

# Chemistry

Secondary Education

First year

Collection ORBITALES



REVISED EDITION

Center for Educational Research and Development



National  
Textbook

New Curricula

SPECIMEN

# Republic of Lebanon

Ministry of Education and Higher Education

## CHEMISTRY


**Secondary Education**

First year

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**New Curricula**



General Coordinator  
**Moustapha Yaghi**

The translation into English of this book was reviewed and corrected by faculty members at the American University of Beirut.

# CHEMISTRY



**Secondary Education**

First year

**Saïd Chami** (Coordinator)

**Bassam Chahine**

**Mirvat El-Masri**

**Mohammad El-Rifai**

**Elias Kaoukabani**

**Hanadi Sleiman**

Center for Educational Research and Development



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To the memory of Afif Beydoun coordinator of the chemistry committee, our professor and friend, who contributed to the realization of the chemistry curriculum and provided us with ample guidance to write this book.

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- Saint-Esprit University of Kaslik. (U.S.E.K.)
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# Together We Build Through Education!

The Center for Educational Research and Development (CERD) has embarked on an extensive workshop for assessing and developing the educational framework and curricula which have been placed into effect more than three years ago. With full realization of the fact that the educational cycle must continue normally through its components, and until the development process attains its aspired objectives, we are placing in the hands of students, teachers and directors of public schools, this corrected version of textbooks issued by CERD as part of the National Textbook Series.

This version is an interim stage incorporating the corrected typographical and linguistic errors discovered by CERD specialists as well as teachers and students through their daily dealings with the books. The process of assessment and development of the framework and curricula will take into consideration all the comments that have been made, or will be made, in this regard.

It is expected that once the curricula are developed and aligned with the general and specific objectives set for them, the textbooks will be realigned with the new curricular and framework requirements, including tying the content of a course to the number of teaching hours set for it during the school year, taking into consideration vertical alignment within the same course as well as the horizontal alignment with the rest of the courses.

I take this opportunity to invite all school administrators, teachers and students and all officials concerned in public and private schools alike, to promptly send their comments on these curricula and books as their contribution to enrichment of this momentous national process.

This workshop, which was launched under the kind sponsorship of His Excellency the Minister of Education and Higher Education in implementation of Decree No. 10227 embodying the educational curricula and their objectives, fits in with CERD's proclaimed new motto "Together We Build Through Education".

It is our earnest desire to see this national, all-inclusive workshop attracting the greatest amount of interest and participation to define the safest and soundest educational options that directly affect our children, as we vow to continually modernize education and develop its ways and means to keep abreast of modern developments and progress in science and technology.

**Dr. Leila MALEEHA**  
President CERD



# I ntroduction

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In conformity with the new chemistry curriculum, this textbook has been compiled to fulfil the needs of both the students and the teachers. It facilitates the change from the old program to the newly-planned curriculum. It meets the requirements of the latter as to content and the teaching methodology.

Expressed as *Objectives*, the content is made more readily accessible to the student and helps enhancing his intellectual development.

The grasping of the general concepts is achieved through performing simple activities, the majority of which are taken directly for everyday life, thus enabling students to understand and appreciate the quality of learning they are required to obtain.

The simplicity and the clarity of the text, the limited but sufficient number of *Exercises*, are important features of the organization of the textbook.

The environmental concern pervades throughout the book, addressing some of the world-wide environmental problems, their effects on our planet and life, and the socio-economical restrictions which intervene to hinder their solution.

This importance is justified by the relation existing between chemistry and the nature of these environmental problems.

The historical data introduced allow the student to appreciate the integrated world effort and the importance of the contributions of individual scientists to the advancement of mankind.

