THE DEVELOPMENT OF LEARNING ACHIEVEMENT IN CHEMISTRY ON CHEMICAL REACTIONS USING AN EXPERIMENTAL METHOD FOR YEAR ONE HIGH SCHOOL STUDENTS

BY

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Abstract

The effectiveness of an experimental method for improving year one high school students' learning achievement and satisfaction in chemistry was investigated in this study. Thirty students from a high school in China were randomly assigned to participate in the study, which utilized a one-group pretest-posttest design.

The research used four lesson plans focusing on chemical reactions, specifically between metal sodium and its compounds. These lessons were validated for effectiveness using the 80/80 criterion. Additionally, a chemistry achievement test and a student satisfaction questionnaire were employed, both demonstrating appropriate difficulty and discrimination indices and high reliability.

The results demonstrated that the students'learning achievement in chemistry significantly improved after using the experimental method. The mean score before studying was 14.90 (SD = 2.04), while the mean score after studying was 18.43 (SD = 2.06). This difference was statistically significant at the .01 level.

Furthermore, the students expressed high satisfaction with the experimental learning approach. The overall satisfaction score was 4.64 (SD = 0.49). This study suggested that utilizing experimental method as part of the chemistry curriculum can effectively enhance learning achievement and positive student satisfaction towards the subject, particularly in year one high school students.

(Total 159 pages)

Keywords: Chemical Reactions, Experimental Method, Learning Achievement, Student Satisfaction, Year One High School Students

Student's Signature …..... Thesis Advisor's Signature .....

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CHAPTER 1

INTRODUCTION

This chapter explains the background and rationale of the study, research objectives; research questions; research hypothesis; scope of the study; conceptual framework, operational definitions, expected outcomes of the study, and limitations.

1.1 Background and Rationale of the Study

Chemistry classes in high school were divided into two parts. The first part was conceptual chemistry teaching in high school, which was a large part of conceptual chemistry teaching in high school. It was the most important and difficult content of teaching and the prerequisite for building the subject-knowledge system. The second part was a chemical experiment, which mainly aimed at observation, analysis, comparison, and application of rational knowledge such as life phenomena and chemical facts, reflected the nature and laws of chemical things and phenomena, and helped students learn and master chemical knowledge intuitively (Lin, 2023).

In the research topic of "Practical Research to Improve Chemistry Teachers' Experimental Teaching Skills" (Liu, 2015), the experimental results showed that with the continuous development and progress in education, the new curriculum should have paid more attention to students' in-depth understanding and practical application of teaching knowledge. In the past, teachers had paid more attention to students' performance and repetition of theoretical knowledge and had neglected to promote students' experimental thinking. As a result, students had poor practical skills, could not understand abstract experimental phenomena, and their experimental performance was not standardized, etc. Therefore, teachers should have avoided teaching only theoretical knowledge in class. They should have considered the difficulty of not understanding the phenomenon of chemical experiments from the students' perspective and designed appropriate courses.

However, for students who had just entered high school, because junior high school chemistry knowledge was relatively simple if they had not participated in some chemical competitions and had not expanded their knowledge, usually, most of the students had mastered only basic chemical knowledge and needed to further expand their chemical knowledge base. Especially for some basic chemical substances, the pictures in the textbook could give students a superficial impression but could not be profound. Students could not develop an intuitive sense of the actual state and nature of these substances. They could only choose to memorize these symbols (Jiang, 2019).

Guo (2014) found that chemistry experiments, as practical courses for the knowledge learned in high school, greatly ensured students' practical ability and thinking ability. Many students were hindered by the neglect of experimental thinking in school. At the same time, students' ability to create independently was suppressed, which led to problems in high school chemistry experiment classes and affected students' achievement in chemistry.

Chemical experiments cultivated students' basic knowledge and skills related to chemical experiments, the ability to explore complex experimental phenomena in experiments, and the ability to correctly acquire relevant knowledge and information. More importantly, in junior high school education, many experimental courses had not been conducted, and students' experimental skills had not been effectively trained because the chemicals used in experiments were all dangerous. At that time, the development of school education in China was not balanced. Some students even went to high school without knowing that there were experiment courses in chemistry classes. This led to a big difference in students' ability to do experiments, and it was very necessary to improve the basic knowledge of chemical experiments and the popularization of chemical experiments (Yuan, 2019).

In the early days of chemistry, the subject was not about teaching students knowledge through experimentation, but about establishing chemistry courses with the chemical elements as the main stem. In the 1950s, the United States took the lead in thinking and drew some conclusions when the textbook favored theoretical knowledge and ignored experiments. Based on the teaching materials, it was found that the teaching materials at that time placed more emphasis on teaching knowledge but ignored students' actual understanding and mastery of knowledge (Hu, 2016). More than 10 years later, experts and scholars realized that chemical experiments played an irreplaceable role in students' mastery and understanding of chemical knowledge (Jin, 2021). In the 1970s, the attention to chemical experiments increased significantly in the reform of the chemistry curriculum. In chemistry education, chemistry experiments played an important role in students' learning of chemistry. In the 1990s, the United States began to link chemistry textbooks with the reality of social life and the development of The Times, with chemistry experiments as the most prominent feature. In this century, many countries made clear the important position of chemistry experiments in the whole chemistry curriculum and started to attach importance to the reform of chemistry experiment in teaching reform. The most notable feature was the increase in the proportion of chemistry experiments in the classroom. Middle school students in the United States spent about 30 percent of their time on chemistry experiments, and they held two chemistry experiment classes almost every week. Japanese students spent about 18 percent of their time in chemistry class doing chemistry experiments. British students went to the laboratory on average three times a week for about three hours, and chemistry experiments took up about one-third of the total chemistry lessons (Deng, 2003).

Compared to other countries, China was relatively late in studying chemistry education. In China, the curriculum for teaching chemistry in full-time middle schools

was formulated in 1978, in which chemistry experiments accounted for 14% of the total teaching hours in chemistry classes. In the 1980s, chemistry experiments accounted for 17% of chemistry teaching hours, but they were mainly demonstration experiments. By the end of the 1990s, chemistry was inseparable from real life, and some small chemistry experiments related to life were also conducted in experimental classes. Based on the original curriculum, the 2003 standard emphasized the relationship between experimental teaching and scientific investigation and its important place in chemistry teaching. The 2017 edition of the standard again emphasized the importance of experimental teaching in chemistry. The 2018 edition of the standard suggested cultivating students' ability to conduct scientific inquiry. Chemistry was an experimental science, and compared with the teaching of chemistry theory teaching, it was intuitive, practical, designed, and innovative. Chemistry experiment teaching could cultivate students' various abilities, such as observation ability, practical ability, innovation ability, data processing,an computing ability, and the ability to analyze and solve problems. It was related to whether students could master general chemistry knowledge and related skills, whether they could effectively master scientific thinking methods and develop good scientific habits and quality (Guo, Li, & Zhu, 2014).

With the development of The Times, chemistry experiments played an increasingly important role in chemistry education in China. Even conducting chemistry experiments was included in the entrance examination, and the curriculum made it clear that chemistry experiments occupied an irreplaceable position in chemistry education.

Based on the above condition of the problem and its importance, the researcher had an idea to develop learning success in the subject of chemistry on the topic of

chemical reactions between metal sodium and its compounds for grade 1 high school students by using an experimental method to guide the development of learners so that they had knowledge and skills in the next opportunity through appropriate learning arrangements.

1.2 Research Objectives

1.2.1 To compare year one high school students'learning achievement in Chemistry before and after using an experimental methods

1.2.2 To investigate year one high school students'satisfaction towards using an experimental method in Chemistry.

1.3 Research Questions

1.3.1 Could the experimental method improve the learning achievement in Chemistry of year one high school students in Yinchuan?

1.3.2 To what extent were year one high school students in a high school in Yinchuan satisfied with learning using the experimental method?

1.4 Research Hypotheses

1.4.1 Year one High School students had statistically significantly higher post-learning achievement with experimental teaching methods than before learning at .05.

1.4.2 Students' satisfaction towards the experimental method was at a high level.

1.5 Scope of the Study

This study was conducted within a specific framework as described here. Therefore, caution needed to be exercised in generalizing the results, especially in the context of different levels of education and using different research instruments.

First, the study was conducted in a high school in YinChuan, China. Data were collected using questionnaire and test items for high school students in the designated school.

Second, standard textbooks were available for teachers in YinChuan to rely on when conducting chemistry experiments. However, teachers could realize their own teaching methods and objectives according to students' needs, the degree of abstraction of the experimental phenomenon, and the safety of the experiment. Therefore, with this experiment, the researcher wanted to propose the use of the experimental method as a teaching method to improve students' achievement in chemistry.

1.5.1 Location of the Study

This research was conducted in a full-time experimental demonstration high school in Yinchuan, Ningxia. China, located on the south side of Baohu Cultural Park, Baohu West Road, Yinchuan City. The first phase covered an area of 85 hectares, the second phase covered an area of 65 hectares, and the construction area was 28,000 square meters. The environment was beautiful, and the school running conditions were first-class. The location of the school is shown in Figure 1.1.

Figure 1.1 Location of the Research School

Source: Guge, 2023

1.5.2 Research Population

Population: The population used in the research was the year 1 students of 246 schools in YinChuan, China, totaling 4,591 students.

Sample: The research sample consisted of 30 students from a high school in YinChuan, using cluster random sampling which used the number of classrooms as a base for random sampling. The random samples were mixed genders and ability.

1.5.3 Timeframe

The study was carried out in the first term, from October to November, for a period of four weeks in 2023. There were eight sessions in total, with 45 minutes in each session. Two sessions were conducted in a week.

Table 1.1Time frame for the Research Process

Activity	2023								2024
	MAy	June	July	Aug	Sept	Oct	Nov	Dec	Jan
Literature Review									
Research Proposal									
Data Collection									
Data Analysis									
Report Writing									
Final Defense									

In this study, the investigator designed four classes, each lasting 45 minutes. The theme of each class was dominated by the official chemistry textbook of the Chinese Ministry of Education, based on Section 1, Chapter 2, Sodium and Its Compounds of General High School Chemistry Curriculum standard (experiment) 2003.

1.5.4 Content of Lesson plans

Table 1.2 Content of Lesson plans

Lesson Plans	Topics	Experimental method
Lesson plan 1 Session: 1-2	reaction of sodium and oxygen	The steps of the sodium–oxygen reaction and the corresponding oxide formation conditions were noted.

Table 1.2 Content of Lesson plans (Cont.)

Lesson Plans	Topics	Experimental method
Lesson plan 2 Session: 3-4	The reaction of sodium with water	Advise students to conduct experiments well and record experiments well.
Lesson plan 3 Session: 5-6	Reaction of sodium compounds and water	Compounds based on sodium: compare the color and shape of sodium oxide, sodium peroxide, sodium carbonate, and sodium bicarbonate. Investigate products by reacting compounds with water
Lesson plan 4 Session: 7-8	flame reaction	Based on the color of the flame, guess the metal composition of the sample, and draw a conclusion.

