# VIRTUAL CHEMICAL LABORATORY VIA DISTANCE LEARNING

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***Abstract:*** *The problems of representation and learning material in distance learning are successfully solved, but development of professional skills is a problem, that requires a solution, especially for teaching natural sciences such as Chemistry. The article deals with issues related to the organization and implementation of laboratory chemical experiments via distance learning. This paper covers a classification of virtual chemical laboratory. The author proposes to use free ware program Virtual Chemistry Laboratory teaching Chemistry. Distance learning has the advantages that this program can be installed on a local computer and on-line. Moreover the local version and on-line version of this software can be presented in different languages. The paper gives examples of laboratory work. The author studies the creation of new laboratory work in chemistry using this program.*

**Keywords**: distance learning, virtual chemistry laboratory

## INTRODUCTION

Distance learning has already become reality in education, so the questions of determination of the definite problems for its organization have been appearing. The problems of presentation and getting the educational material for distance learning are solved successfully. However there is a problem of forming the practical skills and abilities. This problem needs solving especially to teach natural sciences including chemistry. According to (Jarkykh, Lysochenko, Sus, Tretyak, Shkavro, 2010) the student gains knowledge and acquires skills doing the experiments. And this is an essential condition of forming the specialist's professional competences.

The virtual chemical laboratories are recommended to be used for organization and implementation of experiments for distance learning. This is emphasized in (Morozov, Tanakov, Gerasymov, Bystrov, Tsvyrko, Dorofeev, 2004), (Truhyn, 2005), (Grygorieva, Grygoriev, 2010).

## 1. VIRTUAL CHEMICAL LABORATORYS

***Virtual chemical laboratory*** are complex of the programs which are necessary to imitate the implementation of experiments in a chemical laboratory.

Nowadays there are a lot of virtual chemical laboratories. They can be divided into three groups. It is depended on the commands a user chooses (Truhyn 2002):

- ***Programs for visualization of experiments establishing some parameters of its course***. For example, *VirtuLab* is one of such programs, developed by *Virtual laboratory "VirtuLab",* at *www.virtulab.net*. Some parameters of the experiment can be changed using this program, so and a user course watches the differences in course.
- ***Simulation programs for experiments of separate class.*** For example, *Interactive Simulations* is one of such programs developed by *University of Colorado,* site*http://phet.colorado.edu*. This program consists of modules that help simulate separate experiments. Different parameters can be set to do them as well as different tools can be chosen.
- ***Chemical laboratory simulation programs*** are complicated simulation systems. There is a powerful mathematical apparatus in their base. A user can add the models and set their parameters to do new experiments. And this is a key difference of these programs. The programs of this group can be divided into two sub-groups: *simulation programs for various natural effects* and *simulation programs of the type of effects*. For example, commercial program *Yenka* developed by *Crocodile Clips Ltd,* site *http://www.yenka.com* appertains to the first sub-group. Free ware *Virtual Chemistry Laboratory* is one of those appertain to the second sub-group.

## 2. VIRTUAL CHEMICAL LABORATORY

*Virtual Chemistry Laboratory* can be described as a program that has got some advantages of using it in distance learning:

- that program can be installed on a local computer (there are versions for operating systems *Windows* and *Macintosh*) and on-line, site *http://chemcollective.org/vlab/vlab.php*;
- the versions of that program are presented in multiple languages: English, Spanish, Catalan, French, Portuguese, Greek, German, Russian, Hebrew, Galiysca, Arabic, Lithuanian, Chinese.

*Virtual Chemistry Laboratory* is a visual simulator of a laboratory and inorganic and analytical chemistry laboratory work. It also includes the editor of new laboratory work. *Virtual Chemistry Laboratory* has been developed and supported by *University Carnegi Mellona* within *IrYdium* project.

*Java!* must be installed for *Virtual Chemistry Laboratory* program running.

*Java!* is loaded from the web-page of *http://www.java.com/en/download /manual.jsp*. The hyperlinks *Downloads* and *Try the offline installer* must be chosen to save the distribution file *Java!* on a local computer. This archive the distribution can be used to install *Java!* on other computers.

