Methodology of Solving Tasks in Chemistry

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ABSTRACT

For learning chemistry is very important to make connection between theory and practice. Ability to solve problems represents the well learned theory knowledge, and good methodology in work on theory classes. Usually the strategy of solving of the problem consists from three parts: studying the conditions of the task and its analysis, formation of the opinion, solving the task and its check. In order to better understand the significance and advantages which methodical preparation gives during solving of the problem, we have made two groups with fourteen students of the second year high school-course agricultural technician. The first group of the students had the opportunity to have methodical explanation of ways and means of problems solving in chemistry. The second group only got the problems to be solved without methodical preparation. The aim of our experimental work was to establish the contribution of methodical preparation during task solving. Group of the students that got methodically explained exercises have achieved significantly better results, so it serves as a proof of the assumption in theoretical part that methodical preparation in problem solving is inevitable and necessary, and its practical importance is multiple.

Keywords: chemistry learning, methodology, tasks

INTRODUCTION

Experience has shown that for the successful teaching of chemistry it is important to connect theory and practice. Practical application of knowledge is reflected in the performance of experiments and solving of arithmetic problems. While solving arithmetic problems in order to get results, it is necessary to apply previously acquired knowledge, notice the problem correctly, to separate the known from the unknown sizes. In the process of learning chemistry different problem types have different meaning and purpose. Ability of solving problems represents the proof of the adoption of teaching materials.

The task in the educational process may make sense if the student is asked to do something, in this case to solve a problem (Zusho, 2003). There are many types of tasks, and all tasks can be grouped into two big groups: tasks in which memory is getting developed (reproductive) and tasks in which perception is getting developed, performances, thinking and imagination (productive) (Zhou, 2010). Tasks of reproductive character are those where particular act is getting rehearsed, aimed at fostering memory (Stieff, 2011). However, this way of acquiring new knowledge should not prevail. Productive tasks require from students self-seeking into certain knowledge sources, to observe, analyze, compare, synthesize, generalize and conclude (Spencer, 2006). In the search for the solutions of these tasks, students must be intellectually active; they can't solve the problem using only acquired knowledge. Pure theoretical knowledge is abstractedly, formal and passive. Theoretical knowledge is only the first step towards real knowledge. Acquired knowledge becomes our property

only if it is applied (Gabel, 1999). In order theoretical knowledge to be concrete, active and applicable, it needs to be substantiated by solving arithmetic problems, experiments and lab works. Using terms, formulae and laws when solving tasks, the durability of knowledge is increasing (Kozma, 1997).

METHODOLOGY OF RESEARCH AND DISCUSSION

Solving of problems should not be regarded as exchanging of symbols with numbers, browsing of books until finding of corresponding formula or any similar problem and the way how it is solved (Russell, 1997). In solving tasks, it must be used properly mathematical apparatus. If that part of mathematical material is not processed and approved, then it is a big problem in task solving (Hewson, 1989). Solving of tasks must be gradual and systematic, and it is ensured by respecting the following rules: from here to there; from simple to complex; from easy to hard; from known to unknown. On the solution of any task two factors affect: structural characteristics of the task (its components) and the ability of person to solve the task, and from psychological aspect, solution means finding of relations, causes and consequences not mentioned in the task. Usually the strategy of solving of the problem consists from three parts: studying the conditions of the task and its analysis, formation of the opinion, solving the task and its check (Herron, 1996). Types of methods for problem solving are:

- Analytical methods come from the relation containing required size and then necessary sizes are expressed over the size given in the task; analysis can be defined as the ability of parsing information into components;

- Synthesis methods use known relations in which given sizes are present in specified, in order, using this way, to come to the required size (Sandlin, 2015). Synthesis can be defined as the ability to manage parts to come into entirety (Friedman & Deek, 2002).

Next step is process for solving problems. Each task is entirety for itself and it does not exist the unique model which can be used for solving each task. There are several rules which must be obeyed for each task in order to come to results easier (Ausubel, 1978; Eilks & Hofstein, 2013; Schoenfeld,1992):

1. Read the problem carefully and write down what is given (and where appropriate several times) to capture the essence and a sense of the task, and understand the problem means comprehension which chemical law or phenomenon to use, which sizes are known and which must be determined.

2. Make a plan for problem solving.

3. If you can't make a plan, read the problem again and break it down into parts.

4. Name of each element or compound replace with its symbol.

5. Determine which interconnected sizes are given in the problem.

6. Write down conclusions stemming from the conditions of the task, solve part of the problem.

7. Try to solve the problem till the end.

8. During entering the solutions look done, whether it is possible to simplify the solution.

9. Try to explain your solution

As methodical preparation of the exercise went into five phases, examiners accepted one unique way of marking results. Each successfully made up step during problem solving was evaluated with one point, so solving of the whole exercise was evaluated with five points. On that way it is possible objective consideration of even incomplete exercises.

In order to better understand the significance and advantages which methodical preparation gives during solving of the problem, we have made two groups with fourteen students of the second year high school-course agricultural technician. The first group of the students had the opportunity to have methodical explanation of ways and means of problems solving in chemistry. The second group only got the problems to be solved without methodical preparation. The aim of our experimental work was to establish the contribution of methodical preparation during task solving. Almost all stoichiometric tasks can be solved into five simple steps, with only a basic knowledge of mathematics (Fach, 2007). Steps in problems solving are: extract data from tasks; reduction of all units to the same measure; writing of balanced reactions; determination of stoichiometry; calculation of required sizes (Greenfield, 1987; Polya, 1985). Firstly it was set a specific task and methodical solving with the explanation of each step of the work. The following problem was given to the first group:

Calculate the concentration of hydrochloric acid if for the titration of 0.2451 g of sodium carbonate was spent 23.09 cm³ of hydrochloric acid.