1.6 Definitions of Terms

Chemistry experiment: refers to the chemistry teacher's management of chemistry learning for first-year students in a high school in Yinchuan, Ningxia, China. Using metallic sodium, water, oxygen, and acid-base solutions to react allows students to observe and understand experimental phenomena. This part includes Step 1, Preparation before the experiment. Step 2 Experimental procedure, Step 3 Presenting the experimental results, Step 4 Discussion and conclusion, Step 5 Stage of learning evaluation.

Learning achievement: Students' academic performance refers to the ability of year 1 Chinese high school students to understand the properties of matter through chemical experiments and improve their performance. These could be measured by: Achievement tests (pre-test and post-test).

Satisfaction: The satisfaction of year one high school students in China towards the use of experimental methods to learn chemistry was analyzed through the use of a questionnaire including three parts: 1. interest & motivation; 2. engagement; and 3. The function of the experimental method on the students.

A high school in Yinchuan year one students： Referring to the first year of high school students in a secondary school in YinChuan, China, who were the study population in this study.

1.7 Conceptual Framework of this Study

The researcher had studied the theoretical concepts related to the development of learning achievement in chemistry through an experimental teaching method based on relevant documents and research. Two variables could be identified: independent and dependent variables as follows:

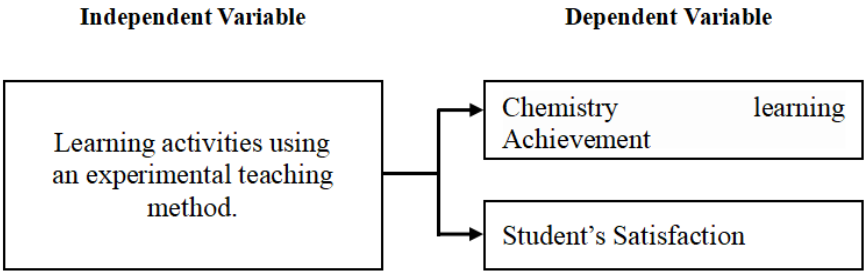

Figure 1.2 Research Conceptual Framework

1.8 Limitations of the Study

1.8.1 Time constraint

The study was conducted only for a period of one month, with four lesson plans in eight sessions. Therefore, the result might have varied if conducted over a longer period.

1.8.2 Limited participants

The study had been conducted on a sample of 30 high school students at a school in Yinchuan, China, so the results may not have applied to all Chinese students.

1.8.3 Location of the study

Since this study was conducted in school that was well equipped in terms of educational management. Therefore, the results of the study cannot be compared with students in other schools with different readiness and conditions.

1.9 Significance of the Study

1.9.1 Using an experimental approach helped teachers to improve their students' achievement in chemistry.

1.9.2 The use of teaching methods that involved active learning with students conducting their own experiments helped students gain satisfaction in learning, which led to an effective learning atmosphere.

1.9.3 This study provided teachers with an attractive student-centered approach to teaching that positively changed their teaching behavior.

CHAPTER 2

LITERATURE REVIEW

This chapter introduced the development of chemistry in China from three aspects: Chinese education policy, Chinese culture, and the globalization process, and expounded on the study of chemistry by using experimental methods in the development process. The chapter also discussed the experiment as an important component of chemistry learning, the application and importance of the experimental method, the cognitive characteristics of high school students, and the principles and degrees that needed to be observed to realize the experimental method. On this basis, the study theory and literature of high school chemistry experimental method teaching methods were summarized.

2.1 The Development of Chemistry in China

The ancient Chinese chemistry achievements were brilliant, but they did not give birth to modern chemistry, which was something the academic circle always thought about. At the same time, the academic circle had basically reached an agreement on when Western chemistry was introduced into China, that is, Western chemistry was introduced into China after the Opium War.

In 1842, due to the defeat in the Opium War, the Marison School was moved from Macao to Hong Kong. In addition to Chinese and English, the curriculum included natural sciences such as algebra, geometry, chemistry, physiology, and geography, which represented the earliest chemistry courses in China. (Wang, 1987)

After the founding of the People's Republic of China in 1949, a new education

system was established and was constantly reformed and improved, which led to great development and improvement in China's chemistry education. Basic chemistry education had been implemented from middle school, from the third grade of junior high school to the third grade of senior high school, with a total of 380~430 credit hours. (Chemistry Education in China, 1862)

In 2016, the reform of chemistry textbooks had been carried out, which mainly involved the adjustment of the examination content and policy changes. In terms of examination content, chemistry would focus on basic knowledge, thinking methods, and scientific literacy, and strengthen the topic setting closely related to actual life; some knowledge points that were complicated, difficult, and with fewer application scenarios were eliminated. In the new version of the new chemistry of the 2019 Human Education Edition, the intensive experiment section was highlighted so that students could strengthen their understanding from practice and cultivate their 'open thinking ability, practical ability, and communication ability in order to improve their' chemistry performance. (Chemistry Education in China, 1862)

2.1.1 Impact on China's education policy

At the end of the Qing dynasty, the development of new education in China, the urgent need for textbooks, and our country's science education is still in the bud, and chemistry professionals is very lacking, a higher degree in middle school science courses will have to rely on foreign textbooks, Japan, the two States is the modern in the field of education, science had important influence on China, both countries from the chemical textbooks also become the main reference object. More than half a century after the introduction of modern chemistry into China, there are still many chemistry textbooks. On the one hand, the development of Chinese chemistry was still relatively backward, and chemistry still a long way to go to achieve localization; on

the other hand, we can also see the great influence of the American culture on China. (Zhang & Xia, 2007)

After the third Plenary Session of the 11th Central Committee of the Communist Party of China in 1978, education underwent corrections, adjustments, and reforms, leading to significant progress. By the mid-1980s, there were about 100,000 ordinary middle schools in China, with about 50 million students and approximately 170,000 middle school chemistry teachers. Basic education in chemistry had become widely popularized. There were 1,056 institutions of higher learning in China, with about 22,000 chemistry professors, associate professors, lecturers, teaching assistants, and teachers. Around 250 institutions of higher learning across the country had established departments of chemistry or applied chemistry. (Chemistry Education in China, 1862)

2.1.2 Impact on China's chemical industry

The rapid development of chemical science and technology had made people realize that chemistry is ubiquitous. Modern tools had made people's lives more convenient, relaxed, and comfortable. (Wang, L., Wang, Z., Li, & Hu, 2002)

After the founding of the People's Republic of China in 1949, the Communist Party of China clearly articulated the scientific development policy of "combining theory with practice." By 2023, the "Chinese Academy of Sciences" was established as the core of the academic leadership of the national science. With the establishment of institutes such as the Beijing Institute of Chemistry, Changchun Institute of Applied Chemistry, Shanghai Institute of Organic Chemistry, Shanghai Institute of Materia Medica, and Dalian Institute of Chemical Physics, the impact on people's lives became increasingly significant. For instance, polymer chemistry had brought synthetic rubber,

chemical fiber products, plastics, and paint to the Chinese people, altering their quality of life to some extent. The development of organic synthesis and medicinal chemistry had brought about many types of drugs. On the eve of liberation, China had a very small pharmaceutical industry, but by 1959, 50% of drugs could be produced domestically. China had developed gentamicin, which had unique efficacy. (Baidu Baike, 2022)

This development showed that since the Westernization Movement of the late Qing Dynasty, Chinese chemistry had been continuously evolving and had entered people's lives as a basic and applied discipline. People's lives had become inseparable from chemistry, and development could not proceed without it.

2.1.3 The impact of the Chinese culture

The Curriculum Standard of Senior High School Chemistry 2017 edition proposed that the curriculum content should be organically integrated into traditional culture, paying attention to excavating the ideas and humanistic spirit contained in the excellent traditional culture of the Chinese nation, and inheriting and carrying forward the spirit of the craftsman and technological innovation.

Chinese traditional culture was extensive and profound, with a long history. Ancient ceramics, Chinese herbal medicine, the four great inventions, brewing, metallurgy, and the "Silk Road," which originated from China's trade, had profoundly influenced China and even the world. The development of alchemy, traditional Chinese medicine, porcelain, and bronze ware was based on chemistry. Gunpowder and papermaking were the peaks of chemical development in China. The invention of gunpowder was related to alchemy, and the raw materials of alchemy included sulfur and saltpeter. The alchemy division gradually found a way to make gunpowder

because of explosions during alchemy. After the invention of black gunpowder, it was separated from alchemy and then was always used in the military, such as in artillery, and finally spread to Europe. It slowly created a new era of hot weapons in the military. (Baidu Baike, 2021)

In the history of modern chemistry, the names of Chinese scientists were not visible. A letter from Einstein had said: "The development of Western science and technology benefited from a number of significant achievements, that is, the Greek philosopher invented the form of logic system, and the Renaissance found in the new period through systematic experiments can find causality. However, the lack of Chinese sages and sages did not step on these two steps." Therefore, in terms of the development of modern chemistry higher education in the Republic of China, the development of modern higher education in China was mostly the result of the introduction of the modern Western higher education system, and modern chemistry higher education also took the same journey. The overseas students who returned from studying abroad played an important role in introducing the Western chemical system. These students studied in Europe and the United States, through their efforts to master the forefront of discipline knowledge and methods, understand and grasp the basic situation of foreign chemical systems, and upon returning home began to establish universities of chemistry or chemical professions, and then opened chemistry courses, wrote chemistry textbooks, and spread chemical knowledge. These students became the constructors of modern chemical higher education, gradually exploring a chemistry teaching mode suitable for China's national conditions. (Zuo, 2002)

2.1.4 The impact of the globalization process

Most foreign countries had attached great importance to the experimental teaching of chemistry. Britain had always had a tradition of valuing science education.

They paid special attention to the study of chemistry and the study of chemistry experiments. (Fan & Zhu, 2006).

In the implementation of the course, chemistry held a prominent position, and every chemistry class would be conducted in the laboratory. (Zhu, 2014) The evaluation of experiments was not limited to activity reports and experiment reports but also included experimental operation tests to ensure that experiments were used as a carrier to improve students' abilities. In the United States, there would be 30-40 chemistry experiment classes in a semester, accounting for half of the chemistry class, and the chemistry laboratory was directly open to room fees, allowing students to freely enter and leave the laboratory to conduct chemistry experiments, which helped students to learn chemistry. (Song, 2012).

