program can also be updated over the Internet, which helps to constantly keep its database up-to-date. What’s more, teachers can manually add more substances and reactions and thus enrich the students’ experience.

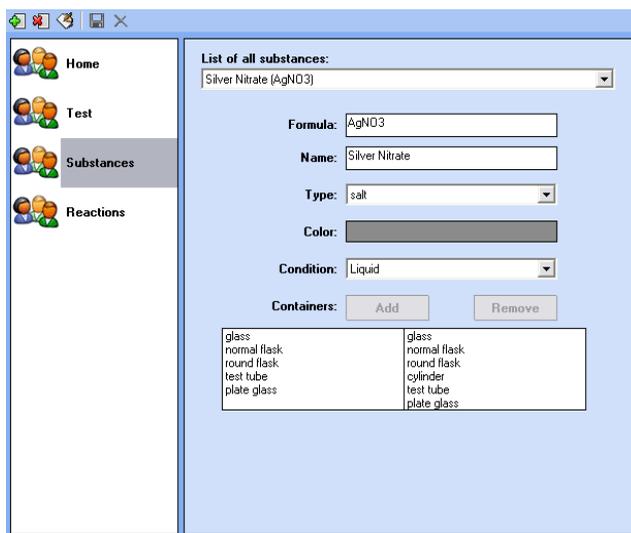
5. REACTIONS

Reactions are performed in several easy steps: the user picks a container and puts it on the virtual worktable and then adds two substances into the container. The assistant will announce the result – whether the reaction went normally or there was some kind of a problem. A problem can often arise, for example, if both substances are metals or a burner is required for the reaction and none



has been put on the worktable or there is no information about the reaction in the database. If there are no problems, the user can see the change and the result of the reaction in the container. The field under the assistant shows an equation of the reaction and sometimes a small animation showing how the atoms are grouped together. There is no limit to the number of containers that can be put on the worktable or the reactions to be performed. When the user has finished with the lab experiments, he can clean the worktable and start a new.

6. INFORMATION



The program has a way to modify the information about elements and reactions and so enrich the database. The login in the administrative panel requires an example password to protect students from accidentally deleting parts of the database in schools. On the first run of the program, a teacher can change the example password as it is initially recorded in the help file.

7. TOOLS & APPLICATIONS

	I	II	III	IV	V	VI	VII	VIII	
1	H						(H)	He	
2	Li	Be	B	C	N	O	F	Ne	
3	Na	Mg	Al	Si	P	S	Cl	Ar	
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co Ni
4	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru Rh Pd	
5	Ag	Cd	In	Sn	Sb	Te	I	Xe	
6	Cs	Ba	La*	Hf	Ta	W	Re	Os Ir Pt	
6	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
7	Fr	Ra	Ac**	Rf	Db	Sg	Bh	Hs Mt Unn	





*** Lanthanides**

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
----	----	----	----	----	----	----	----	----	----	----	----	----	----

**** Actinides**

Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
----	----	---	----	----	----	----	----	----	----	----	----	----	----

	I A	II A	III B	IV B	V B	VI B	VII B	VIII B	VIII B	VIII B	I B	II B	III A	IV A	V A	VI A	VII A	VIII A
1	H															(H)	He	
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac**	Rf	Db	Sg	Bh	Hs	Mt									




*** Lanthanides**

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
----	----	----	----	----	----	----	----	----	----	----	----	----	----

**** Actinides**

Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
----	----	---	----	----	----	----	----	----	----	----	----	----	----



Image



Physical Properties

Chemical sign: **O**

Number: 8

Atomic weight: 15,9994

Temperature of melting: -218,4

Temperature of boiling: -182,962

Electrons by layers: 2:6

Isotopes: 8

Atomic radius: 0,65

History

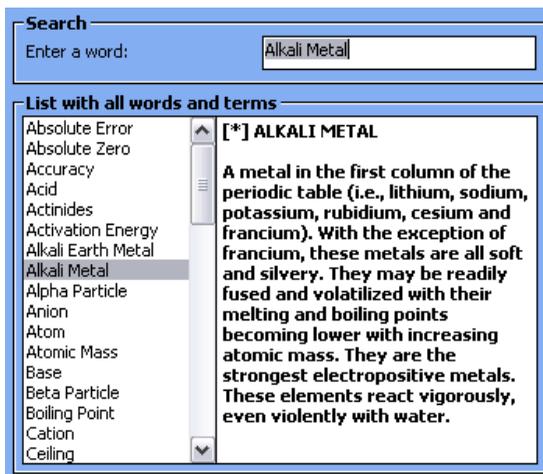
Oxygen is a Group 16 element. While about one fifth of the atmosphere is oxygen gas, the atmosphere of Mars contains only about 0.15% oxygen. Oxygen is the third most abundant element found in the sun, and it plays a part in the carbon-nitrogen cycle, one process responsible for stellar energy production. Oxygen in excited states is responsible for the bright red and yellow-green colours of the aurora. About two thirds of the human body, and nine

One standard tool is the Periodic Table. It is created in two variants: normal and extended. The only difference between this two variants is that in the extended one A and B groups are separated. Metals, non-metals, elements from B groups and inert gases are tinted in different colors. When you click on a element you get a detailed information about it, such as image, atomic weight, temperature of melting, temperature of boiling, etc. There is also additional interesting information about the element.

