The use of mobile applications in studying the topic “Basic classes of inorganic compounds” in the school chemistry curriculum

Kristina S. Prus[1], Pavlo P. Nechypurenko[1,2]

[1]Kryvyi Rih State Pedagogical University, 54 Universytetskyi Ave., Kryvyi Rih, 50086, Ukraine
[2]Academy of Cognitive and Natural Sciences, 54 Universytetskyi Ave., Kryvyi Rih, 50086, Ukraine

Abstract

This study explores the possibilities of using mobile applications when studying the topic “Basic classes of inorganic compounds” in the school chemistry curriculum. The experience of domestic teachers in the use of mobile applications in chemistry lessons is analysed. A proprietary mobile application for studying the classification and properties of the main classes of inorganic compounds with a reference and testing module is proposed. Methodological recommendations for conducting lessons using the created application in grades 8 and 11 have been developed. The results of a teacher survey showed an insufficient level of use of mobile applications in the study of chemistry due to technical and methodological difficulties. The work has practical significance for the development and implementation of mobile applications in the school chemistry course.

Keywords

mobile learning, chemistry education, inorganic compounds, educational technology, school curriculum, teacher survey, interactive applications, digital tools, acid-base chemistry, pedagogical innovation

1. Introduction

The rapid development of information and communication technologies (ICT) in the 21st century has led to their widespread integration into the education system, including the teaching of chemistry [1, 2, 3]. The use of mobile devices such as smartphones and tablets has become particularly prominent, as they provide opportunities for interactive, engaging, and accessible learning experiences [4, 5, 6, 7, 8]. Mobile learning, which involves the use of mobile applications (apps) for educational purposes, has emerged as a promising approach to address some of the challenges in chemistry education, such as abstract concepts, complex visualizations, and disconnect from real-world applications [9, 10, 11]. However, the methodology for using mobile applications to study specific topics in school chemistry, such as basic classes of inorganic compounds, remains underexplored [10]. Ukrainian teachers face challenges in integrating mobile learning due to technical and methodological difficulties [12].

The purpose of this study is to develop a mobile application and methodological materials for its use in studying the topic “Basic classes of inorganic compounds” in the 8th and 11th grades. The objectives of the study are:

1. To generalise the experience of using mobile applications in studying the topic “Basic classes of inorganic compounds” based on the analysis of scientific sources;
2. To determine the methodological features of the topic “Basic classes of inorganic compounds” in the school chemistry course;
3. To clarify the current state of use of mobile applications in the study of basic classes of inorganic compounds in chemistry lessons in schools based on the analysis of the experience of practising teachers;

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nechypurenko@acnsci.org (P. P. Nechypurenko)
https://acnsci.org/nechypurenko/ (P. P. Nechypurenko)
0000-0002-9547-4457 (K. S. Prus); 0000-0001-5397-6523 (P. P. Nechypurenko)

4. To compare methodological and practical aspects of the use of mobile applications in the study of basic classes of inorganic compounds and the study of other topics of the school chemistry course;
5. To develop methodological kits for conducting lessons using mobile applications.

2. Results

The study of basic classes of inorganic compounds is a fundamental part of the school chemistry course. According to the educational programs [13], students begin to acquaint themselves with the concepts of "oxide", "acid", "base", and "salt" in the 7th grade, within the topics "Oxygen" and "Water". The main volume of knowledge about the classes of inorganic compounds is acquired in the 8th grade, in the topic "Basic classes of inorganic compounds", which is the largest topic in the school chemistry course (table 1).

Table 1
Distribution of the study of basic classes of inorganic compounds in the school chemistry course [13, 14].

Grade	Topic	Key concepts
7	Oxygen; Water	Oxides; Acids; Bases
8	Basic Classes of Inorganic Compounds	Classification; Nomenclature; Properties; Preparation methods; Applications
9	Solutions	Electrolytic dissociation of acids, bases, and salts
10	Organic Chemistry	Comparison of properties of organic and inorganic acids and salts
11	Chemical Elements and Inorganic Compounds; Non-metallic and Metallic Elements	Preparation, properties, and applications of representative compounds

In grades 8 and 11, students are expected to master the knowledge of the principles of classification of inorganic substances, the composition and structure of representatives of the main classes of inorganic compounds, modern nomenclature, chemical properties, and genetic relationships between them [13, 14]. The methodology of teaching this topic includes such forms of work as laboratory and practical work, demonstration experiments, scientific projects, and solving calculation problems.