Web-page *http://chemcollective.org/applets/vlab.php* is necessary to load the distribution of *Virtual Chemistry Laboratory* for installation on a local computer using hyperlink *[51MB] Virtual Lab International Version 1.6.4 with Java*. After that, it is necessary unpack the loaded archive and run the appropriate file to use version of the program in a proper language. The name of each file consists of 6 symbols: *VLab* and the last two marks are symbols of the language of version of the program. For example, the Russian name is *VlabRU*. The window of the program is given in Figure 1.

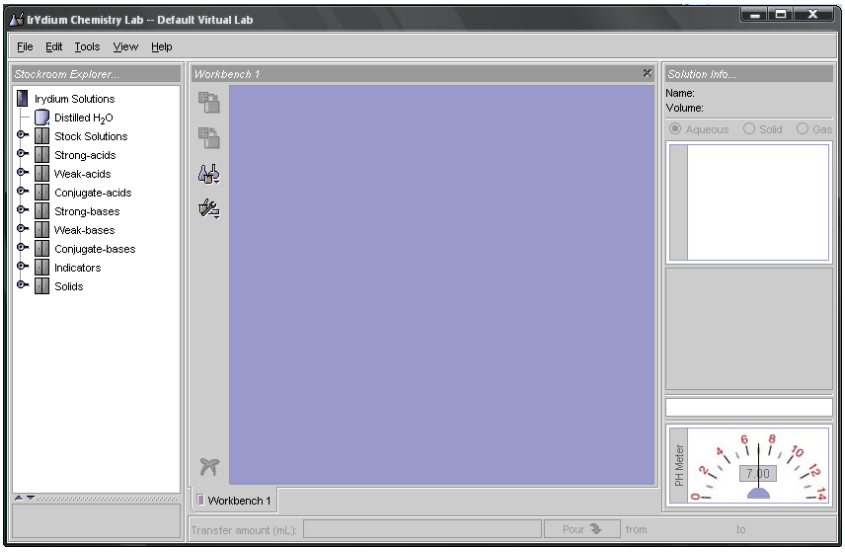


**Figure 1. The window of program *Virtual Chemistry Laboratory***

*Source: The ChemCollective, site http://chemcollective.org/*

The experiments including the standard set of reagents can be simulated with the help of that program. A new set of reagents can be created using the module *VLabAuth* downloaded from the web-page *http://chemcollective.org/authoring.php* and hyperlink *Virtual Lab Authoring Tool [1MB]*.

### 2.1. Simulation of experiments

The command *File / Load Homework* must be chosen to load prepared tasks. The tasks must be chosen from the list in the window of *Load Homework* (Figure 2). All the developed tasks are presented in English.

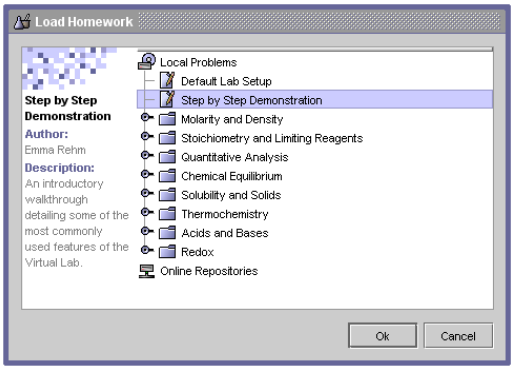


**Figure 2. The window *Load Homework***

*Source: The ChemCollective, site http://chemcollective.org/*

For example: it is necessary to determine the concentration of solution of sodium hydroxide (NaOH) using a 0.500 M potassium hydrogen phthalate (KHP) with help of titration.

***Accomplishment:***

a) "take" from *Stockroom Explorer*... of reagents NaOH, KHP, phenolphthalein and "put" them into the *Workbench:* a suitable reagent must be chosen clicking twice the left key of a mouse or "pressing" the button *Click to retrieve a solution from the stockroom* or „moving" the suitable reagent;

b) a burette and a disposable pipette must be chosen from the list *Click to select new glassware from the drop-down menu* (Figure 3);