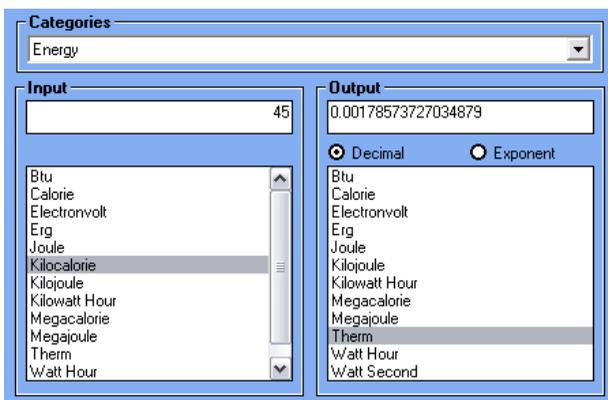
Ions	Names	H ⁺	NH ₄ ⁺	K ⁺	Na ⁺	Ag ⁺	Ba ²⁺	Ca ²⁺	Mg ²⁺	Zn ²⁺	Cu ²⁺	Hg ²⁺	Pb ²⁺	Fe ²⁺	Fe ³⁺	Al ³⁺
OH ⁻	hydroxide	P	P	P	P	-	P	M	H	H	H	-	H	H	H	H
NO ₃ ⁻	nitrate	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
S ²⁻	sulphide	P	P	P	P	H	-	-	-	H	H	H	H	H	H	H
SO ₃ ²⁻	sulphite	P	P	P	P	M	M	M	M	-	-	-	H	M	-	-
SO ₄ ²⁻	sulphate	P	P	P	P	M	H	M	P	P	P	P	H	P	P	P
CO ₃ ²⁻	carbonate	P	P	P	P	H	H	H	H	H	H	H	H	H	-	-
SiO ₃ ²⁻	siliconate	H	-	P	P	H	H	H	H	H	H	H	H	H	H	H
PO ₄ ³⁻	phosphate	P	P	P	P	H	H	H	H	H	H	H	H	H	H	H
F ⁻	fluoride	P	P	P	P	P	M	H	M	P	M	M	H	M	P	P
Cl ⁻	chloride	P	P	P	P	H	P	P	P	P	P	P	M	P	P	P
Br ⁻	bromide	P	P	P	P	H	P	P	P	P	P	P	M	P	P	P
I ⁻	iodide	P	P	P	P	H	P	P	P	P	P	H	H	P	P	P
CrO ₄ ²⁻	chromate	P	P	P	P	H	H	M	P	P	H	H	H	P	P	M
CH ₃ COO ⁻	acetate	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

P Soluble
 M Less soluble
 H Insoluble
 - Breaking down
 ■ Sediment

Solubility Table let us check whether two ions (a cation and an anion) can form a substance and what it would be – either soluble or insoluble. If the two ions form a sediment we can see its color.



When students first encounter with the chemical terminology, they find it hard to remember it without constantly using it. This will no longer be a problem as the program has a built-in glossary of the most widely used terminology. It's a wonderful way to recollect the meaning of any unknown term at any time.



The students in the seventh grade learn about some of the most widely-spread elements, compounds and reactions but they also learn how to solve equations and different problems like the mass and so on. In this case they need to use different units and convert them. The project incorporates an extremely useful unit converter and it can convert all kinds of units. Another useful tool is the calculator which helps the students to calculate any sum they encounter with.

When conducting a laboratory experiments, students write down every important detail. This is why I created the lab log which does the writing down for the students. They can save the log about any experiment and review it afterwards.

It gives off light in the dark, heat without being heated and in the course of time it forms two new elements - one is gaseous, the other is a solid substance. Which element is it?

Nitrogen

Neon

Gallium

Chlorine

Radon

Help

Next

Question: 9/10 Answers: 5 Time: 0:00 Help: Yes

The most interesting thing for some of the students and most of the teachers is the self-test feature of the program. There are several tests – the first is the standard one – several answers and only one of them is the right one. After the test is completed, a mark is generated depending on the number of the right answers. This is a good way for teachers to check their students' knowledge. The questions in the test can be modified in the administrative panel.