## Features of the Textbook

- The contents of the textbook are centered on three major themes and are subdivided into nine chapters organized according to a uniform structure.
  - The first page includes a brief description of the chapter contents, an illustration depicting the subject to be treated, the Objective to be attained, the Prerequisites and the chapter's outline.
  - The following pages are reserved for the course and, when needed, to the Activities. Each activity is given a title and is defined by an objective.  
The authors have described the procedures of the Activities, having in mind the time that should be allotted to perform each activity. However, the comprehension and the representation of an activity does not depend on just doing it. The analysis of each activity should clearly justify the result(s) obtained, as well as the different steps applied.
- **Sample Exercise** is a direct application related to the notion or concept studied.
- **Chapter Review** lists the major concepts in the chapter.
- **Method Sheet and Technical Sheet** guide the student to organize and develop their mental ability and manipulative skills.
- **Documentary Activities** are accompanied by questions relating exercises to documentary reading.  
The use of contradictory documents in some cases aims at giving the student the opportunity to compare information and analyze and evaluate what is relevant.
- **The Exercises** are divided into multiple choice questions (MCQ), completion (fill-in the blank), and conventional exercises that allow evaluation of the student's acquired knowledge as to his intellectual development, understanding of key words and the application of the studied concepts and notions.
- **Activities** designed for work outside the classroom, aim at bringing the student into close contact with applied chemistry in the workplace and eventually help him build his future career.

We appreciate any suggestions and comments which may help rendering this textbook more efficient.

The Authors



# Features of the textbook

## Chapter opener

Chapter is introduced with a photo.

**QUALITATIVE ANALYSIS**

Qualitative analysis allows us to identify the constituents of a substance or a solution. Quantitative analysis allows us to determine their composition by mass or by moles. These two types of analysis constitute **Analytical Chemistry**.

The **analytical characteristics** of some ions in solution allow us to make use of some reactions to identify these ions and confirm their presence or absence in a solution.

Small amount of a solution that includes a high number of ions, anions.

**Objectives**

- Understand the importance of chemical analysis
- Write net ionic equations for the most important reactions used for characteristic ions in solutions
- Detect the presence of an ion in solution
- Follow specific steps to identify an ion in solution

**Prerequisites**

- Names and formulas for common ions
- Electronegativity of elements
- Concept of concentration

**Chapter Contents**

- Analytical Characteristics of Some Ions
- Tests to Identify Some Ions
- Chapter Review
- Method Sheet
- Documentary Activities
- Chemistry in the Workplace
- Exercises

Title

Major objectives of the chapters.

Prerequisites : indispensable to understand the chapter.

Chapter content

Brief description of the chapter content.

Short biography to show the importance of the individual's contribution to the development of mankind.

Remark: applications, units of measurements and others...

Definitions, properties, and net equations are emphasized.

## Course

**Arsenic (1869-1917)**  
Nobel Prize 1912  
Inventor of the first X-ray sensitive photographic process for medical diagnosis in radiology

Quantitative analysis allows to identify ions in a solution. Quantitative analysis allows to determine their composition by mass or by moles.

The identification test of ions is the first step of the analytical procedure to recognize the chemical species of a molecule.

The color of an aqueous solution can give an indication of the nature of the ions present, but it cannot conclusively identify them.

The identification of an ion requires performing a specific reaction to confirm the presence or the absence of the ion.

Each reaction may involve:

- gas release
- precipitate formation
- color change of a solution (with or without an indicator)
- Change in pH

The procedure to identify ions in a sample should be made according to a well defined scheme that should be strictly followed to avoid any reaction which may mask other reactions.

**7.1 Analytical Characteristics of Some Ions**

**7.1.1 Colors of Ions**

Hydrogen is the study of the proportion of mass present in an element. An absorption spectrum indicates an element by based on the capacity of cobalt chloride to turn blue in dry air and pink in humid air.

When natural water passes through soil layers, it dissolves many ionic compounds, becomes more or less mineralized and remains usually colorless.

In aqueous solution, some ions are colored. While others are colorless.

**"Magic tip"**

Writing with dilute  $\text{CuCl}_2$  solution is a good model: "ink" is formed when the paper is gently heated.  $\text{CuCl}_2$  is dehydrated, and the writing appears blue on paper.