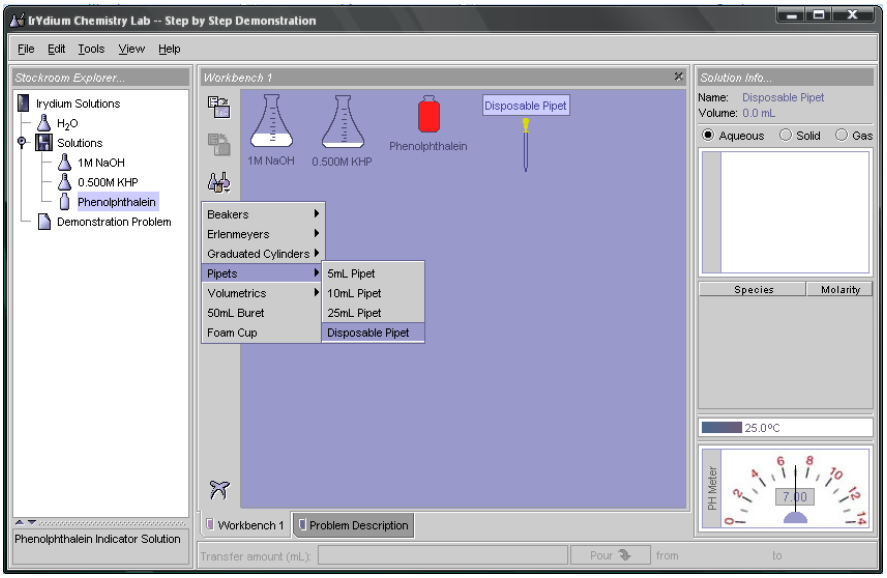


**Figure 3. The window to simulate the experiments**

*Source: The ChemCollective, site http://chemcollective.org/*

c) "take" a little phenolphthalein (~ 0,3 ml) using a disposable pipette: the image of the disposable pipette must be moved on the image of phenolphthalein, enter a proper volume of phenolphthalein in the field *Transfer amount (ml):*and "press" the button *Withdraw* (Figure 4);

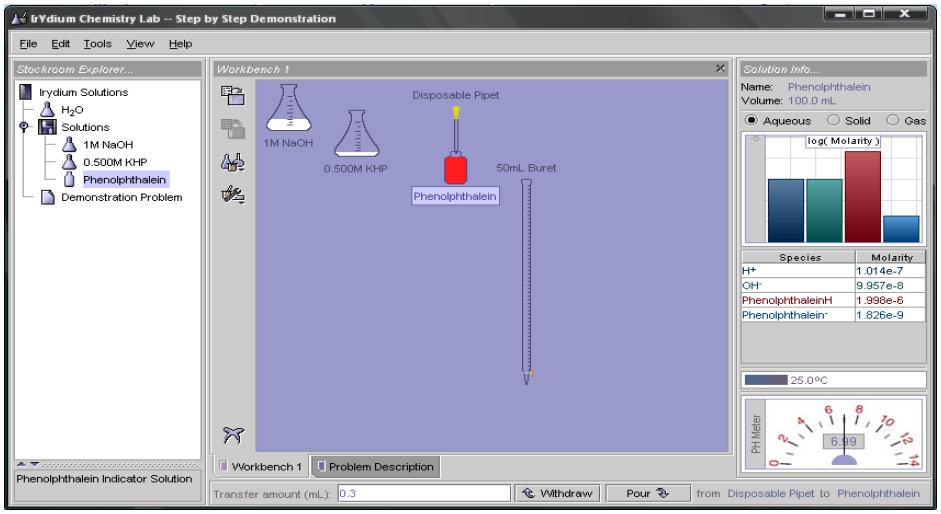


**Figure 4. "Collecting" with a pipette phenolphthalein**

*Source: The ChemCollective, site http://chemcollective.org/*

d) „fill" a burette with solution NaOH: according to the previous point;