In Japan, the purpose of chemistry teaching was to observe the chemical facts and chemical experiments in daily life, promote the study of chemical knowledge (Hua, 2010), and value interesting, quantitative, and inquiry experiments. Experimental courses accounted for one-third of the chemistry courses (Yao, Zhao, & Gao, 2008). In the Netherlands, students' interest in learning chemistry experiments could be increased by adding chemistry experiment assignments and listing chemistry experiments as the final exam subjects (Yang, 2005). Therefore, it was easy to find that most developed countries abroad had attached great importance to implementing chemical experiments. Through investigation, the British inquiry chemical experiment had to start from the purpose of the experiment, re-understand the chemical experiment, design the chemical experiment, improve and innovate the chemical experiment, and make a comprehensive prediction of the safety issues (Liang, 2001). Also, in the United States, American scholar Gregory and other researchers conducted a year-long survey, through seven chemistry teacher interviews, written analysis: chemistry laboratory training was one of the best teaching methods to enhance

students' scientific inquiry abilities (Zeng, Wang, & Li, 2018) and was also the best way to improve students' understanding of chemistry.

In summary, the experimental teaching measures adopted by various countries were different, and the research on experimental teaching had different priorities.

2.2 Experimental method

Chemistry experiments were the most intuitive teaching means, which simulated the practice process of human beings' understanding of things and conformed to the natural law of human beings' comprehension of objective things. Therefore, it was the most successful teaching means of chemistry teaching to make maximum use of experimental teaching. Letting the students do the experiments by themselves was the most effective way to cultivate the students' abilities.

2.2.1 Meaning of Experimental Teaching Method.

The definition of the Experimental Method of Teaching was not clear-cut, as it often overlapped with discovery, field trip, and demonstration teaching methods since practical activities characterized all of them. For instance, experimental was a method where concepts had been taught in abstract and required children to experiment to reaffirm the concepts taught. It was more about doing practical activities. Okon and Ibanga (1982) settled for experimental as a method of teaching in which a pupil was guided to investigate the truth of ideas, facts, or assumptions for ultimate confirmation or rejection.

The influence of experimental pedagogy was almost all over the major capitalist countries in Europe and America, especially in France and the United States. France, the United States, the Soviet Union, Japan, and other countries had translated

and published Experimental Pedagogy, and some countries had established educational research institutes and experimental schools. Therefore, under the influence of some international schools, China began to carry out curriculum reform in 2003, giving more hours to chemical experiments, and influencing students' interest in chemistry through experiments.

2.2.2 The importance of Chemical experimental method teaching

An experiment was an integral part of chemistry and was the main driving force and essential factor of vigorous progress. The experimental practice of students' detailed observation ability, operation ability, and innovative thinking development was of great significance; efficiently promoting high school chemistry experiment education work to carry out the science was the development of the new era of quality education measures.

According to the curriculum standard of general high school chemistry compiled by the Chinese Chemistry Curriculum Standard Development Group (2004), from the perspective of teaching epistemology, a chemistry experiment was an essential method of perceptual cognition. Chemical experiments could make students experience the general process of scientific experiment learning experiment method; from the three dimensions of students' scientific literacy development (knowledge and skills, process and method, emotional attitude and values), chemical experiments not only had epistemology and methodology, and to stimulate students' interest in chemical learning, create a lively chemistry teaching situation, transform students' learning style and develop scientific inquiry ability to the implementation of the "emotional attitude and values" goal, activity experience teaching function. (Zhang & Luo, 2021)

This was consistent with the ideas of scholars from CAI Yaping (2005) that said chemistry experiments were essential for improving students' scientific knowledge, contributing to developing students' thinking ability and creativity, and allowing students to experience the inquiry process.

At the same time, in China's high school chemistry curriculum standards, chemistry experiments were distributed in (chemistry 1, chemistry 2) and elective books (Chemistry and Life, Principles of Chemical Reaction, Chemistry and Technology, Organic Chemistry Foundation, Material Structure and Properties), among which there were 41 required courses (chemistry 1, chemistry 2). There was also a particular experimental chemistry module in the elective, providing ten chemical experiments or inquiries. In the "standard content" and "activities and experimental inquiry" of high school chemistry courses, there was much content related to chemistry experiments that were involved. According to the statistics, the content related to chemical experiments accounted for 36.30% of the total items of the "content standard," the chemical experiment activities accounted for 40.74% of the total number of "activities and research recommendations". From these data, chemical experiments in chemistry textbooks in China had become an essential content of high school chemistry teaching. Chemical experiments as a separate module in experimental chemistry, which could be seen that chemical experiments in high school chemistry course content occupied a critical position, more illustrated the use of chemical experiments, could help students improve chemistry performance. (Li, 2009).

2.2.3 Teaching objectives of the experimental method

In 1956, Bloom, a renowned American educational psychologist, formulated a classification system of educational goals based on the integrity of educational goals. He proposed dividing educational goals into three domains: cognition, emotion, and

motor skills. According to the classification theory of educational objectives by Bloom et al., combined with the education and teaching practice in China, the new curriculum divided the curriculum (learning and teaching) objectives into three dimensions: knowledge and skill, process and method, emotion, attitude, and values.

Three dimensions were mainly used to illustrate the goal of teaching using the experimental method. Chemistry experiments and teaching were based on helping students adapt to the needs of modern life and future development. Therefore, the general teaching goals were divided into skill goals, inquiry goals, and cognitive goals as follows:

1) Skills target

Through many experimental operations teachings, students were required to have mastered the basic experimental skills:

(1) the use of simple instruments, cleaning, preservation, and the use of drugs.

(2) the choice of drugs and instruments, avoiding direct contact with drugs, not tasting the drugs, and not directly smelling them. Instruments were selected according to the properties of the reactants and products, and the reaction conditions.

(3) distinguishing the properties of compounds: having been able to test the common properties of compounds, and using methods such as filtration and evaporation to separate mixtures.

(4) becoming more familiar with experimental instruments, to have avoided losing points in chemical examinations due to unfamiliarity with the instruments.

2) Explore the goal

In the process of experiments, students could be guided to enhance the understanding of chemical inquiry and develop the ability of inquiry through experiments, observation, data collection, conclusions, and reflection.

3) Cognitive goals

In the General High School Chemistry Curriculum Standard (Experiment), the cognitive goals of chemistry experiments for students mainly included:

(1) Developing students' interest in learning chemistry and being willing to experience the mystery of material changes.

(2) Having the enthusiasm to participate in chemical science and technology activities and were able to apply chemical knowledge to life and production. Made reasonable judgments on social and life issues related to chemistry.

(3) Making students pay attention to the hot social issues related to chemistry, and gradually formed the idea of sustainable development.

(4) Developing a scientific attitude of seeking truth from facts, being brave in innovation, and being positive in time, and established a sense of responsibility and mission to study hard for human civilization and social progress.

The 2017 edition of the Curriculum Standards for General High School Chemistry had outlined five critical features of the chemistry discipline. The fourth achievement had spoken of the pursuit of scientific knowledge and innovative consciousness. The primary interpretation was to have realized that the scientific quest was a scientific activity.

2.2.4 About the theoretical basis of the Experimental teaching method

2.2.4.1 Concept of innovation consciousness

The 2017 edition of the Curriculum Standards for General High School Chemistry outlined five critical features of the chemistry discipline. The fourth achievement spoke of the pursuit of scientific knowledge and innovative consciousness. The primary interpretation was to realize that the scientific quest is a scientific activity, involving discovery, creation, and application of science, having problem consciousness, finding and proposing valuable research problems, and assuming chemical problems that involved clear experimental purpose, design, experimental exploration, and in the process, good communication and cooperation, daring to question the validity of the experimental results. It could also be used with existing experimental innovations. (Ministry of Education of the People's Republic of China, 2018)

2.2.4.2 Constructivism theory

Cognitive psychologist Piaget have first put forward the theory of constructivism. He believed that people, as cognitive subjects, should actively process and construct knowledge systems rather than passively accept knowledge. With the development of the times, Vygotsky made an in-depth summary of constructivism, believing that constructivism should have been based on the existing cognitive

structure of students and could construct knowledge according to the current learning situation of students to achieve the required learning level (Stever & Gale, 2002).

In an article by Li and Zhang (2017), constructivism was advocated for as a student-centered, teacher-led education theory, which required students to take the initiative to learn, explore, discover, and create. Moreover, it called for the integration of knowledge to complete the formation of their own knowledge. Teachers needed to educate more but also guide students to build their knowledge seriously.

Therefore, the main idea of constructivism was to require students to have a subjective consciousness, a consciousness of active learning, and flexible learning. This was in line with the experimental teaching theory in chemistry that the researcher had been studying to help teachers turn their attention to designing the teaching of chemistry experiments so that students could take the initiative to participate.

2.2.4.3 The educational theory of learning by doing.

Shi, Zhang, and Wang (2016) discussed that the educational theory of "learning by doing," proposed in Dewey's article, had been put forward by the famous American pragmatist educator Dewey. He had believed that the best education should be learned from life and experience and that "learning by doing" should be learned from activities and experience, so that knowledge and activities could be linked (Wang, 1990). Students should have learned from life, as life things or phenomena contain many knowledge points, and students could also have gotten more knowledge from life, thus being able to better adapt to life. Students should have learned from activities, which, while enriching knowledge, could also have cultivated students' practical ability, improving their comprehensive ability. Dewey had also opposed the traditional

education model of pure knowledge, had advocated the "children-centered and learning from doing" concept, and had advocated that active courses should replace the teaching form of textbooks (General High School Chemistry Curriculum Standard 2017 edition, 2018). By changing the traditional teaching method, students could have participated in more activities, and then they could have learned more knowledge in the activities, which was also important for experimental exploration activities.

Therefore, the educational concept of learning by doing had laid a foundation for the teaching activities of chemistry experiments, avoiding teachers linking knowledge in operation and ignoring the activities of students themselves. To carry out the activities, the students could have obtained the corresponding chemical knowledge by completing the experimental activities by themselves to improve their chemical experiment ability and achievements.

2.2.4.4 Teaching theory of chemistry experiment

Chemistry experiment was not only an important scientific research method, but also an important method and content in chemistry teaching. With the continuous maturation of chemistry education theory, people had gained a more and more comprehensive understanding of the role of chemistry experiments in chemistry course teaching. On the one hand, the discipline characteristics and essence of the chemistry discipline had determined the functional value of chemical experiment understanding. On the other hand, students' ways of understanding had required educators to constantly improve and optimize the teaching of learning experiments. Experimental teaching ability was an essential basic teaching ability for chemistry teachers. In summary, it mainly had included the following aspects (General High School Chemistry Curriculum Standard 2017 edition, 2018):

1) The analytical ability and control ability of the chemical experiment content in the textbook.

2) Ability to design and implement chemistry experiment teaching.

3) Reflective ability of chemistry experiment teaching and research ability of chemistry experiment and research ability of chemistry experiment teaching.