Introduction to the chapter

## Activities

Introduction

Purpose of the activity

Objective

Safety rules

**7.1.2 Precipitation Reactions and the Classification of the Formed Precipitate**

When an appropriate reagent is added to some ions in solution, usually specific ions, a precipitate is formed. This precipitate may be dissolved upon adding an excess of the same reagent or adding another reagent.

**Activity 5**

**Study the behavior of some ions in solution.**

**Objective** Perform some precipitation and dissolving reactions.

**Materials**

- 5 Test tubes
- Pipet, safety bulb
- Distilled water
- Solution of aluminum chloride (1 mol/L)
- Solution of sodium hydroxide (2 mol/L)

**Sample Exercise**

A solution (S) contains few species of cations and two types of anions. The cations could be  $\text{Ag}^+$ ,  $\text{Al}^{3+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{K}^+$ . The anions could be  $\text{Cl}^-$ ,  $\text{I}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{CO}_3^{2-}$ ,  $\text{NO}_3^-$ .

- Solution (S) is colorless.
- A sample of (S) gives a pink color with phenolphthalein.
- When hydrofluoric acid is added to a sample of (S), vigorous gas bubbling is observed.

What are the ions present in solution (S)?

The fact that (S) is colorless implies the absence of the ions  $\text{Cu}^{2+}$  (blue),  $\text{Fe}^{3+}$  (green) and  $\text{Fe}^{2+}$  (yellow-orange). The pink color of phenolphthalein with (S) indicates the presence of  $\text{OH}^-$ . We know the ions  $\text{Ag}^+$ ,  $\text{Al}^{3+}$  which do not coexist with  $\text{OH}^-$  in the same solution. The cations present in (S) are  $\text{K}^+$  and  $\text{Na}^+$ .

The sample (S) contains two types of anions: one has been identified as  $\text{OH}^-$ . We have to identify the second. This second anion must be carbonate  $\text{CO}_3^{2-}$ , since it is the only anion which upon adding  $\text{HF}$  gives a vigorous gas bubbling. The ions present in (S) are therefore  $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{OH}^-$  and  $\text{CO}_3^{2-}$ .

**Chapter Review**

- The color of an ionic solution is due to the color of the ions present in this solution.
- The color of a solution fades with dilution.
- The identification of an ion is mainly based on the ability of this ion to coexist with other ions in the same solution.
- Most metallic cations can be identified by hydroxide ion,  $\text{OH}^-$ .
- Qualitative analysis confirms the presence or absence of specific ions in solution.

Sample exercise: involves effective problem solving techniques which are related to the notions or concepts studied.

Detailed description of results.

Interpretation of results.

Questions : To guide the students through the interpretation of the results.

**Activity 7**

**Comparative study of the composition of different samples of water.**

**Objective** Identify some qualitative and quantitative amounts. Compare some cations ions.

**Materials**

- Table 7.1 summarizing the analysis results of three water samples, as well as the maximum allowed concentration (MAC) of ions in drinking water.

Water	Cations					Anions				
	$\text{Ca}^{2+}$	$\text{Mg}^{2+}$	$\text{K}^+$	$\text{Na}^+$	$\text{NH}_4^+$	$\text{HCO}_3^-$	$\text{Cl}^-$	$\text{SO}_4^{2-}$	$\text{PO}_4^{3-}$	$\text{F}^-$
Tap water A	31.30	6.12	0.50	3.60	10.62	6.1	19.8	1.8	0.01	-
Mineral water B	79.8	48.20	18.17	0.80	428	28	0.4	4.4	0.1	-
Sea water	410	1290	300	10700	150	16200	2800	-	-	-
Drinking water MAC	100	50	12	150	-	350	450	50	1.8	-

**Discussion**

The results given in the table have been obtained using two kinds of analysis. Which?

What distinguishes sea-water from mineral water A and B?

Why is seawater not potable?

**Conclusion**

The table shows that seawater and mineral water contain the same ions, but having different concentrations. These same ions are also contained in drinking water.

**Analysis**

The qualitative and quantitative analysis of water samples have allowed the identification of ions present, as well as their concentrations. Strong salt water, mineral water and drinking water are usually colorless. The ions contained in these waters are colorless. The high concentration of ions in seawater makes it non-potable even if it is bacteriologically clean.