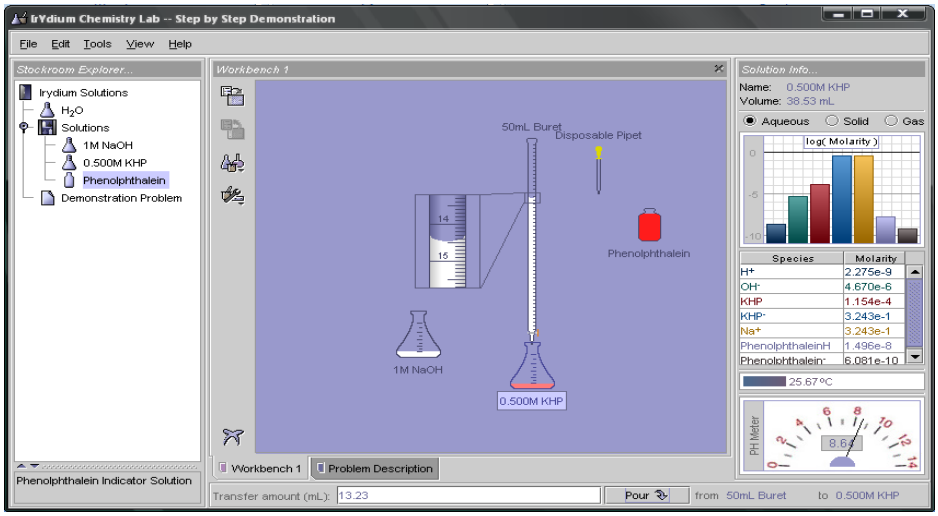


**Figure 5. The result of exercise**

*Source: The ChemCollective, site http://chemcollective.org/*

e) make „titration" NaOH from a burette to KHP, until a little change of colour. „Titration" is carried out according to the point c). That can be also made with help of precise mode of „addition" of the reagent: choose the

command *Transfer Bar /Precise transfer* in the menu *Tools*, introduce 13.23 to the field *Transfer amount (ml):*, "click" the button *Withdraw*. The concentration NaOH is 0,9445 M and there is some light pink liquid in the retort (Figure 5).

### 2.2. Create a new task

A teacher can create new tasks in two ways:

- a proper file with extension of *.xml* must be chosen from the list with help of the command *File* / *Open* on the basis of the already existent task (edit);
- the creation of a new task with help of the command *File / New*.

After choosing the command *File / New* a new window will be opened to enter parameters of a new task (Figure 6).

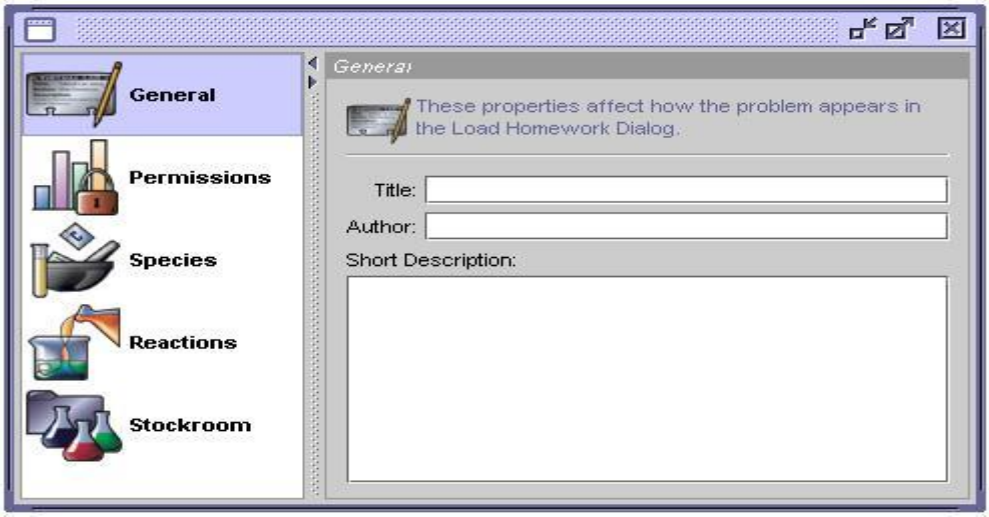


**Figure 6. The window for entering task parameters**

*Source: The ChemCollective, site http://chemcollective.org/*

It is necessary to set all the parameters of the new task for each and all points: *General, Permission, Species, Reaction, Stockroom*.

*General*:

*Title* is the name of a task.

*Author* is the author of the created task.

*Short Description* – a short description of the task: the description of a task and supplementary information which is necessary to do this task.

It is reasonable to create a folder to save the task in the file with expansion .xml with help of the command *File / Save as*. Files are saved in the folder *My documents* by default.