2.2.5 Experimental teaching method

The experimental teaching method referred to the teaching method in which students used certain equipment and materials under the guidance of teachers by controlling the operation process of the conditions, causing some changes in the experimental object, and obtaining new knowledge or verifying knowledge by observing the changes of these phenomena. Experiments were an important method in the teaching of physics, chemistry, biology, geography, and natural knowledge. (Baidu Baike, 2001)

Through the experimental method, students could make a certain direct connection with the book knowledge to obtain complete knowledge, but also to cultivate their independent exploration ability, experimental operation ability, and scientific research interest. It was an indispensable condition for improving the teaching quality of related subjects in natural science.

In addition to observing the principles of chemical experiments, teachers also needed to pay attention to the following principles when designing chemical experiments. (Que, Bao, & Chen, 2011)

1) Principle of direct observation

Students were encouraged to use their senses to experience the charm of chemistry. In the Great Teaching, Comenius wrote: "The teaching should have been felt through the senses as much as possible, so that it could be remembered with the least effort." (Fu,1984) In the study of chemistry, there was a lot of material properties that needed to be mastered by students; rote memorization would not only have made students feel bored, but also, because of the complexity of the content of memory, they might not understand the underlying reasons and easily confuse them. For example, when learning about sodium metal, students needed to master that sodium metal was a soft metal, with a silver-white metallic luster, smaller density than water, and active chemical properties. Then the teacher could have instructed the student to personally remove a small piece of sodium from the kerosene, cut it, observe it, and then place it in water dripping with phenolphthalein. Thus, students could have seen the sodium floating on the surface of the water, the solution turning from colorless to red, heard the hissing sound, and felt the temperature of the beaker rise with their own hands. These intuitive feelings could have made students impressed and consolidated the multi-dimensional construction of metal sodium knowledge.

2) The principle of process

In chemistry teaching, in addition to some teachers' demonstration experiments, students were given more hands-on opportunities to experience the process of scientific inquiry and learned to apply empirically verified research methods based on experiments.

Tao (1919), a famous educationist, had once put forward the idea of "unity of teaching and doing," which also demonstrated the important position of "doing" in teaching. Time and space that belonged to students were given back to them. Students were actively participating in learning.

3) Principles of development

The root cause of students' poor performance and confused memory of basic knowledge was that, except for the experimental phenomena given in books, students had no ability and willingness to explore and verify experiments. Therefore, the teacher should have helped the students come up with several whys: Why was the experiment designed this way? What did each of these substances do? Why did the experiment go wrong? Teachers guided students to find problems and solve problems, to better address the different problems on paper.

2.2.6 Characteristics of cognitive ability development of high school students

Cognitive characteristics: The body developed rapidly, self-awareness increased significantly, and the ability to think and process things independently developed significantly. (Franzoi & Stephen, 1919)

Psychological characteristics: Polarization in learning led to different mental states. For students with higher grades, their positive psychology had been developed, their interest had risen to fun, curiosity had turned into curiosity and exploration, full of confidence, and learning had become a conscious behavior. On the other hand, some students with less impressive results experienced discouragement, inferiority, and even fear of learning. (Lin, 2003) In the first year of high school, students attached more importance to the influence of individual learner behavior, that is, the internal cause, rather than the external cause caused by objective conditions. That is, for the improvement of academic performance, they wanted to improve their learning behavior and learning emotions and the formation of good habits. The improvement of

time utilization, rather than the change of objective conditions, such as the learning environment, the level of teachers, etc.

Therefore, in facing students in the first grade of high school, educators could not blindly believe that children could solve problems by themselves, because the knowledge of high school was extensive, and when problems were found, they should have discussed with their children and helped them solve them.

2.3 The concept of academic achievement and satisfaction

2.3.1 Satisfaction

Huang (2008) had surveyed students in three schools. More than 85 percent of each school had said they liked to do experiments by themselves, because they could clearly observe the experimental phenomena, feel the charm of the experiment, and be more impressed, which could help them to connect with and understand theoretical knowledge. In addition, more than 85% of students in each school did not believe that the implementation of experimental assessment would exert pressure on themselves but could promote their enthusiasm for chemical experiments and learning effects.

Zeng (2013), after investigating some schools, found that the chemistry experiment in provincial middle schools had been relatively poor and had not played the function of chemistry experiment. After designing and implementing the experiment, she discovered that the experiment had connected students' learning interest with learning content to a certain extent, which stimulated students' learning motivation and improved their learning initiative.

Fan (2012) had conducted practical research on students' interest in chemistry experiments, among which the students who accounted for the largest proportion had

thought chemistry experiments were interesting and were willing to spend time participating in various experimental activities. Similarly, nearly 85 percent of students had thought chemistry experiments were very helpful to improve chemical performance. After a semester of practice, Fan Dandan found that students who had implemented experimental teaching had significantly improved their interest in chemistry, and their grades had also improved significantly.

2.3.2 Achievement

Kong (2008) scholars believed that abnormal phenomena of chemical experiments had become a hot topic in the chemistry of the college entrance examination, and it was also a difficult point for students because experimental inquiry was an important investigation content of the college entrance examination of chemistry. Therefore, paying attention to the abnormal phenomena of chemical experiments was conducive to improving students' performance. Then it was necessary for students to understand the experiment after the actual operation of the experiment before they could better complete the chemical experiment investigation.

Wu (2020) scholars also put forward that students would encounter many abnormal phenomena in practical experiments, which might be the key point of the college entrance examination of chemistry. Therefore, teachers should have paid close attention to the abnormal situations of students in the experiment and guided students to record the different experimental phenomena. They should have grasped the details of each experiment, let students boldly put forward imagination or hypotheses, and after communicating with classmates and teachers, designed experimental schemes to verify. This not only allowed students to experience the fun of experimental exploration but also correctly guided students to make the best solutions in the face of different experimental situations.

Lin (2010) scholars believed that different chemical experimental phenomena could be used as materials for students to explore. Because chemical experiments themselves were uncertain and original, this could well satisfy students' curiosity, stimulate students' exploration consciousness of chemistry, and greatly promote chemical learning.

2.4 The teaching process focuses on experiments in this research.

For this research, the researcher had designed an experimental teaching method based on the study of teaching concepts that were similar and interesting in accordance with the research objectives as follows.

Wang (2019) had discussed the application of micro-chemical experiments using WeChat video technology for classroom demonstration experiments. About general first-class chlorine gas, WeChat's video features and students' practical experiments had been used to cultivate students' observation and practical skills. The procedure was as follows:

Step 1: the multimedia display of the mineral resources in the ocean and the explanation of the importance of chlorine gas.

Step 2: involved initiating the video and converting the shooting camera to a rear camera and agreeing to the video invitation on the computer side. Then the camera was aimed at the experimental device, and the orientation of the mobile phone of the experimental device was displayed on the screen. A student was asked to come to the stage to hold the mobile phone to shoot video demonstrating the reaction of chlorine and sodium, and then the experimental steps and phenomena were summarized according to the experiment.

Step 3: where students experimented with the reaction of chlorine, dry petals, and fresh petals.

Step 4: summarizes the properties of the chlorine gas based on the two experiments.

Step 5: involved asking students who were interested to use bleaching powder as raw material, independently founded experimental equipment to make chlorine gas, and exploring what substances chlorine gas could bleach.

Guo (2022) discussed in his research on the topic of experimental chemistry teaching in vocational high schools based on deep learning. He approached the subject from three aspects: experimental attitude, experimental design, and experimental effect, formulating evaluation indicators. He used experimental research methods and questionnaires to reflect the teaching effect of chemical experiments. The lesson was on the refinement of coarse salt through experimental teaching design. The steps were as follows:

Step 1: the video playing a video about the production of sea salt in Changlu Salt Field, which has the largest sea salt production in China, so that students could understand that the subject of this lesson was the purification of crude salt.

Step 2: letting the students read the textbook video about testing for barium ions and analyze the experimental phenomena.

Step 3: to derive the precipitation method according to the experiment in the book, and the students were asked to use the precipitation method to remove the impurities of magnesium chloride, calcium chloride, and sodium sulfate. They worked in groups to explore and design experimental plans.

Step 4: each group discussing their experimental plan and new discoveries in the experiment, and the teacher guided the students to summarize the experiment according to the questions.

Step 5: to arrange after-school homework to allow students to consolidate knowledge points.

Duan (2020) discussed the experimental teaching process in her research topic of exploratory teaching mode, using No. 1 Middle School in Pu'er City, Yunnan Province as an example. She stated that heuristic teaching ideas should be implemented in high school chemistry experimental teaching and that there should be a focus on cultivating students' experimental interest. She emphasized that any teaching link should be carried out under the guidance of the teacher. She explained the reason why the experimental project solution causes the phenolphthalein solution to turn red first and then fade after the reaction of sodium peroxide with water. The specific operations were as follows:

Step 1: The teacher demonstrated the experiment by adding an appropriate amount of sodium peroxide to the water dripped with phenolphthalein and asked the students to explain the experimental phenomenon.

Step 2: The teacher guided the students to think about the reason for the fading and asked students to make bold guesses.

Step 3: The experimental steps were discussed according to the students, and after the teacher's guidance, the students conducted experiments to explore the reasons.

Step 4: At the end of the experiment, the teacher acted as the moderator, guided the group spokesperson to report, and guided other students to ask questions

about the group after each group report was completed. The session was then concluded.

Step 5: Homework was arranged to improve the experiment content and the experiment report. The chemistry experiment teaching method, many scholars had emphasized cultivating students' core chemical literacy as the primary task, focusing on students' hands-on ability and inquiry ability. Taking the experiment "Exploring the Gradual Law of Oxidation Strength of Halogen Elemental Substances" from the article by scholar Zhao (2022) as an example, the specific operation steps were as follows:

Step 1: the teacher raising a group discussion question: how to prove that the oxidizing properties corresponding to non-metallic elements have a law of gradual change. The teacher helped students choose the best experimental plan.

Step 2: observing students' experimental operations and guiding them. The teacher guided students to do a good job in division of labor and cooperation and make experimental records. The teacher observed the comprehensive situation of each group and gave a comprehensive evaluation.

Step 3: listening to student reports, offering help and guidance, and asking for critiques from other groups.

Step 4: guiding students to make analyses based on the experimental results and exploring the deficiencies in the experimental process.

Step 5: the homework assignment requiring students to further improve the experimental report.

In his research on the design and application of chemical experiments in 2019, Li (2020) showed different methods for teachers to ask questions, including analytical, recall, and predictive questions. The main purpose was to develop students' cognition of models. The experimental project was to explore the reaction between copper and ferric chloride. The process operation was as follows:

Step 1: the teacher's analytical question: Did copper and ferric chloride react? What happened? Students were asked to try to explain this phenomenon.

