

***El desarrollo de la competencia profesional elaboración  
de problemas químicos con cálculos en la Educación de  
Adultos***  
***The development of professional competence elaboration  
of chemical problems with calculations in Adult  
Education***

**Luís Manuel Bucheró Portuondo** ORCID: 0000-0003-1949-8390

**René Planche Jardines**

Universidad de Guantánamo, Cuba

**Correo(s) electrónico(s):**

yiyanen@cug.co.cu

planche@cug.co.cu

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**Resumen:** La resolución de problemas químicos con cálculo es un objetivo básico de la Química y una problemática en la Educación de Jóvenes y Adultos. Con el presente artículo se contribuirá al desarrollo de la competencia profesional resolución de estos problemas, y elevar la preparación didáctica metodológica de los profesores de Química de esta enseñanza. A través de conferencias, talleres y secciones de entrenamiento donde se modelaron actividades prácticas para desarrollar dicha competencia se contribuyó a elevar el desempeño profesional de los docentes y el nivel de desarrollo de las habilidades de los estudiantes para resolver este tipo de problemas.

**Palabras clave:** Problemas químico; Cálculo químico; Competencia profesional; Razonamiento científico

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**Abstract:** Chemical calculation problems constitute one basic objective of Chemistry and a problematic in Adult and Youth Education. Throughout this research it is a purpose to contribute to the development of the methodology for chemical calculation problem solving exercises and its professional competence in Chemistry teachers of adult level as well as to raise in quality its didactic and methodological preparation. In that sense, conference, workshops and performance of problem solving activities were developed. As a final result it was raised in quality the professional performance of teachers, and correspondingly a higher level of chemical calculation solving skills in students.

**Keywords:** Chemical problems; Chemical calculation; Professional competence; Scientific reasoning.

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## **Introduction**

The raising of the quality of teaching and education constitutes the main task of teachers, in the Education of Young People and Adults, which contributes to the achievement of the fundamental objective: the comprehensive and harmonious formation of personality and preparation for life.

In our country, the undergraduate curriculum in all education subsystems is designed by skills, but in modern times, many investigations have been carried out on competency-based curriculum design, since the latter are more comprehensive than skills.

The formation of curricula by competences has become today one of the modern options most used by the education and culture systems of many countries. In our country, many researches carried out promote competency-based curricular designs, bearing in mind that competence is more comprehensive and comprehensive than ability, and that it may even include several of the latter in just one of the former.

There are multiple definitions of competencies. Most of them are conceived as performance units that express what a person must know and know how to do in order to perform well. It includes cognitive, metacognitive, and behavioral and experience aspects.

In the teaching of Chemistry, one of the competences that contributes to the intellectual development and logical thinking of students is solving chemical problems with calculations, which is why the authors consider their improvement a necessity.

Chemical calculations studied at the middle level include: the relationships between masses, amount of substance, volume, and number of particles between substances and during chemical reactions. Others are related to the concentration of solutions, determination of heats of reaction and the electrochemical part. In all cases it is necessary to know the units in which these magnitudes are expressed.

Many researches carried out confirm limitations in the performance of Chemistry teachers of Youth and Adult Education when teaching this content and in the students during the resolution of these types of chemical problems with calculations, their proposals emphasize the need for their improvement, for which we consider it necessary not only to master the mathematical algorithm, but the exercise of the ability to understand texts and involve the transit through the operations of thought, so that, in addition to education, instruction in student development is achieved, as well as its relationship with data that shows the reality of local development that connotes the significance of the chemical content and its link with life.

The empirical verification made by the authors to know the state of development of the Solving Chemical Problems of Calculation competence, in students of Youth and Adult Education, allowed to find some limitations, among which are:

- 1.-Deficiencies in the didactic and methodological preparation of teachers that limit the development of professional competence solving chemical problems with calculation in students.

2.-Insufficient training in the comprehension of texts and the use of chemical background knowledge necessary for solving problems.

3.-Poor command of the system of actions and operations for solving chemical problems with calculations by students.

From the insufficiencies found and to make a didactic contribution to this problem, it is the objective of the authors of this work: To develop practical, didactic and methodological recommendations for the development of professional competence, elaboration of chemical problems with calculations in Youth Education and Adults.

## Development

In the 1960, the term competence was introduced as part of the objective assessment of learning (British Columbia University). This approach consists in the design, development and evaluation of the curriculum being oriented to the probability of mobilizing a set of resources (knowing, knowing how to do and knowing how to be), to solve a problem situation. The term competence is more than knowledge and skills, it implies understanding the problem and acting rationally and ethically to solve it.

This approach emerges as one of the responses to a set of existing insufficiencies in students upon graduating at different levels or professions, which often limit it to act in solving reality problems in their different contexts.

