



# DEVELOPING PROBLEM-SOLVING SKILLS IN CHEMISTRY BASED ON DIDACTIC MATERIALS

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## Abstract

This article examines the role of didactic materials in developing students' problem-solving skills in chemistry. The study highlights the importance of using visual aids, interactive tasks, structured exercises, and methodological tools to enhance learners' understanding of chemical concepts and improve their ability to solve various types of problems. Special attention is given to the organization of learning activities that promote logical thinking, independent analysis, and practical application of theoretical knowledge. The results show that systematic use of didactic materials increases students' engagement, strengthens their cognitive abilities, and leads to more effective learning outcomes in chemistry education.

**Keywords:** chemistry education, didactic materials, problem-solving skills, chemical problems, teaching methods, interactive learning, cognitive development, independent learning, practical skills, logical thinking.

## Introduction

In the context of the continuous development of the educational process, teachers strive to enhance students' interest in science by applying various teaching methods and approaches to achieve effective learning outcomes. In teaching chemistry, educators widely use visual aids, presentations, handouts, and other instructional materials to improve students' theoretical knowledge. However, in lessons focused on problem-solving, the process is often limited to using methods provided in textbooks or supplementary literature. This indicates the need to more effectively integrate didactic materials into problem-solving activities in order to develop students' independent thinking, analytical abilities, and practical skills.



In teaching chemistry, especially when students are divided into small groups and assigned independent tasks, effective results can be achieved. During problem-solving lessons, students tend to develop independent thinking and strive for creative work. Even lower-performing students are motivated to reach the level of higher-achieving peers, which ultimately improves overall class performance. Engaging in various forms of independent work, such as individual and pair-based activities, helps deepen students' knowledge and develop essential skills, making the learning process more effective and purposeful. In solving chemical problems and exercises, it is important to encourage independent work with textbooks, promote the use of additional literature, and enrich lessons through activities such as crosswords and quizzes.

Didactic materials encompass all types of elements and tools specifically designed for teaching purposes. In other words, they are resources that teachers use to effectively organize and conduct the learning process together with students. These materials play a crucial role in facilitating understanding and supporting the teaching–learning process.

Teaching methods, in this context, can be defined as material means that simplify and enhance instructional activities. They may be presented in physical or digital forms and are aimed at stimulating and developing students' interest. Didactic materials serve as guiding resources that help structure the content of a subject. Typically, such materials are prepared by the teacher, who adapts them according to their teaching style and the objectives of the lesson. However, there are also many specialized publishers that develop and provide educational resources.

It is important to note that the method of teaching and learning represents a set of steps aimed at transforming the learner by improving their knowledge and developing their skills. The characteristics of didactic materials may vary depending on instructional goals, students' abilities, learning conditions, and access to infrastructure and technology. For example, didactic materials designed for chemistry education differ significantly from those prepared for subjects such as art history, as they require a more practical, experimental, and visual approach.

### **Characteristics and Functions of Didactic Materials**



Among the key characteristics, didactic materials can be adapted for use both with and without teacher guidance. They may be applied individually or in group settings, making them flexible and versatile in different learning environments. Didactic materials are designed to stimulate students' interest; therefore, their structure and presentation should attract attention and encourage engagement with the subject matter.

They also serve as important sources of information, helping to organize and present knowledge in a more accessible and understandable way. In addition, didactic materials help regulate the pace of learning by considering students' cognitive development, abilities, interests, and individual differences. They provide opportunities for learners to evaluate their own knowledge, plan and organize their learning strategies, and reflect on or reassess their understanding, thereby promoting deeper comprehension.

Another essential requirement is that didactic materials should be readily available when needed and specifically designed according to the target group to ensure their effectiveness. Among their main functions is to act as a medium for delivering relevant information in a clear and structured manner. Ultimately, all didactic materials are goal-oriented; their development begins with identifying the specific purpose or objective they are intended to achieve.

### **Importance of Educational Materials**

Since didactic materials are an integral part of the learning process, they play a crucial role in ensuring the effectiveness of the interaction between teaching and learning. Any resource used as a didactic material helps create appropriate conditions for the successful implementation of the teaching methodology planned by the teacher.

Moreover, didactic materials provide an optimal way for teachers to establish a productive learning environment in the classroom. Through their proper selection and application, teachers can more effectively achieve the intended educational objectives and enhance the overall quality of instruction.

### **Results and Recommendations**



Didactic materials facilitate the learning process, establish effective interaction between teachers and students, and provide a structured framework that allows learners to perceive their progress. Therefore, they become an essential resource in any educational process.

### **General Guidelines for Solving Chemistry Problems**

It is well known that in chemistry, mastering theoretical knowledge and reinforcing it is often achieved through problem-solving. Therefore, organizing the process of solving problems correctly is of great importance.