Step 2: the recall question: Students had learned about the two valences of iron before, so what properties did ferric iron have? The teacher guided students from the rise and fall of valence to redox reactions. Predictive questions included: writing the word 'chemistry' on a copper-clad board, putting it in ferric chloride solution, and after a period of time, the teacher took it out and washed it. Students were asked to predict what would have happened to the copper plate.

Step 3: the video display of the experiment.

Step 4: the analytical type question: General waste liquid could be dumped directly, but the random dumping of metal waste liquid would cause environmental pollution. Chemical plants were required to treat sewage before discharging it, so the question was how should it be dealt with?

Step 5: the summary: Students were asked to write down the phenomena and explanations they had predicted before in their books, how they were obtained, how they differed from other people's views, and how their views changed later. The teacher organized the design steps in the class, wrote them on the blackboard, and explained the ideas behind each step.

Step 6: the homework: a summary of experimental questions.

From the study of the concept of the instructional management process emphasizing on the students to practice experiments in the classroom of the above scholars, the researcher was able to summarize and synthesize an experimental teaching process for learning management in this research. The details were as follows.

Step 1 Preparation before the experiment

1.1 Set learning objectives in which the teacher had to study the curriculum, teacher manual, or lesson plan and set the learning objectives used in teaching clearly how they wanted students to develop learning behaviors in each aspect of learning by doing experiments.

1.2 Planned the experiment It was the step where the teacher had to sequence the teaching steps and prepare the activities in advance for how to bring them into the lesson so that the students could experiment in the sequence. Summarized the results of the experiment and presented the results when, how, or by what method, etc.

1.3 Provided experimental materials and equipment, a form to record experimental results, and an evaluation form. Teachers had to be prepared to have a sufficient number of students and in usable condition.

1.4 Checked the accuracy and efficiency of the equipment and experimental materials. Teachers would try out tools before teaching to see problems that might occur in advance and to be helpful in advising and admonishing students while experimenting.

1.5 Prepared to divide students into groups. The teacher had to determine the appropriate group of students. It should have been a small group so all students could learn how to experiment thoroughly. The division into groups of students had to be consistent with the amount of materials, tools, and equipment available.

Step 2 Experimental procedure

2.1 Introduced the lesson It was the stage where the teacher aroused the students' interest. Teachers had to inform the purpose of the experiment, steps, and experimental methods and introduce the use of tools and materials to students to know their roles. Moreover, they had students study the operating manual before doing the actual experiment.

2.2 The Experimental stage was where the students performed the experiment, with teachers supervising, advising, and helping. If an experiment could cause danger, the teacher had to supervise closely for safety.

Step 3 Presenting the experimental results

At this stage, students presented exciting and useful experimental results and details such as experimental topics, plans, preparations, methods, and results.

Step 4 Discussion and conclusion

Students had gained from learning activities; for example, a group whose experimental results were inaccurate or different from others learned the cause by analyzing what steps went wrong. As for how to solve the problem at this stage, the teacher had a role in providing additional feedback, reiterating essential points, and summarizing the principles and concepts derived from experiments.

Step 5 Stage of learning evaluation

When the discussion and conclusions of all groups of students were finished, teachers evaluated students' learning outcomes in various aspects. Moreover, they notified the students so that they could improve in the following experiment. For example, they assessed the use of tools in detail in the experiment, recording of experimental results, reporting of results, cooperation with groups, etc.

2.5 Related Research and Studies

Many researchers and teachers studied experimental chemistry teaching methods in teaching chemistry. From the related research studies, the researcher found them to be very suitable for teaching chemistry at the high school level. These teaching methods had a positive effect on learning outcomes in chemistry. Moreover, they significantly improved students' chemistry scores. They also stimulated students' enthusiasm for chemistry. Furthermore, they helped students solve complex chemistry experiments on exams, as presented below.

Liu (2003) believed that the design of chemical experiments should have been determined according to the teaching situation, which was not simply to teach students how to do experiments but to solve how to do it from the two perspectives of epistemology and methodology and what teaching methods and strategies should have been adopted to ensure the realization of the function and value of chemical experiments.

Zheng (2009) pointed out that the ability of chemical experiment teaching was one of the basic abilities of chemistry teachers in middle schools. His paper introduced the current chemistry experiment research from the current curriculum and teaching perspective. It discussed the concepts of chemistry experiment curriculum and

experiment teaching, teaching experiment and experiment teaching, teaching experiment research, and experiment teaching research, and summarized the four aspects of chemistry experiment teaching ability that chemistry teachers should have had. These four aspects included the ability to control experimental courses and teaching materials, the ability to design and implement experimental teaching, the ability to research teaching experiments, and the ability to research experimental teaching. His paper systematically discussed the course of chemical experiments, including the significance of experiments to chemical science, the significance of experiment teaching to chemistry teaching, and how to design and implement chemical experiment teaching.

Wang (2010) research on chemical experiments and teaching in middle schools conducted classified statistics on chemical experiments in compulsory education and ordinary high school courses. It analyzed and interpreted the emphasis and characteristics of each module of chemical experiments. The author gave his own ideas and methods for designing and implementing chemistry experiment teaching in middle schools. The structure and form of teaching material experiments were discussed theoretically.

Guo (2016) addressed a learning process perspective that defined deep learning as a meaningful learning process in which students, under the active guidance of teachers, focused on challenging learning topics—dedicated to learning activities to gain a successful learning experience and self-development.

Peng (2019) of Hunan Normal University combined high school chemistry teaching with in-depth learning routes to construct a flow chart of in-depth learning chemistry teaching design and, combined with case studies, designed teaching through

teaching practice. She concluded that the chemistry teaching design based on in-depth learning could promote students' learning.

Chen (2019) analyzed the essential components of scientific inquiry ability. Different teaching strategies were used for each session when cultivating students' ability to seek scientific knowledge.

Sheng (2020) interviewed about the current situation of teaching experimental chemistry in a high school in Chengdu. It was found that most teachers believed that chemistry experiments were essential for building knowledge of chemistry. Most students believed that experiments could increase their interest in learning chemistry. Most teachers, therefore, chose to teach experiments or demonstrate experiments through video demonstrations.

In conclusion, the research studies related to teaching methods of chemical experiments by scholars in the country and abroad mentioned above showed that adopting experimental chemistry teaching methods in high school could be very effective. Their research confirmed that using experimental-based teaching methods in chemistry for upper secondary school students could improve academic achievement and student satisfaction.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter will present a detailed research methodology, as follows:

3.1 Research Design

3.2 Research population

3.3 Research Instruments

3.4 Validity and Reliability of the research Instrument

3.5 Data collection procedure

3.6 Data analysis

3.1 Research Design

The research on the development of learning achievement in the chemistry subject on the topic of chemical reactions between metal sodium and its compounds for year one high school students using the experimental method was conducted. It was the form of a one group pre-test – post-test design. The objectives were 1) To compare year one high school students' learning achievement in Chemistry before and after using an experimental method 2) To investigate year one high school students'satisfaction towards using an experimental method in Chemistry.

3.2 Population and Sample

3.2.1 Population

The population used in the research was the high school year one students of 246 schools in Yinchuan, China, totaling 4,591 students.

3.2.2 Sample group

The number of research sample was 30 students from a high school in Yinchuan, using the cluster random sampling method. This method used the number of classrooms as a base for random sampling. The random samples were of mixed gender and ability.

3.2.3 Location

This research was conducted in a full-time experimental demonstration high school in Yinchuan, Ningxia. Located on the south side of Baohu Cultural Park, Baohu West Road, Yinchuan City, the first phase covered an area of 85 hectares, the second phase of land acquisition was 65 hectares, and the construction area was 28,000 square meters. The environment was beautiful and the school running conditions were first-class. The location of the school was shown in Figure 1.1.

3.3 Research Instruments

The research tools included 4 lesson plans, divided into 8 sections, a chemistry learning achievement test, and a student satisfaction questionnaire. The creation and quality, validity, and credibility of the research tools were as follows.

3.3.1 Lesson Plans

The researcher created four chemistry lesson plans by studying information from related documents, consisting of studying the details of the Chinese compulsory education curriculum in high school chemistry and studying the method of creating a teaching plan according to the experimental teaching method as a guideline for

creating a teaching plan. Then, the researcher created a chemistry lesson plan with an experimental teaching method, with 4 lesson plans divided into 8 sessions as follows:

Table 3.1 Lesson Plan Structure

Lesson Plans	Sections	Learning Objectives	minutes
1	1. The reaction of sodium and oxygen 1	1. To know the physical properties of sodium. 2. To understand its existence and uses. 3. To cultivate students' ability to explore, analyze and reason based on experimental phenomena	45
	2. The reaction of sodium and oxygen 2	1. To learn about the chemistry of sodium 2. To remember the products generated by the sodium and oxygen reaction under different conditions 3.To learn basic experimental operation methods such as access and heating test drugs.	45
2	3. The reaction of sodium to water 1	1.To master the reaction of sodium and water 2.To know how to deal with sodium fire in daily life 3.To memorize the operation steps of sodium and water experiments	45
	4. The reaction of sodium to water 2	1.To familiar with the specific phenomena in the reaction process of sodium and water 2.To explore the gas composition generated during the experiment 3. To understand the confirmatory experiment proces	45

Table 3.1 Lesson Plan Structure (Cont.)

Lesson Plans	Sections	Learning Objectives	minutes
3	5. Reaction of sodium compounds and water 1	1、To master the difference between sodium oxide and sodium peroxide 2、To memorize the reaction products of sodium peroxide and water 3、To master the operation process of sodium peroxide and water experiments	45
	6. Reaction of sodium compounds and water 2	1. To familiar with the use of sodium carbonate and sodium bicarbonate 2. To master the reaction products of sodium carbonate, sodium bicarbonate and water 3. To master the operation process of comparative experiments	45
4	7. flame reaction 1	1.To master the flame reaction of sodium and potassium 2.To understand the experimental process of flame reaction	45
	8. flame reaction 2	1.To master the flame color of common metals 2. To memorize the process of flame test 3. To master the principles of using various instruments in the flame test	45

The lesson plan was then presented to 1 chemistry content expert, 1 curriculum and teaching expert, and 1 measurement and evaluation expert to check the appropriateness of language and content validity. The criteria for determining the opinion score of Taweerat (2004) were used as follows:

Score +1 for content that was certain to be consistent with that purpose.

Score 0 for content that was uncertain whether it met that purpose or not.

Score -1 for content that was certain not to be in line with that purpose.

The results of the experts' considerations were recorded, and an index of item Objective Congruence (IOC) acceptable from .50 or higher was found. The lesson plan was then improved according to the advice of the experts.