One of the senses of competence is understood as the ability to mobilize various cognitive resources to cope with a type of situation. It contains four aspects:

1. Competencies are not in themselves knowledge, skills or attitudes, in isolation, but they do mobilize and integrate such resources.
2. This mobilization is only relevant in a situation, and each situation is unique, although it can be treated by analogy with others already known.
3. The exercise of competition goes through complex mental operations, sustained by thought patterns, which allow determining and carrying out an action relatively adapted to the situation.
4. Professional competencies are created, in training, also at the mercy of the daily navigation of the practitioner, from one work situation to another.

Competence: gives meaning to learning; by relying on problem solving, it makes students more effective, by ensuring better permanence of achievement, distinction of essentials, and linkages between notions; it supports further learning, favors the use of strategies by students to manage new learning and fosters self-learning, guiding the student to self-manage their own knowledge.

According to Resolution 21/99 of the Ministry of Labor and Social Security in Chapter 1, Article 3, subsection c, defines competence as:

... set of theoretical knowledge, abilities, skills and aptitudes that are applied by the worker in the performance of his occupation or position, in correspondence with the technical, productive and service requirements, as well as those of quality, that are required for the proper performance of its functions. (p.1)

Spencer and Spencer (1993) define competence as "... an underlying characteristic of an individual that is causally related to effective or superior performance in a situation or job defined in terms of criteria". (p.65)

From a psychological point of view, González (1999) quotes Rodríguez and Feliu (1996), who define professional competence as: "a set of characteristics of a person directly related to successful execution in a given task or job." (p.2)

Thus, González (1999) highlights competencies as permanent characteristics of people, which have a causal relationship with job performance, that is, they are not associated with success but actually cause it, they can be generalized to more than one activity and combine the cognitive, the metacognitive and the behavioral. (p.2)

Such points of view lead the authors of this article to reflection and analysis on the development of the development of chemical problems with calculations in the teaching of Chemistry in Youth and Adult Education. This teaching aims to develop the conviction of the relationship of chemical knowledge with life, but without departing from the term ability, to which is added the role of metacognition and the motivational affective character in the process.

Generally when talking about chemical problems, these are linked to the so-called "chemical calculation" or what is the same, the concept is reduced to a type of problems that are what in the Chemistry teaching methodology are known as problems quantitative chemicals.

Related to the chemical problems of calculation, Zuieva (1978), refers "... at present in different manuals there are problems for the solution of which, the students use only the mathematical knowledge... but the chemical part, that is, the essence of phenomena and concepts are not elucidated", quoted in Rojas.et.al. (p.70).

It is important to bear in mind that the quantitative problems for their solution require not only the application of mathematical knowledge, but also chemical knowledge, where the scientific method can be used during its analysis and solution, since if the mathematical aspect is overvalued, the pedagogical approach to the problem and the scientific reasoning of the students.

Thus, mathematical knowledge supports operations to solve the problem, while chemical knowledge represents the essence of this problem. Hence, quantitative chemical problems must be chemical in nature and arithmetic in form.

In arithmetic problems all the data are offered in their statement, while in quantitative chemical problems, many of the data must be inferred from certain concepts, laws or principles that the student must master in order to solve it, however, it is the criteria of the authors that during the elaboration of the same, the scientific method must be taken into account, which leads the student to the approach, verification and reformulation of hypotheses that contribute to their scientific reasoning.

At the national and international level, there have been several authors that the field of Chemistry have made proposals to enhance the formation and development of scientific reasoning as a superior operation of scientific thought, among them we quote Huffman, D. (1997), Quintanilla, M. (2012); Y.J. Hedesá, (2013): these recognize the curricular pathways for the development of scientific reasoning.

Reasoning is a mental process by which new judgments are obtained from others already known, that although it cannot be directly observed, there are observable manifestations of that thought, which allow us to infer some characteristic processes of individual activity and, in particular, of the way to act before problem situations.

Based on the above, scientific reasoning in Chemistry, understood as a mental process, cannot be directly observed. However, from observable manifestations of this thought we can infer some characteristic processes of activity of the chemist and, in particular, of the way of acting of the chemist before situations that involve in their solution to Chemistry.

In general, these authors highlight some aspects, linked to the reasoning manifested in the work of Chemistry scientists and researchers, although we will refer to those that, in the opinion of the authors of this work, manifest themselves systematically.