Then it was continued with methodical treatment of the problem step by step.

Step 1 - Extract information from the task. Before doing anything, read the problem carefully. When you know what is required to do, separate it from other data, and arrange them on the basis of compounds. The purpose of this is to make easier dealing with the task and to help you to find necessary formulae. Take care when you write physical sizes to always label (in parenthesis or as an index) (it can be atom, molecule, ion, …). Physical quantity without label of the compound has no meaning.

$$c\,(HCl)= ?\ mol\ dm^{-3}$$
$$V\,(HCl)= 23.09\ cm^3$$
$$m\,(Na_2CO_3)= 0.2451\ g$$
$$M\,(Na_2CO_3)= 106\ g\ mol^{-1}$$

Figure 1. Starting purpose of exam

Students are made aware that the last data is not present in the problem. If we know that, whenever it is necessary, and usually it is the case when you are working with weighs, mass of the mole of one element or the compound can be found in the periodic system of the elements.

Step 2 - All units are getting reduced to the same measure. Very often it is the case that all unites are mixed in the problem (as it is the case in the problem-volume is given in cm³ and the concentration in mol dm⁻³), so it is necessary to reduce them to the same measure (it is the best to transform everything into mol, dm³, g). For this job it is best to use simple dimensional analysis. It is necessary to be careful and remember: always when some mathematical operation is performed with the unit, you must do the same with the number in front of it (and *vice versa*). For example, if 1 dm contains 10 cm, then 1 dm³ contains 10 cm³, 1 dm³ contains 1000 cm³ or written in the mathematical way 1 dm³=1000 cm³. The reciprocal relation (1000 cm³/1 dm³) can be written if it is more appropriate for the problem. In both cases the result is the same. You should choose the form, in which when all collapse, on the right side stay only the unit into which we are performing the conversion.

$$23.09\ cm^3 = ?\ dm^3$$
$$23.09\ cm^3 \cdot \frac{1\,dm^3}{10^3\ cm^3} = 23.09 \cdot 10^{-3}\ dm^3$$
$$id\ est\ 23.09\ cm^3 = 23.09 \cdot 10^{-3}\ dm^3$$

Figure 2. Conversion of units with the aim for easier calculation

Step 3 - Write the balanced equation. Now, when we find out what is required, we are crossing to the most important step-balancing of the chemical equation.

$$Na_2CO_3 + 2\,HCl \rightarrow H_2O + CO_2 + 2\,NaCl$$
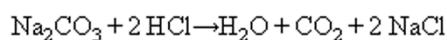
Figure 3. Balanced chemical equation of exam reaction

Without balanced chemical equation, it is not possible to solve the problem. When the equation of the chemical reaction is balanced, from it the ratio can be determined (stoichiometry).

Step 4 - Stoichiometry is being determined. The purpose is to connect what is asked with what is present. The process is simple. Looking into balanced equation, the ratio is written of two compounds on one side and ratios of numbers beside them (otherwise known as stoichiometric numbers or stoichiometric coefficients) from the other side of the equal sign. If in front of the formula of some species there is no number-stoichiometric coefficient is 1. The above expression you can read as follows: number of molecules of sodium carbonate regarding the number of molecules is related as 1:2, and you can use the same rules as to the numbers in algebra.

Step 5 - Required size is being calculated. From data it can be seen that units of concentration (mol/dm^3) and molar mass (g/mol) inside contain mole. The formula is written:

$$n(HCl) = c(HCl) \cdot V(HCl)$$
$$n(Na_2CO_3) = m(Na_2CO_3)/M(Na_2CO_3) = 0.2451g/106gmol^{-1} = 0.0023 \, mol \, Na_2CO_3$$
1 mol of Na_2CO_3 reacts with two moles of HCl
1 mol Na_2CO_3 : 2 mol HCl = 0.0023 mol Na_2CO_3 : x mol HCl
Solving a set proportion, we are getting the solution x=0.0046 mol.
Now, we can calculate the concentration of HCl because we have all necessary data:
$$c(HCl) = n(HCl)/V(HCl) = 0.0046 \, mol/23.09 \cdot 10^{-3} \, dm^3 = 0.2 \, mol/dm^3$$

Figure 4. Main calculation of exam

After methodical processing of data, it was approached to solving of two more problems, so students went in front of blackboard and with the help of professor solved problems. They got for the homework two exercises of similar type. The next class exercises were analyzed which were done at home and it was pointed out to mistakes made by students. The next week the term was defined for the solving of problems in which it was merged the first group which had an opportunity to exercise the problems of that type, and the group which met that problems only on the basis of theoretical knowledge and knowledge possessing from before in problems solving.

The following exercises were set:

1. Calculate the quantity of barium-chloride and sulfuric acid necessary to obtain 850 g of barium-sulfate.

2. Calculate how much oxygen for the oxidation of 15.4 g of iron is necessary, and how much you got iron (III)-oxide.

RESULTS OF RESEARCH

The first group has achieved much better results. The number of points on the group level is 42 points in favor of the first group. The success of the first group is approximately 64 %, and the success of the second group is 37 %.

Table 1. Results of experimental study

Number of points	Number of students	1-2	3-4	5-6	7-8	9-10	Total	Average
1st group	13	0	3	3	3	4	83	6.38
2nd group	11	4	3	1	2	1	41	3.73

CONCLUSIONS

On the basis of the results of methodical and didactic experiment, we are drawing the following conclusions: group of the students that got methodically explained exercises have achieved significantly better results, so it serves as a proof of the assumption in theoretical part that methodical preparation in problem solving is inevitable and necessary, and its practical importance is multiple.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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