The revised lesson plan was used to find effectiveness by trying out with the non-sample group of first-year high school students, and the efficiency was determined according to the 80/80 criterion from the E1/E2 formula (Phromwong, 1994) by conducting the experiments as follows:

Step 1: Individual Tryout: The researcher used the lesson plan to try it out on 3 non-sample high school students who had never studied this subject before and had competency at proficiency, moderate, and weak levels, one person each, by considering their academic achievements in chemistry from the past semester. The researcher had informed the students of the purpose and how to practice activities. They took a test before studying, then proceeded with the activities according to the teaching plan for 8 sessions, and practiced until all activities were completed. The students took a test after studying, and the researcher calculated the efficiency according to the E1/E2 criterion to check the suitability and consistency of the image with the article, font size, and the accuracy of the worksheet. The consistency of the questions in the test was also assessed. The average efficiency, measured at 57.92/62.22, was found to be insufficient, as the student inquiry results revealed problems hindering the try-out from meeting the 80/80 criterion. During this process, through interviews with three students, the researcher discovered the following

problems: 1. Don't speak too fast during class, as this will cause students to not hear clearly. 2. Pay attention to the difficulties of each student. These problems lead to students not mastering the knowledge points well.

Step 2: Small Group Tryout: The researcher used the individualized lesson plan to try it out on 9 first-year high school students who had never studied this subject before. The students were selected as good, average, and weak, with 3 students each who were not part of the sample group, and the same criteria as the individual experiment were used. Data from the experiment were analyzed for the effectiveness of the learning management plan according to the 72/74 criterion to check the appropriateness of time and the use of language in the teaching and learning process. The findings were then used to make improvements. Afterwards, the researcher still talked with 9 students and came up with the following improvement measures: 1. After class, the knowledge points of this course should be emphasized to help students strengthen. 2. Some students lack self-confidence in learning. Students should be encouraged and given more opportunities to demonstrate.

Step 3: Field Tryout: The researcher took the revised lesson plan from Step 2 and tested it on 30 first-year high school students who had not studied the subject before. The students were selected, with 10 each from those who studied well, moderately, and mildly, none of whom were part of the sample group. The same criteria from the individual trials were applied. The data from the experiment were analyzed to determine the effectiveness of the teaching plan according to the 80/80 criterion to identify further flaws in the teaching plan.This experiment achieve the goal of 80/80, and the sample group of students would use the same lesson plan.

When it could be concluded that the teaching plan was effective according to the specified criteria, then the teaching plan was used with the sample group.

3.3.2 The achievement test (Pretest and Posttest)

To create a chemistry achievement test, it was designed as a multiple choice type, with four options, each with only one correct answer, covering all the key content used in the study, for a total of 60 questions. Among the 60 questions, 30 questions were selected based on the theory, principles and guidelines of the achievement test. Each question had 4 options and each question had only one correct answer. These issues included studying China's compulsory education curriculum and high school chemistry.

The chemistry learning achievement test was then presented to 1 content expert, 1 curriculum and teaching expert, and 1 expert in measurement and evaluation to check the suitability of language and content validity by using opinion score criteria. The experts' reviews were recorded, and an acceptable Index of Item Objective Congruence (IOC) of .50 or higher was sought. The results of the inspection found that the acceptable Index of Item Objective Congruence (IOC) was 1.00. This indicated that the questions and options of the achievement test are congruent and appropriate.

Then, the chemistry achievement test was improved according to the advice of the experts. The revised Chemistry Achievement Test was then taken for a tryout with 30 high school students who had already studied the reaction of sodium. Afterward, the test scores were checked by awarding 1 point for each correct answer. Questions that were answered incorrectly or not answered were given 0 points. These were analyzed to find the difficulty (p) between 0.20-0.80 and the discriminating power (r) between 0.20-1.00, after which 30 multiple-choice items were selected for use with the sample.

Table 3.2 Criteria for interpretation of correct answer analysis for test difficulty (p)

Test difficulty (p)	meaning
0.81-1.00	It's that simple.
0.60-0.80	Quite simply.
0.40-0.59	moderate
0.20-0.39	Quite difficult.
0-0.19	Very hard.

Table 3.3 Criteria for interpreting the results of the correct answer analysis of the test (r)

Discriminant power of the exam (r)	meaning
0.60-1.00	Very good
0.40-0.59	good
0.20-0.39	fairly
0.10-0.19	Relatively low, should be improved.
0-0.09	Very low, should improve.

The results of the analysis of 60 test items found that the usable items had difficulty indices (p) between 0.20 and 0.80 and discrimination indices (r) between 0.20 and 1.00. Then, 30 valid exams were selected and prepared as a pre-test, and one copy as the post-test. The pre-test and post-test differed in that the items were switched. The test was then applied to the sample group of students.

3.3.3 Student's Satisfaction Questionnaire

The construction of a questionnaire on students' opinions toward the development of learning achievement in chemistry with an experimental teaching method was conducted as follows:

The theory, principles, and guidelines for constructing an opinion questionnaire were studied. Questions or guidelines for asking and constructing questions were created by constructing an opinion questionnaire as a 5-level evaluation scale based on the concept of the Likert Scale, consisting of:

Level 5 means most satisfied.

Level 4 means very satisfied.

Level 3 means moderately satisfied.

Level 2 means less satisfaction.

Level 1 means least satisfied.

The questionnaire was then presented to one content expert, one expert in curriculum and instruction, and one measurement and evaluation expert to check the suitability of the language and content validity (Content Validity) according to the .50 . The analysis of the index of item-objective congruence found a value of 1.00. This indicates that the questions in the questionnaire are appropriate in terms of language and content, and are consistent with the research objectives. The questionnaire was then used with the sample group.

To assess the reliability of the skills test and questionnaire, the researcher used Cronbach's Alpha. According to Heale, reliability refers to the consistency of results obtained from repeated measurements using the same test instrument. Therefore, the researchers plan to conduct a questionnaire survey with another 30 students in the same grade to evaluate the reliability of the instrument.

Table 3.4 Cronbach's Alpha Rule of Thumb

Cronbach's Alpha Rule of Thumb	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Source: Habidin, 2015

The questionnaire for this study was piloted on 30 students who were not part of the sample group. The reliability result is 0.816, indicating that the reliability of the questionnaire items is high

3.4 Validity and Reliability of the Research Instrument

3.4.1 Language and Content Validity

To check the appropriateness of the language and content validity of the lesson plan, the Chemistry Learning Achievement Test, and the opinion questionnaire, the researcher followed the steps below:

1) To identify the objectives of the research instrument. What were the specific concepts, skills, or knowledge that the instrument was designed to measure?

2) To review the instrument carefully to ensure that each item was aligned with the objectives. Were the items clear, concise, and easy to understand? Did the items cover all of the relevant content?

3) To ask a group of experts (e.g., content experts, curriculum and instruction experts, measurement, and evaluation experts) to review the instrument and provide feedback. Did they agree that the items were aligned with the objectives? Did they have any suggestions for improvement?

3.4.2 Suitability and Consistency of the Lesson Plan

To check the suitability and consistency of the lesson plan, the researcher followed the steps below:

1) To identifiy the key learning objectives for the lesson. What were the specific concepts, skills, or knowledge that students were expected to learn by the end of the lesson?

2) To review the lesson plan carefully to ensure that each activity was aligned with the learning objectives. Were the activities appropriate for the students' age and developmental level? Did the activities provide students with opportunities to practice and apply the concepts they were learning?

3) To use the 80/80 criterion analysis to ensure that 80% of the learning objectives were covered in 80% of the lesson time.

3.4.3 Chemistry Learning Achievement Test

To check the Chemistry Learning Achievement Test, the researcher used the following analyses:

1) Difficulty (p): This analysis measured the proportion of respondents who answered an item correctly. A difficulty level of 0.5 indicated that half of the

respondents answered the item correctly. A difficulty level of 0.75 indicated that 75% of the respondents answered the item correctly.

2) Discriminatory power (r): This analysis measured how well an item discriminated between high-performing and low-performing respondents. A discriminatory power of 0.30 or higher was considered to be acceptable.

3) Reliability: This analysis measured the consistency of the results of a research instrument over time. There are a number of different reliability coefficients that can be used, such as Cronbach's alpha and inter-rater reliability. A reliability coefficient of 0.70 or higher was considered to be acceptable.

3.5 Data Collection Procedure

The researcher followed a specific procedure to collect data.

3.5.1 Experimental procedure

1) A pre-test had been conducted using the 30-item Chemistry Learning Achievement Test created by the researcher. It took 1 hour.

2) The sample students had studied according to the teaching plan created by the researcher for 8 sessions. The session time was 45 minutes over 4 weeks. Each student had learned the content of the unit according to the learning schedule shown in the following table.

Table 3.5 Schedule for Each Session

Lesson Plans/week	Sections	minutes
1	1. The reaction of sodium and oxygen 1	45
	2. The reaction of sodium and oxygen 2	45

Table 3.5 Schedule for Each Session (Cont.)

Lesson Plans/week	Sections	minutes
1	1. The reaction of sodium and oxygen 1	45
	2. The reaction of sodium and oxygen 2	45
3	5. Reaction of sodium compounds and water 1	45
	6. Reaction of sodium compounds and water 2	45
4	7. flame reaction 1	45
	8. flame reaction 2	45

3) A post-test had been administered using the 30-item chemistry learning achievement test created by the researcher. Takes 1 hour.

4) The students were asked to answer the student opinion questionnaire on the development of learning achievement in chemistry on the reaction of sodium, which was created by the researcher. This took 10 minutes.

5) The obtained scores were used to replace the statistics according to the assumptions set.

The data was summarized and analyzed.

3.5.2 Ethical Approvement

To conduct the study at the school, the researcher had obtained approval documents from a high school in Yinchuan. Since the participants in this study were between 16 and 17 years old, the researchers also obtained permission from the school's responsible department and the parents.

3.5.3 Confidentiality

The investigator kept all biological data and responses to the questionnaire confidential. The researcher deleted all the data after the study was completed.

3.6 Data analysis

The statistics used to analyze the data were as follows:

1) To check the appropriateness of the language and the content validity of the lesson plan, the Chemistry Learning Achievement Test, and the opinion questionnaire by using the Index of Item Objective Congruence (IOC) analysis.

2) To check the suitability and consistency of the lesson plan by using the analysis of efficiency according to the 80/80 criterion.

3) To check the chemistry achievement test by analyzing the difficulty (p), the discriminating power (r), and the reliability.

4) To check the pre-test scores and post-test scores, as well as the students' opinion levels, using mean analysis and standard deviation.

5) To check the mean difference using t-test statistics.