However, students face difficulties in classifying oxides, understanding the concept of amphotericity, and studying certain chemical properties, such as the interaction of oxides with water, obtaining bases insoluble in water, and exchange reactions [15]. Therefore, there is a need for innovative teaching methods and tools, such as mobile applications, to facilitate the learning of this complex topic.

The use of mobile applications in chemistry education has been investigated in several studies. Dekhane and Tsoi [9] developed a mobile app that integrated multiple learning theories to support students' understanding of organic chemistry concepts. The app used interactive visualizations and self-assessment activities, resulting in improved conceptual understanding and positive student perceptions. Talib et al. [16] created an authentic mobile app that allowed students to construct and manipulate organic molecules using touch gestures. The app provided a visual and interactive way to explore reaction mechanisms, leading to increased engagement and understanding of chemistry concepts.

Sievertsen and Carreira [17] developed a mobile platform for collaborative problem-solving in organic chemistry. The app enabled students to work together on complex problems, share ideas, and receive feedback from peers and instructors. The study found that the collaborative features enhanced students' motivation and learning outcomes. In a quasi-experimental study, Cahyana et al. [18] investigated the effects of a mobile game-based learning app on high school students' performance in chemistry. The results showed that students who used the app had significantly higher learning outcomes compared to the control group, particularly among students with high learning independence.

Despite these promising findings, the use of mobile applications in teaching basic classes of inorganic compounds in Ukrainian schools remains limited. A survey of 30 chemistry teachers conducted as part

of this study revealed that 70% do not use mobile applications in lessons, while 30% do (figure 1). The main reasons for not using mobile apps include the inability of some students' phones to support the application, the predominance of English-language apps, the paid access to high-quality apps, the low quality of information reproduction in some apps, and the distracting factor for students.

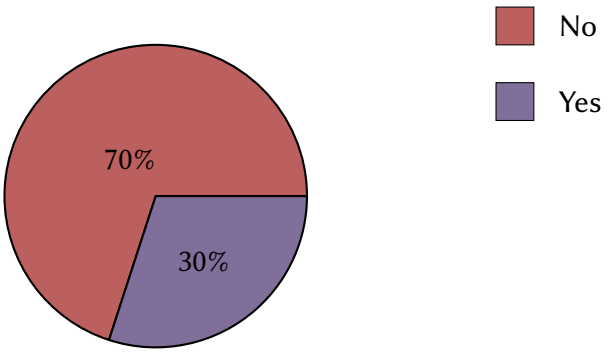

Figure 1: Results of the survey "Do you use mobile applications in your lessons?"

To address these challenges and provide chemistry teachers with a tool for teaching the topic "Basic classes of inorganic compounds" using mobile learning, a proprietary mobile application was developed in this study using the SkillzRun platform. The development process included the following stages:

1. Preparatory stage:
    - Analysis of scientific and methodological literature on the use of mobile applications in chemistry education;
    - Determination of methodological features of the topic "Basic classes of inorganic compounds" in the school curriculum.
2. Main stage:
    - Selection of theoretical material and development of tests for the 8th and 11th grades;
    - Creation of the mobile application using the SkillzRun platform;
    - Preparation of methodological kits for conducting lessons with the use of the developed application.
3. Final stage:
    - Conducting a survey among chemistry teachers to clarify the current state of use of mobile applications in studying basic classes of inorganic compounds;
    - Analysis and discussion of the results.

The developed mobile application contains two main modules:

1. Reference module with theoretical material on the classification, nomenclature, and properties of oxides, acids, bases, and salts, adapted for the 8th and 11th grades (figure 2).
2. Testing module for self-assessment of knowledge, containing interactive tests with different types of questions (figure 3).

The application can be used in lessons for learning new knowledge, generalising and systematising knowledge, and conducting tests and independent work. Methodological kits have been developed for conducting lessons on the topics "Physical properties of acids. Chemical properties of acids: effect on indicators, interaction with metals, basic oxides, bases, salts" for the 8th grade and "Properties of sulfuric acid" for the 11th grade using the mobile application. The kits include a lesson plan, didactic materials (in the mobile application), and criteria for assessing student achievement. Sample lesson plans are provided in appendices A and B.