How are chemical problems and exercises solved? To solve any problem effectively, a clear plan is required. The following plan can be widely applied and will be helpful in solving various types of problems. The problem-solving process consists of four main stages:

1. Understanding the problem – carefully read the task, identify given data, and determine what is required.
2. Planning the solution – select appropriate formulas, concepts, or laws needed to solve the problem.
3. Carrying out the solution – perform calculations or logical steps systematically.
4. Checking the result – verify the correctness of the answer and ensure it is reasonable and consistent with the problem.

Following this structured approach helps students develop logical thinking, accuracy, and confidence in solving chemical problems.

#### **Stage I: Understanding the Problem**

1. **Identify what is given and what is required** – Determine what data is provided in the problem and what you are asked to find or prove. Restate the problem in your own words to ensure you fully understand it.
2. **Analyze the given information** – Identify the chemical formulas, reactions, or concepts mentioned in the problem and their properties. Recall what you already know about these concepts. Highlight the key information provided in the problem statement.
3. **Visualize the problem** – If possible, draw a diagram, chart, or scheme. Visual representation can clarify relationships between elements and make the problem easier to understand.



4. **Determine additional information needed** – Consider what other data, rules, or properties may be necessary to solve the problem. Recall relevant chemical formulas, reaction relationships, and principles that connect the given elements to the ones you are asked to find.

5. **Check completeness of information** – Ensure that all necessary data about the chemical concept, law, or reaction involved is available. Identify any missing information required to solve the problem and make sure you have a clear understanding of all elements before proceeding to the solution.

### **Stage II: Planning the Solution**

1. **Recall similar problems** – Have you solved a problem like this before? Think about other problems that are similar and how they were solved.

2. **Identify applicable rules or principles** – Determine which chemical laws, formulas, or properties can be applied to solve this problem.

3. **Choose a solution strategy** – Decide on the method or approach you will use to solve the problem. Outline a step-by-step plan for implementing this strategy.

### **Stage III: Implementing the Solution Plan**

1. **Follow the plan step by step** – Solve the problem systematically according to your outlined plan. Clearly show each step in your work.

2. **Use visual aids if necessary** – If helpful, include diagrams, charts, or other supporting elements to clarify your solution.

3. **Write the answer** – Present the final solution clearly and concisely.

### **Stage IV: Verification**

1. **Check your answer** – Did you answer the question posed in the problem? Make sure your solution directly addresses the task.

2. **Evaluate the solution** – Does your answer satisfy the conditions of the problem?

3. **Consider alternative methods** – Could the problem be solved in a different, perhaps more efficient way? Reflect on other approaches.

4. **Reflect on learning** – What have you learned that can help in solving other problems? Recall previous problems or methods that could be applied to new situations.

## Using Didactic Materials to Enhance Interest in Problem-Solving Lessons

In problem-solving lessons, students' interest in chemistry can be increased through the use of various didactic materials that combine theoretical knowledge with practical exercises. For example, colored cards corresponding to the periodic table can be prepared: red, yellow, blue, and green cards cut into different shapes such as circles, squares, and triangles from sturdy cardboard. Problems are written on these cards.

The answers to the problems are designed so that each result corresponds to a specific card color:

**Yellow cards** – elements of the P-family

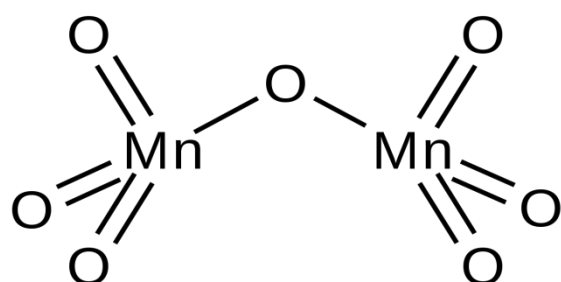
**Red cards** – elements of the S-family

**Blue cards** – elements of the D-family

**Green cards** – elements of the F-family

When a student calculates the correct number, it matches the color of the corresponding card, indicating the element's family. The student then identifies which element it represents and presents information about it. This interactive approach not only reinforces problem-solving skills but also strengthens students' understanding of periodic table patterns and element properties, making the learning process engaging and memorable.

**Problem:** How many total bonds are present in  $\text{Mn}_2\text{O}_7$ ?



**Nitrogen (N)**

**Physical properties:** Colorless, odorless gas.

**Chemical activity:** Extremely inert under normal conditions; reacts only with lithium under standard conditions.

**Biological role:** Nitrogen is one of the essential nutrients for plants.

**Occurrence in soil:** Its mineral and organic compounds enter the soil through precipitation or as fertilizers.

**Presence in plants:** Most nitrogen in plants is found in proteins. The nitrogen content in various seed proteins ranges from 16.5% to 17.5%.