CHAPTER 4

RESULTS AND DATA ANALYSIS

The findings and analysis of the research project entitled "The development of learning achievement in chemistry on chemical reactions between metal sodium and its compounds for year one high school students using an experimental method" were presented in this chapter. To answer this question study investigated whether experimental methods can improve the chemistry performance of year one high school students in China. The researcher collected pre-test and post-test data from 30 Chinese year one students and analyzed them to collect quantitative information on students' learning performance levels after incorporating chemistry learning intervention. 30 Chinese students took the pre-test and post-test, with 30 different multiple-choice questions for each student. A paired samples t-test was used to compare the sample group's pretest and post-test results and evaluate the chemistry classroom's efficiency. Moreover, the efficiency of teaching chemistry experiments was then assessed. Statistical analyses employing the mean, standard deviation, and significant value were conducted to compare the pre-and post-test scores. The second research question is whether using experimental methods in teaching affects year one Chinese high school students' satisfaction toward chemistry. To collect data in this regard, a questionnaire survey was conducted, and the data collected was analyzed using a five-point Likert scale.

The data findings were presented in the following order:

4.1 Analysis of learning performance of year one Chinese high school students before and after class using experimental method to learn chemistry.

4.2 Analysis of the satisfaction of year one Chinese high school students towards experimental method in learning chemistry.

4.1 Analysis of students' learning achievement

This section compares the academic performance of year one high school students in China who use experimental method to learn chemistry. The results of the study were obtained through pre-test and post-test. For fairness, two evaluators were also involved. By comparing the difference between the scores before and after the study using a dependent t-test, the following results are shown in the table:

Table 4.1 compares learning achievement before and after the study using an experimental method.

Group	Pretest		Posttest		Mean difference	T	P-value
Sample Group	$\bar{X}$	SD	$\bar{X}$	SD	3.53	20.65	.01**
	14.90	2.04	18.43	2.06			

Significance level (p): <0.05=significant

The mean scores of the pretest and posttest were 14.90 and 18.43, respectively, as shown in Table 4.1. The results in Table 4.1 showed that the group's mean posttest score (x=18.43) was higher than the mean pretest score (x=14.90), with a mean score difference of 3.53. Research clearly shows that before using experimental methods to learn chemistry, students' academic performance is lower than after using it. The standard deviation of the pretest was 2.04, and the standard deviation of the posttest was 2.06. The comparison of all these scores confirms the validity of the academic performance of year one high school students in China.The significant value (P) obtained was .04, which was lower than .05 (P*.05). There was a statistically significances in the posttest scores as compared to the pretest scores for the group. The

significant value (P) obtained was .01, which was lower than .05 (P*.05).This group's posttest scores were statistically significant compared to the pretest scores.

The researcher also created a graph to show the comparison of the pre-test and post-test scores. The graph is shown in Figure 4.2.

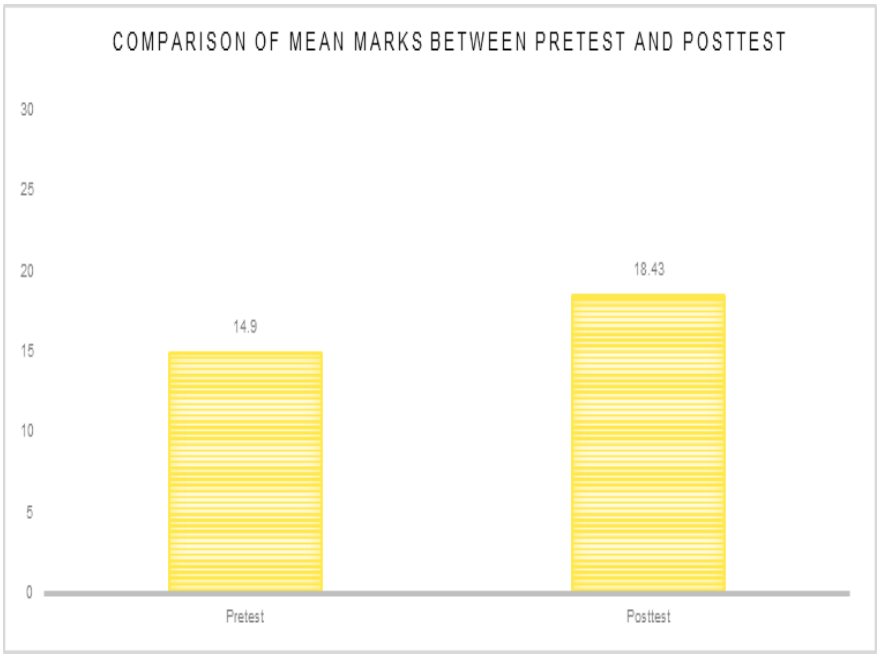

Figure 4.1 Pretest and Posttest Mean Comparison

According to Figure 4.2, the learning achievement of all students after the study were higher than their learning achievement before the study using the development of learning achievement in chemistry on chemical reactions for year one high school students using an experimental method.

The researcher prepared a graph showing the learning achievement during the study of the development of learning achievement in chemistry on chemical reactions for year one high school students using an experimental method, a total of 8 worksheets, as shown in appendix.

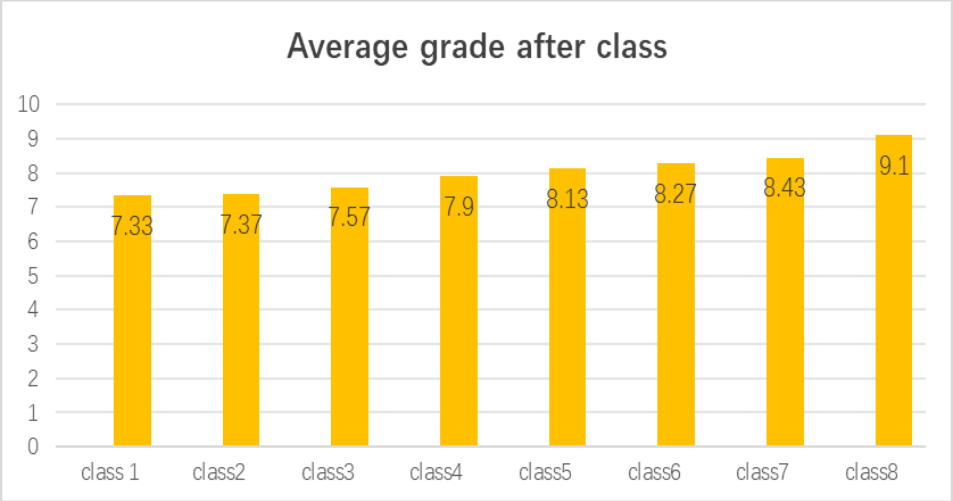

Figure 4.2 Average grade after class

Figure 4.11 shows that the mean student score on all eight worksheets was above 70%. This was because the worksheets at the end of the study plan were reviewed to ensure their appropriateness and consistency with the study plan and were therefore considered valid. Students answered questions on assigned worksheets. The highest average student score in Figure 4.10 was 91%, and the lowest average student score in Figure 4.3 was 73.3%.

4.2 Analysis of students' Satisfaction

A five-level scale questionnaire was used to collect quantitative data and study students' satisfaction toward using experimental methods to learn chemistry. The questionnaire has 14 questions in total. It was divided into PART A (interest and motivation), PART B (engagement), and PART C (The function of the experimental method on the students). The questionnaire was administered to all 30(N=30) study participants. The survey results were analyzed using descriptive statistics (mean and standard deviation).

As mentioned earlier in Chapter 3 the statistics (mean and standard deviation) were used to examine the survey findings. A five-point Likert scale was adopted: 1 = strongly disagree, 5= strongly agree.

Table 4.2 shows students' overall views on the development of chemistry performance using the chemistry experiment method.

NO	Part	Mean	S.D.	Interpretation
1	PART A: Interest & Motivation	4.68	0.49	Highest
2	PART B: Engagement	4.60	0.52	Highest
3	PART C: The function of the experimental method on the students	4.65	0.48	Highest
Average		4.64	0.49	Highest

From Table 4.2, it can be found that year one high school students are generally satisfied with the development of their learning performance in chemical reaction experiments, with an average of 4.64 and a standard deviation (S.D. = 0.49). When considering opinions by aspect, it was found that students were most satisfied with the aspect of interest and motivation at the highest level, with an average of 4.68 and a standard deviation of (S.D. = 0.49). Second, the aspect of the function of the experimental method on the students had an average of 4.65 and a standard deviation of (S.D. = 0.48), respectively, which is consistent with the second research hypothesis set. It can be shown by aspect as shown in the following table:

Table 4.3 Mean and Standard Deviation: Part A (n=30)

No.	Part A- Interest & Motivation	Mean	SD	Interpretation
1	The process of using the chemical experimental method is very interesting	4.76	0.43	Highest

Table 4.3 Mean and Standard Deviation: Part A (n=30) (Cont.)

No.	Part A- Interest & Motivation	Mean	SD	Interpretation
2	Learning chemistry using experimental methods makes chemistry more meaningful	4.73	0.44	Highest
3	Learning chemistry by experimental methods can develop my interest in chemistry	4.56	0.56	Highest
4	The experimental method can encourage me to have more confidence in my chemistry study	4.66	0.54	Highest
	Average	4.68	0.49	Highest

From Table 4.3, it was found the mean scores and standard deviations for student satisfaction with Part A, Interest and Motivation. The highest average score is 4.76 and a standard deviation (S.D. = 0.43). Students generally believed that the process of learning chemistry using experimental methods is very interesting. The average score of Part A is 4.68 and a standard deviation (S.D. = 0.49) . The explanation of the average score shows that students' views, interests, and motivation for Part A of the questionnaire are at the highest level.

Table 4.4 Mean and Standard Deviation: Part B (n=30)

No.	PART B: ENGAGEMENT	Mean	SD	Interpretation
1	All the activities related to the experimental method are very interesting	4.53	0.57	Highest
2	All of the activities related to the experimental methods are very meaningful	4.30	0.65	Highest

Table 4.4 Mean and Standard Deviation: Part B (n=30) (Cont.)

No.	PART B: ENGAGEMENT	Mean	SD	Interpretation
3	All the activities related to experimental methods can help me remember chemical experimental phenomena	4.73	0.52	Highest
4	Using experiments can help me understand the abstract concepts of textbooks	4,76	0.43	Highest
5	I like participating in classroom activities related to experimental methods	4.70	0.46	Highest
	Average	4.60	0.52	Highest

From Table 4.4, it was found the means and standard deviations of student scores in Part B, Effectiveness. From the data point of view, all project scores were above 4.30 and a standard deviation (S.D. = 0.43), and the final average score was 4.60 with a standard deviation (S.D. = 0.52). Most students agree that chemical experiments can be an effective way to help understand abstract chemical concepts.

Table 4.5 Mean and Standard Deviation: Part C (n=30)

No.	PART C: The function of the experimental method on the students	Mean	SD	Interpretation
1	Using experimental method teaching can improve my chemical experiment ability	4.56	0.56	Highest
2	Using experimental method teaching can improve my understanding of experiment	4.50	0.57	Highest
3	Using experimental method teaching can help me understand abstract conceptual knowledge	4.73	0.44	Highest
4	Using experimental method teaching can help me improve the score of experimental questions	4.80	0.40	Highest

Table 4.5 Mean and Standard Deviation: Part C (n=30) (Cont.)