- They seek to know the essence of the phenomenon, based on the scientific method;
- They carry out a process of abstraction and generalization of the chemical phenomenon under study;

- Questions are asked, investigated for demonstration or rebuttal;
  - They use experimentation as the main source of knowledge of the phenomenon under study;
  - They try to recognize the applicability of the phenomenon and from it guide their cognitive activity;
- 1) Basic steps to enhance students' scientific reasoning based on a problem based on the development of the competence, elaboration of chemical problems with calculus.
  - 2) 1) Approach to the problem (chemical problem with calculation):
  - 3) it is the first step, it can be raised or brought up by the teacher or by the students, in this it must be guaranteed that the learning situation contained in the problem is contextualized, enhancing knowledge chemicals and have a problem approach.
  - 4) 2) Interpretation of the problem:
  - 5) this stage includes a detailed analysis of the task, starting from the determination of the object of study, here the modeling of the system is carried out and the essential, non-essential and unknown data are determined. It requires a theoretical study of the content of the situation presented.
  - 6) 3) Approach to the hypothesis: it consists of predicting the expected results, which is done based on the theoretical and practical knowledge acquired and previous calculations, if necessary.
  - 7) 4) Preparation of the solution plan: it is the logical outline of the solution to the task, the sequence of operations to be performed, proposed by the students.
  - 8) 5) Execution of the solution plan: it is the performance of the different actions of a theoretical - experimental nature and the corresponding interpretations and explanations of the observed phenomena.
  - 9) 6) Conclusions: they are reached at the end of the activity, where the correspondence or not with the expected results, the possible sources of errors and the corresponding explanations are assessed. The conception of new problems should be oriented.

One of the greatest difficulties in the statement of these problems lies in the ranking of arithmetic skills above the chemical reasoning that students must carry out and the lack of an educational approach in such statement, which very rarely involves data related to local, productive or some community problem development.

As for the place occupied by the study of chemical problems with calculations, we can say that these are addressed throughout the study of Chemistry. From the first concepts and laws that are studied at the basic intermediate level, the need arises to apply mathematical calculation to chemical

knowledge. Thus, for example, when studying the concepts of relative atomic mass, molar mass, symbols, formulas, reactions, and chemical equations, the law of conservation of mass, and Avogadro's principle, the necessary conditions exist to solve problems of type: mass - mass; mass - volume and volume - volume.

Chemical problems with calculations are studied in secondary education as a way to acquire, consolidate, and verify chemical knowledge, but they must be addressed systematically to achieve the development of the skill until reaching competence and to achieve the development of both logical thinking. as a scientist and enhance chemical knowledge in students. These problems will become more complex as new content is studied. Thus, in the case of gaseous substances and the students have already studied the molar volume, a combined calculation can be carried out where, knowing the volume, they determine the mass and vice versa.

The adequate formulation of chemical calculation problems, guarantee the polytechnical training of students, the link of the chemical content with life, professional orientation, and fulfill the educational work from instruction, as a way to achieve cognitive independence in young and adult students.

Chemical calculation problems must be solved independently by the students under the direction of the teacher, who must always keep in mind the follow-up to the diagnosis and the use of the potentialities and capacities of their students; hence, they must be differentiated.

In the transition from one stage to another, the recommendations for the training of skills suggested by Chernovielskaya (1982), in his book on Chemistry Teaching Methodology, are endorsed by Rojas (1990. p. 73), when proposing the points of view that must be taken into account by the teacher as recommended objectives to enhance logical thinking and chemical knowledge during the elaboration of chemical problems with calculus:

1. - What concepts, laws, theories and facts must be consolidated in the resolution process? Which of the properties of the substances studied and which chemical reactions should be taken into account in the resolution process?
2. - What are the procedures for solving the problem that must be formed?
3. - How to analyze and understand the text of the problem for its resolution?
4. - What didactic functions does the resolution of the given problem fulfill, review, generalization, consolidation of the new material, knowledge checking, training, etc.

In this regard, the authors consider taking into account a fifth and sixth objective, which relates to what extent is education from the instruction in the orientation and resolution of the chemical

problem with calculation and how is the local agro-industrial, productive or environmental problem reflected?

How does the problem situation stimulate the student's scientific reasoning?

At the intermediate level, chemical problems with calculation are developed on the basis of formulas of substances, equations of chemical reactions, concentration of solutions, heat involved in chemical reactions, where the behavior of quantities such as: the mass, the amount of substance, the volume and the number of particles, among others. To carry out the calculations on the basis of a chemical reaction, in addition to having the equation of the chemical reaction in question adjusted, it is necessary to have the necessary data for its resolution.

In the correct conception and resolution of chemical problems with calculations that are studied at the intermediate level, the most important thing is that they comply with the chemical essence in the interpretation and application of laws, principles and theories, and also have mastery of skills. of mathematical calculation necessary for the case in question, hence the student must be made aware of the importance of developing skills in solving this type of problem and its application in everyday life.

Reiterating the difference between exercise and problem in broad strokes, it can be said that such distinction is given by the subdivision of the application level, into reproductive and productive (Bermúdez and Rodríguez (1999). During the resolution of exercises, the reproduction of knowledge prevails and instrumentations, during problem solving, the application prevails.