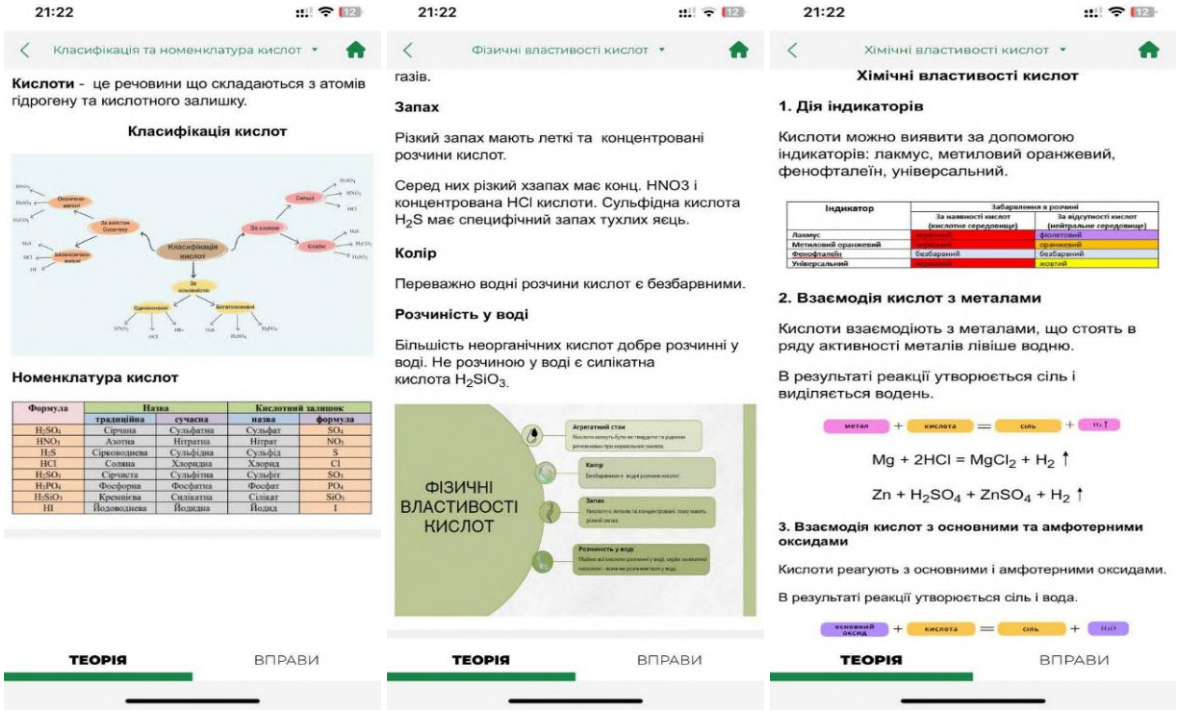

Figure 2: Example of theoretical material in the reference module of the mobile application.