## Method Sheet

1 Release the reactants corresponding equation

2 Equation (1) gives  
 $\text{ion}(\text{OH}^-) = 3.34 \times 10^{-3} \text{ mol}$

3 Equation (2) gives  
 $\text{ion}(\text{OH}^-) = \text{ion}(\text{Al}(\text{OH})_3) = 0.2 \times 10^{-3} \text{ mol}$

For the 1st reaction:

	$\text{Al}^{3+}$	$\text{OH}^-$	$\text{Al}(\text{OH})_3$	$\text{Cl}^-$	$\text{Na}^+$
Initial	0	$3.34 \times 10^{-3}$	0	$3.34 \times 10^{-3}$	$3.34 \times 10^{-3}$
Final	0	0	$0.2 \times 10^{-3}$	0	$3.14 \times 10^{-3}$

To compute the number of moles of chemical species present in a mixture of two solutions.

1 Example  
 200 mL of 0.5 mol L<sup>-1</sup> aluminum chloride solution (Al<sub>3</sub>) is mixed with 100 mL of 3.2 mol L<sup>-1</sup> sodium hydroxide solution.

Compute the number of mol of each species present in the resulting mixture.

1 Calculate the number of moles of each species involved

2 Write the equations of the dissociation of each species and find out the stoichiometric ratios of the number of moles

3 Write the net ionic equation of the reactions which take place

4 Write the relation for the change in number of mol for each species according to the corresponding reaction

Using equation (1)  
 $\frac{\Delta n(\text{Al}^{3+})}{1} = \frac{\Delta n(\text{OH}^-)}{3} = \frac{\Delta n(\text{Al}(\text{OH})_3)}{1}$

Using equation (2)  
 $\frac{\Delta n(\text{Al}(\text{OH})_3)}{1} = \frac{\Delta n(\text{OH}^-)}{3} = \frac{\Delta n(\text{Al}(\text{OH})_3)}{1}$

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Systematic working.

Questions :  
 To discover some of the numerous ways in which chemistry is involved in everyday life either directly or indirectly.

Chemistry in the workplace :  
 suggestions to organize field trips to stimulate curiosity and to inquire about the application of chemistry in everyday life.

## To initiate documents reading skills

1 Mineral Water: Not Always Potable

Mineral water is generally the water of springs. The term is ambiguous, since it French has two meanings. "Mineralized water" implies a high concentration of mineral salts. The Germans have a different conception: they don't consider that water is "mineral" unless it contains more than 100 mg of mineral salts dissolved per litre.

However, one must

From Hard-up to Water  
 The mineral water of other countries, by its soft character, is considered a desirable soft, it means that it is not too hard, and it is free of iron, and it is free of manganese. It will be more useful one or two days of work in following these 100 mg of mineral salts. However, the solution and the way to the life of water when the water is in a bottle, contains generally a hard and an acid both of which will be important.

The water issues in a bottle, contains hard water, which is not good for the health. The water issues in a bottle, contains hard water, which is not good for the health. The water issues in a bottle, contains hard water, which is not good for the health.

Every possible thing can be found in mineral water.

Chemists advise that when water is consumed, one should not drink too much. It is very rich in sodium, but it is not recommended for use by people who suffer from high blood pressure, heart trouble, or renal ailments.

The price of a liter of mineral water is 1.5 mg per liter. The price of a liter of mineral water is 1.5 mg per liter. The price of a liter of mineral water is 1.5 mg per liter.

Questions

1. What difference is there between mineral water and tap water?  
 2. What is the pH of mineral water?  
 3. Describe an experiment that allows us to identify the presence of carbonate ions in water?  
 4. Can mineral water be consumed without any danger?