**Figure 7. The window to select items displayed in the task**

*Source: The ChemCollective, site http://chemcollective.org/*


**Figure 8. The window to select the display mode "transfer" of the substances**

*Source: The ChemCollective, site http://chemcollective.org/*

*Permission* (Figure 7 and 8) is the mode of display of the proper elements of the window *Virtual Chemistry Laboratory*. The elements can be visible or invisible working with the task.

*Species* (Figure 9) – properties of the component reagents can be added or edited.

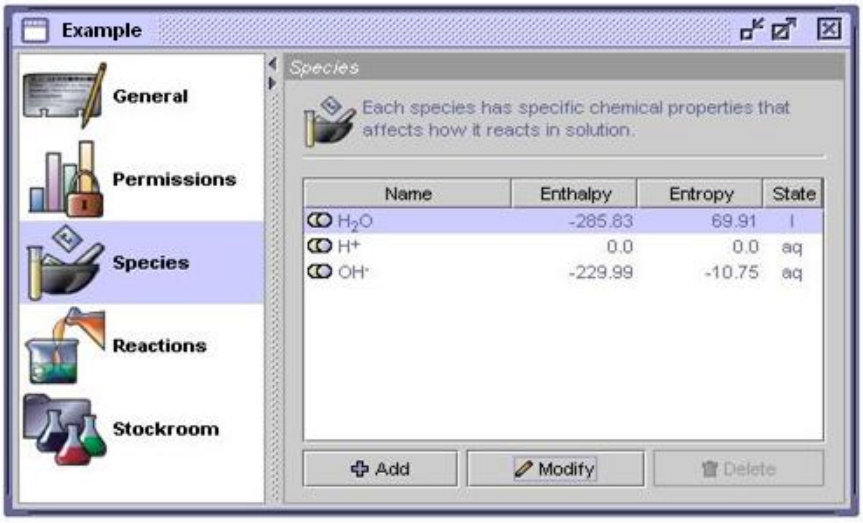


**Figure 9. The window for editing the properties of reactants**

*Source: The ChemCollective, site http://chemcollective.org/*

The properties of components in the reaction are described creating a new task.

***Addition of component reagents:*** the command *File / Open* is used to add the component reagents from another task to this one.

The information about the proper component reagents from another task to this one can be copied with help of the commands *Edit / Copy* and *Edit / Paste* after opening this task in the window of the point *Species* (Figure 9).

It is necessary to press the button *Add* (Figure 9) and open the window to enter parameters of the component reagents (Figure 10):

*Species* is an image of chemistry symbol or formula of component reagents. The standard formatting HTML is used to add an upper index or a low one. <SUB></SUB> is suitable for the low index, <SUP></SUP> is suitable for the upper index. For example, "2" in $H_2O$ is<SUB>2</SUB>, + in $H^+$is<SUP>+</SUP>.

*State* is the state of a reagent (water (aq), liquid (l), solid (s), gaseous (g)).

*Enthalpy (kJ/mol)* is enthalpy (use the proper reference books to enter for introduction of correct value).

*Entropy (kJ*mol)* is entropy (use the proper reference books to enter for introduction of correct value).

*Molecular Weight* is molecular weight.

*Color* is colour of a reagent.

*Color Concentration* is the coefficient of colour changing of changing the concentration of solution.

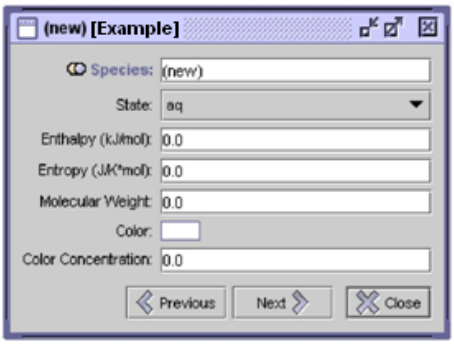


**Figure 10. The window for entering the parameters of component reagents**

*Source: The ChemCollective, site http://chemcollective.org/*

The button *Previous* is used to pass to the description of the previous component of the reaction. The button *Next* is used to describe the next component there action. The button *Close* (Figure 10) is used to close the window to enter the parameters of the substance.