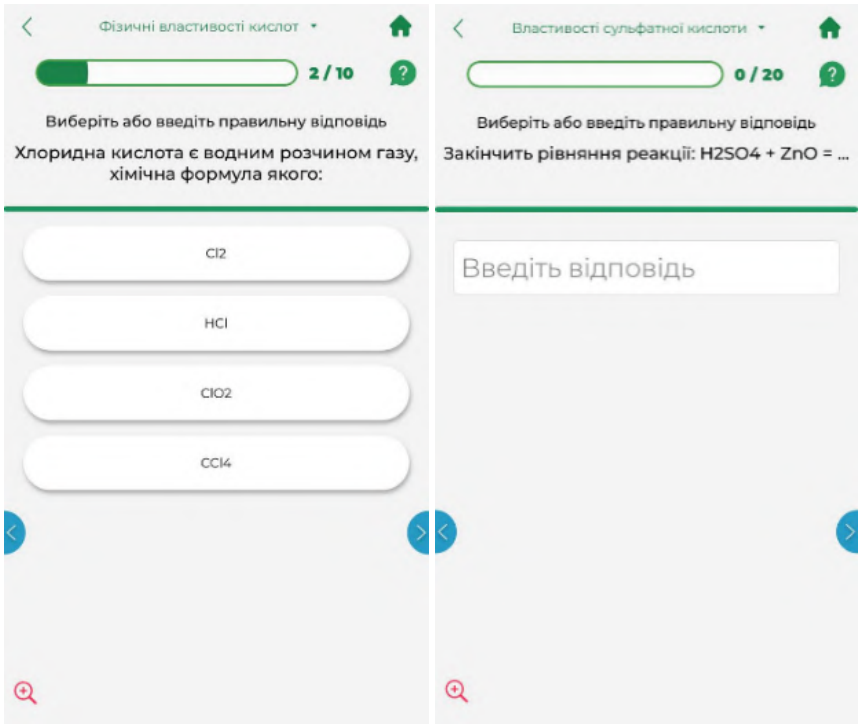

Figure 3: Example of a test question in the testing module of the mobile application.

The developed mobile application and methodological recommendations have practical significance for chemistry teachers. They can help increase students' interest in the subject, encourage the search for information, deepen students' knowledge, and apply information and communication technologies in teaching. The use of the application in lessons corresponds to the key competencies defined in the chemistry curriculum [13], such as:

- Competence in the natural sciences and technologies;
- Information and digital competence;
- Lifelong learning skill;
- Communication in the native language;
- Mathematical competence.

However, the study has some limitations. The developed application covers only a part of the topic "Basic classes of inorganic compounds" and was not tested in a pedagogical experiment. The survey of teachers was conducted on a small sample and may not fully reflect the state of use of mobile applications in chemistry teaching in Ukraine. Further research is needed to expand the content of the application, evaluate its effectiveness in practice, and investigate the long-term impact on student learning outcomes.

3. Conclusions

The study of basic classes of inorganic compounds is an essential part of the school chemistry course, which occurs throughout grades 7-11, with the main volume of knowledge acquired in the 8th grade. Students are expected to master the knowledge of the principles of classification of inorganic substances, the composition and structure of representatives of the main classes of inorganic compounds, modern nomenclature, chemical properties, and genetic relationships between them. However, students face difficulties in understanding certain concepts and properties, such as amphotericity, interaction of oxides with water, and exchange reactions.

The use of mobile applications in chemistry education has the potential to address these challenges by providing interactive, visual, and engaging learning experiences. However, the methodology for using mobile apps to study specific topics, such as basic classes of inorganic compounds, remains underexplored, particularly in the Ukrainian context. Domestic teachers face technical and methodological difficulties in integrating mobile learning into their practice, as evidenced by the survey conducted in this study.

To address this gap, a proprietary mobile application was developed using the SkillzRun platform, containing theoretical material and tests on the properties of acids and sulfuric acid for grades 8 and 11. Methodological kits for conducting lessons using the application have been prepared, which include lesson plans, didactic materials, and assessment criteria. The developed application and recommendations have practical significance for implementing mobile learning in the study of basic inorganic compound classes in the school chemistry course. They can help increase student engagement, deepen knowledge, and integrate modern technologies into chemistry education.

However, the study has limitations in terms of the scope of the application content, lack of practical testing, and a small sample of surveyed teachers. Future research may focus on expanding the application to cover more topics and grades, conducting a pedagogical experiment to evaluate its effectiveness, and investigating the long-term impact on student learning outcomes. Collaboration between educators, researchers, and application developers is needed to create high-quality mobile learning solutions adapted to the needs of chemistry teachers and students in Ukraine.

Declaration on Generative AI

We acknowledge the assistance of Claude 3.7 Sonnet in translating content from Ukrainian.

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A. Lesson plan for grade 8

Topic: Physical properties of acids. Chemical properties of acids: effect on indicators, interaction with metals, basic oxides, bases, salts.

Objectives:

- Educational: to study the physical and chemical properties of acids, namely the effect on indicators, interaction with metals, basic oxides, bases, and salts.
- Developmental: to develop spatial thinking and logical reasoning.
- Upbringing: to foster cognitive interest in the lesson.