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## Exercises

1 Complete the following statements.

a) The ions with symbol  $\text{Cl}^-$  give with  $\text{Ag}^+$  ions a ... precipitate of formula ... which ... with sunlight.

b) The calcium ions, with symbol ... give with ions, with the formula  $\text{CO}_3^{2-}$ , a white precipitate with the formula ...

c) The ... ions, with the formula  $\text{SO}_4^{2-}$ , give with barium ions of formula ... a precipitate of barium sulfate with the formula ...

d) The ions with symbol  $\text{S}^{2-}$  give with hydrochloric acid or ... with the formula  $\text{H}_2\text{S}$ .

2 Answer True or False

a) Silver chloride is very soluble in water.  
 b) Iron(II) hydroxide is a white precipitate.  
 c) Carbon dioxide causes acidity of lime water.  
 d) Only the chloride ion  $\text{Cl}^-$  gives a white precipitate with the silver ion  $\text{Ag}^+$  in aqueous solution.  
 e) Iron(III) ions in aqueous solution is tested by the nitrate ion  $\text{NO}_3^-$ .

3 Complete and balance the following equations

$\text{Al}^{3+} + \dots \rightarrow \text{Al}(\text{OH})_3$   
 $\text{Fe}^{2+} + \text{OH}^- \rightarrow \dots$   
 $\text{Al}^{3+} + \dots \rightarrow \text{Al}(\text{OH})_3$   
 $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \dots$   
 $\text{Ca}^{2+} + \text{CO}_3^{2-} \rightarrow \dots$   
 $\text{Mg}^{2+} + \text{OH}^- \rightarrow \dots$

4 Indicate the correct answer (s).

a) The chloride ion  $\text{Cl}^-$  in an aqueous solution may be identified using a solution which contains:  
 1.  $\text{OH}^-$   
 2.  $\text{Ag}^+$   
 3.  $\text{Fe}^{3+}$

b) The cation calcium  $\text{Ca}^{2+}$  in aqueous solution gives a precipitate with:  
 1.  $\text{NO}_3^-$   
 2.  $\text{CO}_3^{2-}$   
 3.  $\text{C}_2\text{O}_4^{2-}$

c) The solid directly hydrolyzed in suspension in aqueous solution has the following color:  
 1. Yellow  
 2. Pink green  
 3. Pink

d) The carbonate ion  $\text{CO}_3^{2-}$  can be identified in aqueous solution by:  
 1. A hydrochloric acid solution  
 2. A latex calcium hydroxide solution  
 3. A sodium chloride solution

5 Many laundry detergents contain phosphates (they are softeners). These give the calcium  $\text{Ca}^{2+}$  and magnesium  $\text{Mg}^{2+}$  ions in wash water. Write the net ionic equations for the formation of these precipitates

6 The cation  $\text{CO}_3^{2-}$  is found in most very common rocks. Explain the formation of a white precipitate when tap water is used to wash very hard water.

7 Draw a table arranging the ions on a vertical line, and the formula on a horizontal line. Mark in the table the "tools" corresponding to each of these ions. The formula of your product.

8 Draw a table arranging the ions on a vertical line, and the formula on a horizontal line. Mark in the table the "tools" corresponding to each of these ions. The formula of your product.

9 Draw a table arranging the ions on a vertical line, and the formula on a horizontal line. Mark in the table the "tools" corresponding to each of these ions. The formula of your product.

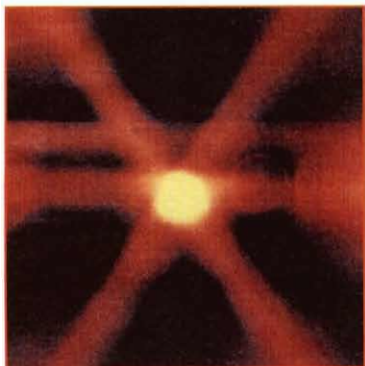
10 Draw a table arranging the ions on a vertical line, and the formula on a horizontal line. Mark in the table the "tools" corresponding to each of these ions. The formula of your product.

Completion, true and false, multiple choice questions matching-type and other conventional exercises.

At the end of the book:

- Safety rules
- Careers, realistic opportunities in the domain of chemistry.
- Periodic classification of the elements.

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