**Agricultural significance:** In crop rotation with cotton and clover, one hectare of clover produces up to 20 tons of organic matter rich in biological nitrogen, containing approximately 400–600 kg of nitrogen per hectare.

This summary can be used as a reference card for your didactic material activity, linking the nitrogen element to its properties and practical significance.

**Example Problem: Calculating the Mass of Dolomite ( $\text{CaCO}_3 \cdot \text{MgCO}_3$ )**

**Step 1: Analyze the formula**

The chemical formula is  $\text{CaCO}_3 \cdot \text{MgCO}_3$ .

We need to calculate its **molecular mass**.

**Step 2: Determine atomic masses**

Calcium (Ca) = 40

Magnesium (Mg) = 24

Carbon (C) = 12  $\rightarrow$  2 atoms  $\rightarrow 12 \times 2 = 24$

Oxygen (O) = 16  $\rightarrow$  6 atoms  $\rightarrow 16 \times 6 = 96$

**Step 3: Calculate total molecular mass**

$$\text{Molecular mass} = Ca + Mg + 2C + 6O = 40 + 24 + 24 + 96 = 184$$

**Answer:** The **molecular mass of dolomite** is **184 g/mol**.

**Didactic material link:** This value corresponds to the atomic mass of tungsten (W) in the periodic table. In the activity with colored cards, this problem would be placed on a blue card, representing D-family elements. This approach helps students connect calculations with periodic table elements and reinforces both problem-solving and conceptual understanding.

**W – Tungsten (Volfram)** Origin of the name: W, or tungsten, gets its name from the mineral “tungsten,” also called “heavy stone”. Properties and uses: When heated in any electric bulb, tungsten filaments emit light. For electrotechnical purposes, only a small amount of tungsten is needed—approximately 1 kg of tungsten is sufficient for 20,000 light bulbs. Classroom application: During lessons, the teacher monitors students’ progress and evaluates their understanding. Additionally, tests and handouts can be used to assess students’ knowledge throughout the lesson.

The context of a chemistry problem refers to a situation that involves specific elements and their properties within the environment. These situations often relate to real-life scenarios and may require a certain level of chemical analysis. In problem-solving lessons, didactic materials are particularly effective in stimulating students’ interest and connecting content to situations familiar to their personal experiences.

The use of handouts and other didactic materials in chemistry problem-solving lessons is increasingly common and demonstrates clear positive effects. Successfully integrating such materials requires high pedagogical skill to simultaneously develop students' knowledge, abilities, and practical skills. Providing relevant information, rules, and example texts as handouts plays a critical role in making lessons more engaging, structured, and effective.

<p><b>1</b> How many sigma bonds are in <math>(\text{CuOH})_2\text{CO}_3</math> (Malachite)?</p> <p>Answer: <b>9 <math>\sigma</math></b></p> <p>Be – Red (S-family)</p>	<p><b>2</b> How much <math>\text{O}_2</math> is needed to obtain <b>26 g</b> of <math>\text{H}_2\text{O}</math>?</p> <p>Answer: <b>23 g</b></p> <p>Na – Red (S-family)</p>	<p><b>3</b> Find the mass fraction of <b>Ca</b> in <math>\text{CaCO}_3</math>.</p> <p>Answer: <b>40%</b></p> <p>Ca – Red (S-family)</p>	<p><b>4</b> 23.4 g Li reacts with <math>\text{N}_2</math>, How much <math>\text{Li}_3\text{N}</math> is formed?</p> <p>Answer: <b>39 g</b></p> <p>K – Red (S-family)</p>
<p><b>5</b> How many <b>total bonds</b> are in <math>\text{Mn}_2\text{O}_7</math>?</p> <p>Answer: <b>14</b></p> <p>N – Yellow (P-family)</p>	<p><b>6</b> Calculate the sum of coefficients: <math>\text{P} + \text{O}_2 \rightarrow \text{P}_2\text{O}_5</math></p> <p>Answer: <b>11</b></p> <p>B – Yellow (P-family)</p>	<p><b>7</b> Molecular mass of <math>(\text{CuOH})_2\text{CO}_3</math>?</p> <p>Answer: <b>222 g/mol</b></p> <p>Rn – Yellow (P-family)</p>	<p><b>8</b> Mass fraction of <b>S</b> in <math>\text{CuSO}_4</math>?</p> <p>Answer: <b>20%</b></p> <p>Ne – Yellow (P-family)</p>
<p><b>9</b> How much <b>P</b> is needed to get <b>150 g</b> of <math>\text{P}_2\text{O}_5</math>?</p> <p>Answer: <b>65 g</b></p> <p>Cu – Blue (D-family)</p>	<p><b>10</b> Mass of Dolomite (<math>\text{CaCO}_3 \cdot \text{MgCO}_3</math>)?</p> <p>Answer: <b>184 g</b></p> <p>W – Blue (D-family)</p>	<p><b>11</b> Mass of <b>CaO</b>?</p> <p>Answer: <b>56 g</b></p> <p>Fe – Blue (D-family)</p>	<p><b>12</b> Mass of <b>Ag<sub>2</sub>O</b>?</p> <p>Answer: <b>232 g</b></p> <p>Th – Green (F-family)</p>