Type of lesson: Combined.
Methods and forms of work: Independent work; conversation.
Equipment: Smartphone.
Lesson structure:

1. Organizational moment
2. Actualization of basic concepts
3. Motivation of learning activities
4. Study of new material
5. Generalization of knowledge
6. Lesson summary
7. Homework assignment

Lesson progress:

1. *Organizational moment*
   Greeting with students. I hope you will be active in today's lesson and our lesson will be effective. Checking students' attendance.
2. *Actualization of basic concepts*
   a) What are the classes of inorganic compounds?
   b) Describe the structure of acids.

c) What acids are found in everyday life?
d) Indicate the formulas of the most important acids.
e) Acids are ...?

3. *Motivation of learning activities*
Today we will consider an interesting topic "Physical properties of acids. Chemical properties of acids: effect on indicators, interaction with metals, basic oxides, bases, salts" and perform an independent work.
4. *Study of new material*
Physical properties of acids:

- Liquids or low-melting substances;
- Have a pungent odor and sour taste;
- Have a low melting point;
- Some acids are toxic substances;
- Almost all acids are soluble in water.

Chemical properties:

a) Detection of acids using indicators (table 2).

Table 2
Color of indicators in different media.

Indicator	Neutral medium	Acidic medium
Universal paper	yellow	red
Methyl orange	orange	red
Litmus	purple	red
Phenolphthalein	colorless	colorless

b) Acids react with metals, forming a salt and evolution of hydrogen:

$$Mg + 2HCl = MgCl_2 + H_2\uparrow$$
$$Zn + H_2SO_4 = ZnSO_4 + H_2\uparrow$$

c) Acids react with basic and amphoteric oxides, forming a salt and water:

$$K_2O + HNO_3 = 2KNO_3 + H_2O$$
$$ZnO + 2HCl = ZnCl_2 + H_2O$$

d) Acids react with bases, forming a salt and water:

$$2NaOH + H_2SO_4 = Na_2SO_4 + 2H_2O$$

e) Acids react with salts, forming an insoluble salt and an acid:

$$BaCl_2 + H_2SO_4 = BaSO_4\downarrow + 2HCl$$

f) Acids react with salts, forming an insoluble acid and a salt:

$$Na_2SiO_3 + 2HCl = 2NaCl + H_2SiO_3\downarrow$$

Independent work with the use of the mobile application:
Dear students! I suggest you take your smartphones. Now we will download the mobile application. After downloading the mobile application, you will take a test on the topic "Physical properties of acids. Chemical properties of acids: effect on indicators, interaction with metals, basic oxides, bases, salts".
Students listen to the instructions and the algorithm for downloading the mobile application and taking the test.
Algorithm for downloading the mobile application:

a) Open Google Play or App Store.
b) Register with your first and last name.
c) Select the subject "Chemistry" and "Chemistry Grade 8".
d) First, select the topic "Physical properties of acids" and take the test.

e) Select the topic “Chemical properties of acids” and take the test.

At the end of the test, students will receive grades for taking the test.
QR code for downloading the mobile application:

5. *Generalization of knowledge*
   a) Give examples of acids that are soluble in water.
   b) Give examples of oxygen-free acids.
   c) Give examples of oxygen-containing acids.
   d) Give an example of an acid that is insoluble in water.
6. *Lesson summary*
   Evaluation of independent work.
7. *Homework assignment*
   (Homework assignment from the textbook or workbook)

B. Lesson plan for grade 11

Topic: Properties of sulfuric acid.
Objectives:

- Educational: to familiarize students with the physical and chemical properties of sulfuric acid; to consider the applications and occurrence of sulfuric acid.
- Developmental: to develop spatial thinking and critical reasoning.
- Upbringing: to foster cognitive interest in the lesson.

Type of lesson: Lesson of learning new knowledge.
Methods and forms of work: Independent work; conversation.
Equipment: Smartphone.
Lesson structure:

1. Organizational moment
2. Actualization of basic concepts
3. Motivation of learning activities
4. Study of new material
5. Generalization of knowledge
6. Lesson summary
7. Homework assignment