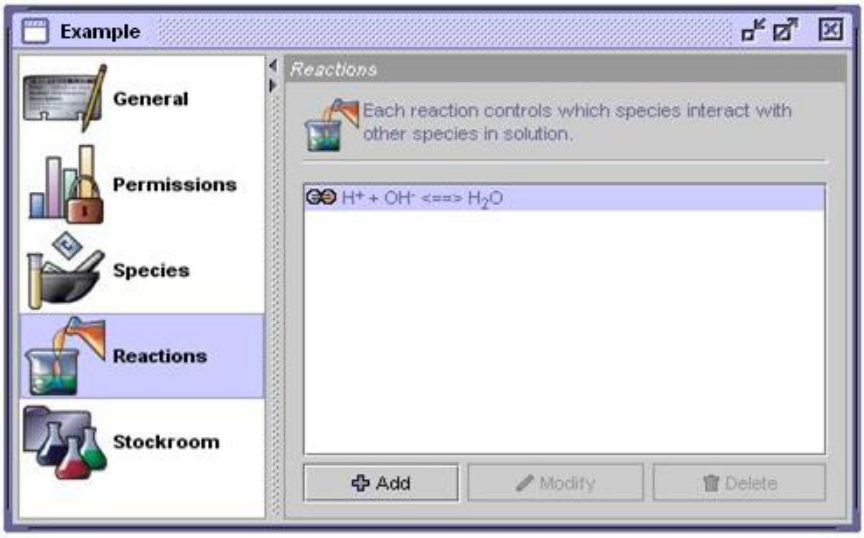


**Figure 11. The window for editing of the reaction equation**

*Source: The ChemCollective, site http://chemcollective.org/*

The button *Modify* is used to call the window for editing of properties of the already determinate substance (Figure 9).

The point *Reaction* (Figure 11) is used to edit the equation of the reactions in the task. All the possible reactions between the reagents must be described accurately.

The button *Add* (Figure 11) is used to open the window for adding a new reaction (Figure 12).

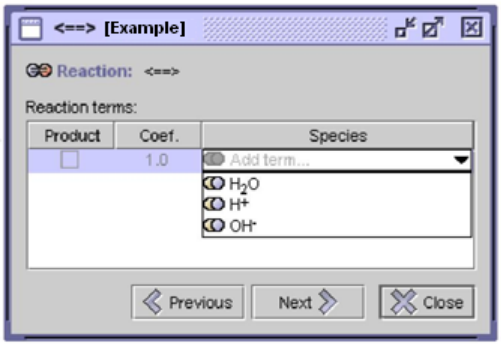


**Figure 12. The window for adding the description of a new reaction**

*Source: The ChemCollective, site http://chemcollective.org/*

At first the reagents must be chosen from the list in the column *Species* and after that the result of the reaction must be marked in the column *Product.* The coefficients must be determined for equalization of the reaction in the column *Coef.* (Figure 12).

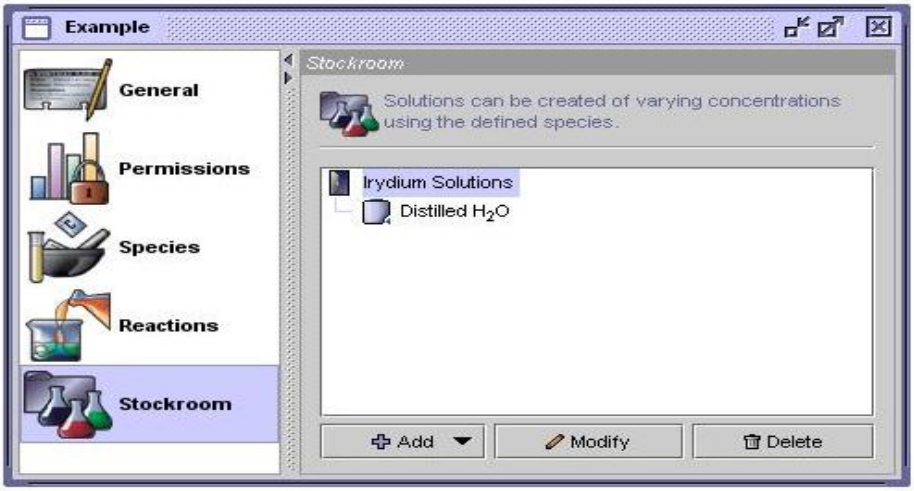


**Figure 13. The window for selection display of the materials in the *Stockroom* laboratory**

*Source: The ChemCollective, site http://chemcollective.org/*

The properties of all the components of the reaction are copied while the reaction of a task is copied from another task.