As the chemistry course progresses at the intermediate level, chemical calculations will become more complex for their contribution to the development of students' logical thinking and professional competence for their resolution. In this way, integrative exercises involving chemical calculation actions, such as the one shown below, can be carried out.

Taking into account the composition of acids and bases, predict the acid - base properties of the ammonia ( $\text{NH}_3$ ) solution. What mass of dinitrogen ( $\text{N}_2$ ) will react with enough dihydrogen ( $\text{H}_2$ ) to obtain 51g of ammonia ( $\text{NH}_3$ )? What volume will the obtained gas occupy? Data:  $M(\text{N}_2) = 28\text{g.mol}^{-1}$   $M(\text{NH}_3) = 17\text{g.mol}^{-1}$  As can be seen in the proposed activity, a problem or contradictory situation is created at the level reached by the students, its solution requires the application of the steps proposed by Chernovielskaya (1982), accompanied by the application of previous knowledge. Of the students, who serve as the basis for the solution of the problem situation previously created.



At first, the acid-base properties of the solutions will be consolidated following the following procedure:

Once the teacher analyzes some examples of acids and bases emphasizing the classification of each of those substances, based on their composition, placing two columns with each type of previously classified substance, you can rethink the students, the first part of the theoretical-practical activity oriented:

Predict the acid - base properties of the aqueous solution of ammonia,  $\text{NH}_3$ .

If its chemical composition is taken into account, the students would classify it as an acid, taking into account the presence of Hydrogen, H atoms, in its composition, ( $\text{NH}_3$ ) The acid-base character of the solution will be verified in practice by the following procedure:

1. - The teacher will guide the students to proceed to the identification of the acid-base properties of the solution using the indicators.

By identifying it experimentally using indicators, its behavior is checked as a basis, this produces a contradictory or problem situation in the students with respect to their previous knowledge, taking into account the composition of the anhydrous substance represented, ( $\text{NH}_3$ ).

To solve the contradiction created, the teacher will guide the completion of a sequence of steps or partial search problem procedures:

- a).- Analysis of the electronic structure of the Nitrogen atom, based on the Lewis theory.
- b).- Determination of the Lewis structure for the ammonia molecule,  $\text{NH}_3$ , emphasizing the unshared electron pair of the nitrogen atom capable of accepting a proton.
- c) .- Analysis of the structure of the water molecule, taking into account the presence of hydrogen bonding and the possibility of autoionizing, promoting the formation of the ammonium ion and the generation of hydroxyl groups.
- d). - Analysis of the formation, composition and structure of the Ammonium Hydroxide molecule, as a product of the union of the molecules of the above substances.

$\text{NH}_3 (\text{g}) + \text{H}_2\text{O} (\text{l}) = \text{NH}_4\text{OH} (\text{ac})$ . The  $\text{OH}^-$  ion present in the solution is the cause of the red coloration and the basic behavior of the aqueous ammonia solution.

In this way, the problem situation created is solved, with the active participation of the students, and the concepts of acid and base until now treated at an empirical-analytical level will be expanded. From this moment, these concepts will be defined in light of a new theory.

e).- Extension of the concepts of acid and base according to the Brönsted - Lowry theory. Acid: Any chemical substance or proton-bearing ion.

Base:

Any ionic or molecular chemical capable of accepting a proton. After solving this first part of the exercise; that is to say, its chemical essence, in itself, very stimulating for students due to its theoretical - experimental nature, we would complete the arithmetic solution of the rest of the exercise.

## Conclusions

The resolution of chemical problems with calculations constitutes one of the objectives of the Chemistry program in the Education of Young People and Adults, its correct realization allows the development of logical thinking and intellectual skills in students, in addition to linking chemistry with life in a developer learning teaching process.

Chemical problems with calculations require analysis of the essence of the phenomenon from the chemical point of view, as well as arithmetic skills for its resolution.

The development of professional competence in solving chemical problems with calculus requires training of students based on the use of certain methodological procedures and their independent activity under the direction of the teacher, who must keep in mind the diagnosis of each of its students and its systematic attention to the transition to a qualitatively higher level of learning.

The Chemistry teacher must take advantage of the potentialities and experience of the students to link the problem solving of quantitative chemical calculations with life and context, consolidating the structure -properties-applications relationship of the substances.

Chemical calculations must be carried out on the basis of real problems in production, industrial or community processes, evidencing the relationship of chemistry with life. As a result of the application of work-oriented procedures and methodological steps, it contributed to the development of professional competence: solving chemical calculation problems, which led to an improvement in the pedagogical professional performance of Chemistry teachers in the Education of Youth and Adults.

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