**1** How many sigma bonds are in  $(\text{CuOH})_2\text{CO}_3$  (malachite)?  
Answer: 9  $\sigma$  bonds  
Be - Red (s-family)

**2** How many grams of  $\text{O}_2$  are needed to obtain 26 g of  $\text{H}_2\text{O}$ ?  
Answer: 23 g  $\text{O}_2$   
Na - Red (s-family)

**3** Find the mass fraction of Ca in  $\text{CaCO}_3$ ?  
Answer: 40% Ca  
Ca - Red (s-family)

**4** 23.4 g of Li reacts with  $\text{N}_2$ . How much  $\text{Li}_3\text{N}$  is formed?  
Answer: 39 g  $\text{Li}_3\text{N}$   
K - Red (s-family)

**5** How many total bonds are in  $\text{Mn}_2\text{O}_7$ ?  
Answer: 14 bonds  
N - Yellow (p-family)

**6** Calculate the sum of coefficients:  
 $\text{P} + \text{O}_2 \rightarrow \text{P}_2\text{O}_5$   
Answer: 11  
 $4\text{P} + 5\text{O}_2 \rightarrow 2\text{P}_2\text{O}_5$   
Rn - Yellow (p-family)

**7** Calculate the molecular mass of  $(\text{CuOH})_2\text{CO}_3$ ?  
Answer: 222 g/mol  
Rn - Yellow (p-family)

**8** Find the mass fraction of S in  $\text{CuSO}_4$ ?  
Answer: 20% S  
Ne - Yellow (p-family)

**9** How much P is needed to obtain 150 g of  $\text{P}_2\text{O}_5$ ?  
Answer: 65 g P  
Cu - Blue (d-family)

**10** Calculate the mass of Dolomite mineral  $\text{CaCO}_3 - \text{MgCO}_3$ ?  
Answer: 184 g  
W - Blue (d-family)

**11** Calculate the mass of  $\text{CaO}$ ?  
Answer: 56 g  
Fe - Blue (d-family)

**12** Calculate the mass of  $\text{Ag}_2\text{O}$ ?  
Answer: 232 g  
Th - Green (f-family)

Figure 1. Problems are written on handouts as follows

1. How many sigma bonds are in 1-  $(\text{CuOH})_2\text{CO}_3$  malachite? 9 sigma B-red
- How many grams of oxygen are needed to obtain 2 - 26 g of water? 23g  $\text{O}_2$  Na-red
- Determine the mass fraction of Ca in the composition of  $\text{CaCO}_3$ . 40% Ca-red
4. 23.4 g of Li react with nitrogen under room conditions, how much  $\text{Li}_3\text{N}$  is formed? 39 g  $\text{Li}_3\text{N}$  K-red
- What is the total number of bonds in 5- $\text{Mn}_2\text{O}_7$  composition? 14 N-yellow
- 6- Calculate the sum of the coefficients in the following reaction:  
 $\text{P} + \text{O}_2 \rightarrow \text{P}_2\text{O}_5$  11 B-yellow.
- Calculate the total molecular mass of 7-  $(\text{CuOH})_2\text{CO}_3$ ? 222 Rn-yellow
- 8- Determine the mass fraction of C in  $\text{CuSO}_4$  composition? 20% Ne-yellow
- How many grams of  $\text{P}_2\text{O}_5$  are needed to obtain 150 g of  $\text{P}_2\text{O}_5$ ? 65 g Cu-blue



10 - Calculate the mass of the mineral dolomite. 184 W-blue

Calculate the mass of CaO. 56 g Fe-blue

Calculate the mass of Ag<sub>2</sub>O. 232 g Th-green

How many grams of CaCO<sub>3</sub> can be obtained from 132.72 g of CaO? 237 g Np-green

In conclusion, it should be noted that the use of didactic materials in solving problems in chemistry contributes to the formation of such characteristics of students as interest and intelligence. How to use this opportunity depends on the pedagogical skills of each teacher. It should not be forgotten that the constant, excessive, or constant monotony of handouts can lead to boredom in students and a decrease in their interest in the lesson. Therefore, it is important to use didactic materials appropriately and in moderation, taking into account the interests and opinions of students. In today's era of rapidly expanding information and knowledge, all information can be gathered through handouts, textbooks, and visual aids during lessons.

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