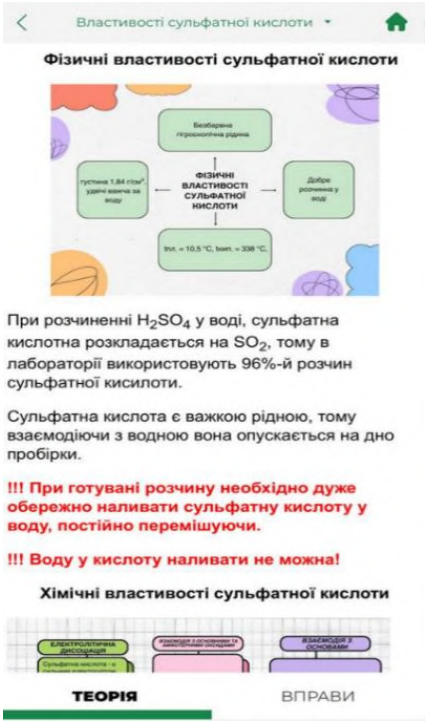
Lesson progress:

1. *Organizational moment*
   Greeting with students. I hope you will be active in today’s lesson and our lesson will be effective.
   Checking students’ attendance.
2. *Actualization of basic concepts*
   a) Acids are ...

b) Give examples of the most important acids.
c) Name the physical properties of acids.
d) How do acids differ from each other (odor, color)?
e) Describe the applications and occurrence of acids.

3. *Motivation of learning activities*
   Today we will study a new topic “Properties of sulfuric acid” and consolidate your knowledge of this topic using a mobile application.
4. *Study of new material*
   Students, to begin with, I suggest downloading the mobile application:
   QR code for downloading the mobile application:

Using the mobile application, review the theoretical material for the topic.



Physical properties of sulfuric acid:

- Colorless hygroscopic liquid;
- Melting point 10.5 °C, boiling point 338 °C;
- Density 1.84 g/cm^3;
- Readily soluble in water;
- Twice as heavy as water.

Chemical properties of sulfuric acid:

a) Sulfuric acid reacts with basic and amphoteric oxides:

$$3H_2SO_4 + Al_2O_3 \rightarrow Al_2(SO_4)_3 + 3H_2O$$
$$2MgO + 2H_2SO_4 \rightarrow Mg_2(SO_4)_2 + 2H_2O$$

b) Sulfuric acid reacts with bases:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
$$2Fe(OH)_3 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 6H_2O$$

c) Sulfuric acid interacts with weak acids:

$$ZnS + H_2SO_4 \rightarrow ZnSO_4 + H_2S$$

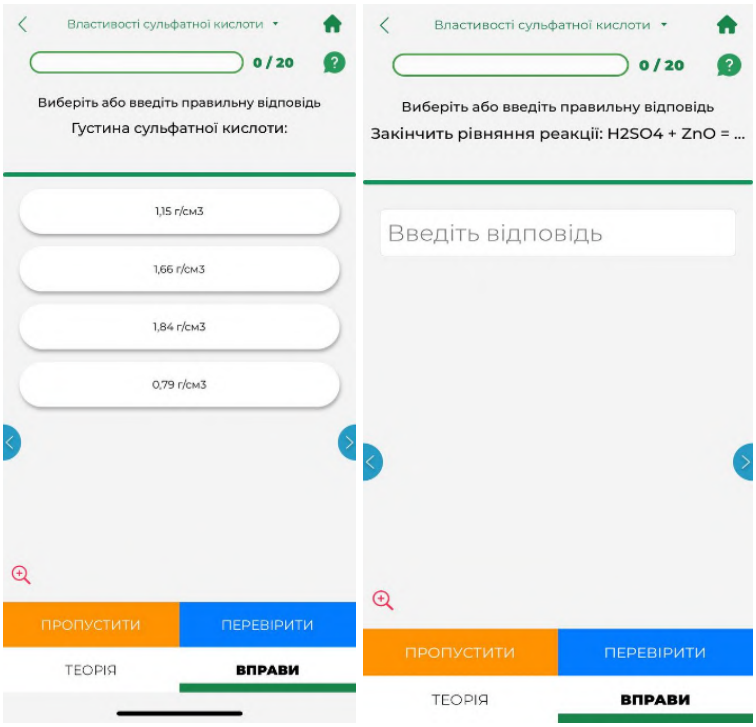
d) Sulfuric acid interacts with metals:

$$2Fe + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2$$

e) Sulfuric acid reacts with alkalis and hydroxides:

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

5. *Generalization of knowledge*
   Students, now I suggest you perform an independent work, open the mobile application and select the topic “Properties of sulfuric acid”.



6. *Lesson summary*
   Discussion and evaluation of independent work.
7. *Homework assignment*
   (Homework assignment from the textbook or workbook)