The point *Stockroom* (Figure 13) is creation and edition of the display of substances in the laboratory stockroom (the creation of realistic images).

The *Cabinet*, the *Solution*, the *Problem Description* for a task can be added with help of the button *Add* (Figure 14).

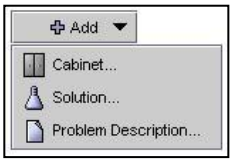


**Figure 14. The menu for adding laboratory items**

*Source: The ChemCollective, site http://chemcollective.org/*

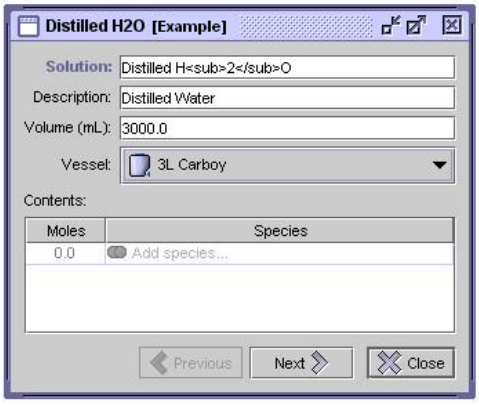


**Figure 15. The window for setting the parameters describing of the solution**

*Source: The ChemCollective, site http://chemcollective.org/*

The parameters of an element are set in the open window in Figure 15 and 16.

***Parameters of description of the solution*** (Figure 15):

*Solution* is the name of solution.

*Description* is a label of the solution on a vessel.

*Volume (ml)* is volume of solution.

*Vessel* is a vessel for solution.

*Contents* are components of solution.

*Moles* are quantity of components of the solution in moles.

*Species* are a denotation of components of the solution.

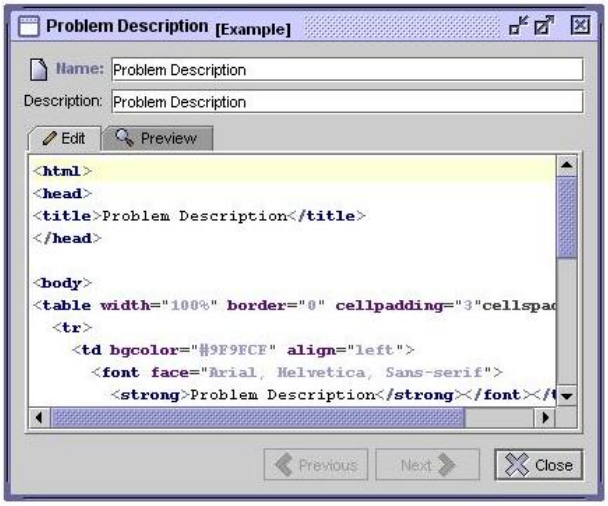


**Figure 16. The window settings the parameters describing the annotations of a task**

*Source: The ChemCollective, site http://chemcollective.org/*

***Parameters of describing the annotation for a task*** (Figure 16):

*Name* is the name of annotation.

*Description* is the label of the annotation.

*Edit* is necessary to edit contents of the annotation as codes HTML.

*Preview* is previous revision of the contents of the annotation.

The command *File / Preview* is used to preview the created task.

Addition of the created task to the *Virtual Chemistry Laboratory:*

1. Copy the file with the saved parameters of a new task to the folder *assignments.*
2. Add such a fragment:

<PROBLEM url="assignments/<**the file name**>.xml">

<TITLE>Назва завдання</TITLE>

<AUTHOR>Прізвище автора</AUTHOR>

<DESCRIPTION>

**thumb-nail sketch of task**

</DESCRIPTION>

</PROBLEM>

A user enters just the name in bold of the file that contains the information about a new task. The short description in bold of the task can be entered if it is necessary. The command *File / Load Homework* in the program *VLab* is used to load this task.

## CONCLUSION

Using of this program for organization and implementation of distance learning is necessary:

- to do chemistry experiments in distance;
- to use own tasks by the teachers the depending on the goals of learning;
- to use the version of the program on-line to expend the range of computers used for distance learning;
- to increase circle of students that can study in distance to using different language versions of the program.

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