Another tool of examination is the equation editor. It can help the teacher to check the students' skills of solving chemical equations. The last but not least important method for examination is using simple lab experiments. A reaction is visualized onscreen and the student is asked a question regarding the reaction. Seeing the changes on the screen, the student has to consider what he sees and answer correctly.

1. Make difference between an acid and a base
2. Produce Sodium Hydroxide
3. Produce Sulfuric Acid

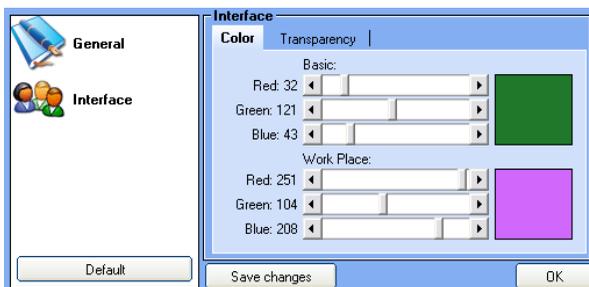


Bromine+Beryllium

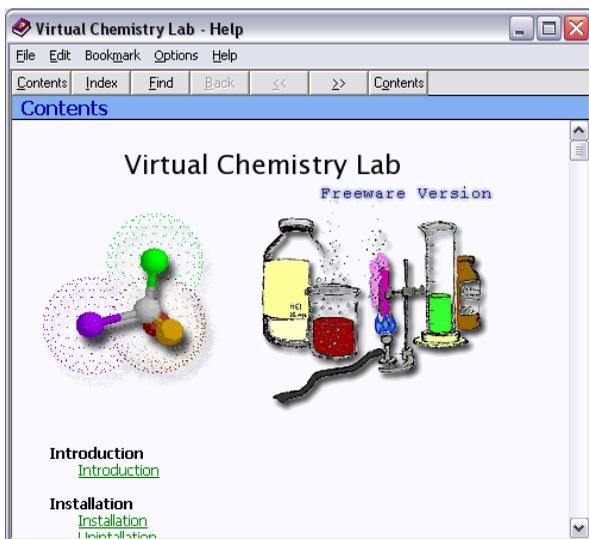
Output substances: --> Products:

K Mg Ca Al Li Ba Na Be Cs Zn Cu Fe H Cl N O S F Br
I C P

In order to make the program more fun and pleasant to use, I've added the option to modify the colors and transparency attributes of some of the program's elements. That way the students can change the appearance of the program to their own liking.



Besides all that functionality, there is also a complete help system in the project. Should there be any problems (which I highly doubt) the user can always look for help in the help system.



8. DEVELOPMENT

The program has been created with MS Visual Basic 6, because our school has a licensed copy of the software. Visual Basic offers a great opportunity for developing professional projects. All the information used in the program is saved in a database. I use MySQL, because it is free and I have enough experience with it. The project is

divided into modules, which implement all the program features. As a result of this the program is well optimized and it can be easily updated thereafter. The graphics in the program are edited with a free-ware program, called GIMP.

9. CONCLUSION

Using the program, students acquire basic knowledge and skills for the work in a lab without the risk of accidents like burning with acids, bases and other toxic substances. The users have the option to check their knowledge and skill in an amusing and un-traditional way. As far as its further development is concerned, the program has the option for updating the existing information in the database. The current Virtual Laboratory of Chemistry was tested by students in the seventh grade in my school and the feedback is very good. The program makes Chemistry more accessible and less “fearsome and detestable”.

REFERENCES

- John Clark Cragg & Jew Web, Programming with Microsoft Visual Basic 6, SoftPress, 1999
- Michael Halwarsun, Microsoft Visual Basic Professional 6.0 Step by step, SoftPress, 2000
- Microsoft Corporation, Software Development with Microsoft Visual Basic 6.0 MCSD Training Kit, SoftPress, 2000
- John Emsly, Elements, Peace, Moscow, 1993
- Borislav Karadov, Analytic Chemistry (in Bulgarian), Technique, 1994
- Vencislav Nanov, Chemistry 7th grade (in Bulgarian), Arhimed, 2002
- Mitka Pavlova, Chemistry 7th grade (in Bulgarian), Pedagog, 2004
- <http://www.webelements.com>
- <http://environmentalchemistry.com/yogi/chemistry/dictionary/>
- <http://www.chemistrydaily.com/>
- <http://chem.hit.bg/>
- <http://www.netsci.org/Science/index.html>
- <http://www.chem.ox.ac.uk/vrchemistry/>



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