No.	PART C: The function of the experimental method on the students	Mean	SD	Interpretation
5	Using the experimental method of teaching can help me improve my overall chemistry performance	4.70	0.46	Highest
	Average	4.65	0.48	Highest

Table 4.5 it was found the mean scores and standard deviations of students' responses to Part C, "Satisfaction." Most students believe chemical experiments can help them understand abstract concepts and remember chemical experimental phenomena. The average score for item 4 is 4.80 and a standard deviation (S.D. = 0.40), which is at the "highest" level. The average score of items 2 is 4.50 a standard deviation (S.D. = 0.57), at the lowest level. The overall average score is 4.65 and a standard deviation (S.D. = 0.48), indicating that most students recognize the chemistry experimental teaching method and believe that learning chemistry through experimental methods is helpful for academic performance.

As mentioned above, among the three parts, Part A and C have higher average scores, with average scores of 4.68 and 4.65, and standard deviations of 1.14 and 1.23 respectively. Part B has the lowest average score, with an average score of 4.60 and a standard deviation of 0.9. Nonetheless, considering the overall average score of 4.64, the researcher believe that the chemistry experiment teaching method can effectively improve the chemistry performance of year one high school students.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

The research titled "The development of learning achievement in chemistry on chemical reactions for year one high school students using an experimental method" has the following objectives: 1) To compare high school year one students' learning achievement in Chemistry using an experimental method. 2) to study year one high school students' satisfaction towards using an experimental method in chemistry.

The sample for this research consisted of a high school in Yinchuan students who were enrolled in the semester of 2 in the academic year of 2023, totaling 30 people. The sample was obtained by using the cluster random sampling, using schools under the jurisdiction of Yinchuan Foreign Languages Experimental School as the sampling unit. The research design was One Group Pretest–Posttest Design. The independent variable using an experimental method the dependent variables are chemistry learning achievement and student's satisfaction.

The research tools used in this study consisted of:

Learning plans (number of plans: 4) that passed the index of consistency (IOC) test. The IOC of all learning plans was equal to 1.00 and were effective according to the 80/80 criteria (Appendix page77).

Tests (multiple-choice, 4 options, number of questions: 30) that passed the index of consistency (IOC) test. The IOC was equal to 1.00, with difficulty (p) between0.20 and 0.80, discrimination (r) between 0.20 and 1.00, and reliability of 0.06 (Appendix page79).

Questionnaires (rating scale, 5 levels, number of questions: 14) that passed the index of consistency (IOC) test. The IOC was equal to 1.00 (Appendix page84).

Data analysis and statistics used to compare the learning achievement before and after studying about using experimental methods learning chemistry. used t-test

dependent and questionnaire of students' opinions on the development of Using experimental methods to improve chemistry scores achievement, by finding the mean ($\overline{X}$) and standard deviation (S.D.)

This chapter presents the summary of the study, and the details are presented in the following order:

5.1 Conclusion

5.2 Discussion

5.3 Recommendations

5.1 Conclusion

5.1.1 The Result of Pretest and Posttest score

The learning achievement of students who studied about learn chemistry with experiments in general, found that the mean score before studying was ($\overline{X}$ = 14.90) and the standard deviation was (S.D. = 2.04), and the mean score after studying was ($\overline{X}$ = 18.43) and the standard deviation was (S.D. = 2.06). The difference was statistically significant at the .05 level, with the post-test scores being higher than the pre-test scores.

The responses of students on the development of chemistry performance using the chemistry experiment method in general were the most satisfied, with a mean score of ($\overline{X}$ = 4.64) and a standard deviation of (S.D. = 0.49). When considering the responses of each item, it was found that interest & motivation had the highest level of satisfaction, with a mean score of ($\overline{X}$ = 4.68) and a standard deviation of (S.D. = 0.49). The next highest was the function of the experimental method on the students, with a mean score of ($\overline{X}$ = 4.65) and a standard deviation of (S.D. = 0.48). had the highest level of satisfaction, with a mean score of ($\overline{X}$ = 4.60) and a standard deviation of (S.D. = 0.52). It is obtained through the data statistics in Table 4.2 in Chapter 4, 4.2 Analysis of student' satisfaction for Engagement, the responses were equally satisfied at the highest level, with a mean score of ($\overline{X}$ = 4.80) and a standard deviation of (S.D. = 0.40).

5.2 Discussion

From the results of the research on Pre-test and post-test scores and questionnaire survey satisfaction, the following conclusions can be drawn:

5.2.1 Comparison of learning achievement before and after studying about using experimental method learning chemistry

The results of the study showed that the achievement of students who used experimental methods to learn chemistry improved significantly after the intervention ($p < .05$). The students' responses on the development of learn chemistry with experiments were generally positive, with the highest level of satisfaction. Discussion most students felt that the intervention helped them to Improved grades. The following results can be discussed:

In this article, each step can be discussed as follows:

5.2.1.1 In the first stage, it was found that the teacher's pre-class preparation was very important. The teacher tests the dosage of experimental drugs in advance, which plays a big role in whether students can complete the experiment safely. This was consistent with the "Pre-Class Preparation for Chemistry Inquiry-Based Teaching" which states that chemistry teachers must carefully analyze teaching materials and dosages. (Xu, 2012)

5.2.1.2 The second stage was the classroom experiment. In this link, we found that it was important to continuously cultivate students' problem-solving and innovation abilities in the processes of observation, questioning, imagination, experimentation, cooperation and communication, etc. This was consistent with the theory of "learning by doing" (Du. 1990).

5.2.1.3 The third stage was to present the experimental results. In this link, the researcher found that giving students the opportunity to show will allow students to fully develop their personalities. Fully develop and discover and explore your strengths and talents to the greatest extent. This was consistent with the theory of teaching students in accordance with their aptitude in "Research on the Design of High

School Chemistry Experiment Teaching from the Perspective of Core Competencies of Chemistry Subject" (Kong, 2021).

5.2.1.4 The fourth stage researcher found that guiding students to discover new problems helps develop students' exploratory thinking. This is consistent with the "Research on the Experimental Part of the New High School Chemistry Curriculum Standard Textbook" which advocated the formation of students' exploratory thinking (Li, 2019).

5.2.1.5 The fifth stage was the learning evaluation stage. In this link, the researcher found that chemical experiments can also cultivate students' emotions of caring about society, loving nature, cooperating with others, and experiencing emotions. This view was confirmed in "Research on the Experimental Part of the New High School Chemistry Curriculum Standard Textbook" (Li, 2019).

According to the research of the researcher, the post-test scores using the Experimental teaching method were higher than the set criteria. This may be due to: The experimental learning approach is a step-by-step process that promotes students to Stimulate interest in learning, use experiments to promote visual memory and understanding, through experimental design, learn scientific methods, develop students' scientific inquiry and problem-solving abilities, and promote students' chemistry learning. of chemical knowledge. It has a clear set of steps, namely Students are the leaders of the experiment, and teachers are only assistants, Involve students in as many practical activities as possible. It also helps students develop analytical and collaborative skills. Teachers play a role in motivating students to think and use their logic and innovation. When students follow all safe laboratory procedures, they will eventually be able to Gain the ability to organize experiments and improve analytical and logical abilities (Wang, 2008).

5.2.2 Students' Satisfaction

From the specific data of the questionnaire survey, we observed scores in interest, participation, satisfaction, etc., indicating that most students have positive satisfaction with experimental methods for learning chemistry. Specific data show that

students' positive evaluations of teaching methods are reflected in multiple aspects. The overall scores obtained indicate that students generally believe that this teaching method has had a positive impact on increasing their interest in chemical experiments, improving their ability in chemical experiments, and improving their satisfaction with the teaching methods. According to the evaluation system, students' views on the application of experimental methods can be understood. This is very consistent with the comprehensive principle proposed by Investigation and Research on the Current Situation of Chemistry Experiment Teaching in General High Schools under the Background of the New Curriculum (Du, 2015) - the content of the evaluation must include both Theoretical knowledge of experiments also includes students' ability to operate experiments, discover problems, solve problems, process data and explore experiments.

The three sections A B C in the questionnaire were all rated as "highest" level. No item was rated as "strongly disagree."

1) The descriptive statistical analysis results of the questionnaire show that students are relatively satisfied with the experimental method for improving chemistry scores. Most notably, none of the questions were marked as "moderately" and "strongly disagree," which strongly indicates students' positive satisfaction with the use of experimental methods in learning chemistry.

2) Most students also believed that using experimental methods improved their understanding and analytical skills in chemistry learning. The results showed that only the experimental significance questions in the questionnaire had lower scores, indicating that students were willing to explore chemical experiments that were more in-depth and closer to life. Looking back on the teaching process, students showed a high degree of concentration and participation in the course; and successfully completed the teaching plan. The classroom atmosphere is always relaxed and happy, which greatly confirms the students' positive satisfaction with the fun of class.

Chemistry experiments can stimulate students' interest in learning chemistry, help students form chemical concepts, acquire chemical knowledge and abilities, cultivate students' observation and experimental abilities, help cultivate students' pragmatic and serious scientific attitude, and cultivate students' logical and creative thinking. habits, it can also mobilize students' enthusiasm for learning chemistry (Baidu, 2023)

5.3 Recommendations

Based on the findings and conclusions made from the study, the following recommendations were proposed.

5.3.1 Recommendations for Implementation

The study found that using experimental methods to improve the chemistry learning performance of first-year high school students in China is effective. The use of experimental methods should also be promoted in chemistry teaching in other schools.

This study was limited to 30 first-year Chinese high school students in Yinchuan, China. Similar studies with larger sample sizes can be conducted in different regions of China, which would be very valuable for similar studies to validate and ensure the credibility of this study. But it is only suitable for students in the first grade of high school. If you want to try it with students of other age groups and in countries other than China, please make different adjustments according to the teaching materials and student acceptance. For example, in other high schools in China, it is necessary to examine the complexity of experiments and the time crunch facing the college entrance examination. Therefore, except for the first grade students, teachers are asked to give priority to more practical experiments.

If used in countries other than China, please strictly consider the type and dosage of the drugs used in the experiment to avoid unsafe experiments and improve the success rate. And record it, you can ask students to analyze the reasons for the differences such as dosage.

Since the experimental method of learning chemistry is a relatively new teaching method, it has certain difficulties and limitations. For one thing, the study was time-constrained, lasting only four weeks. Therefore, further investigation into the matter over a longer period of time is necessary to obtain more accurate results. On the other hand, the conduct of chemical experiments has higher requirements on school laboratory environment, safety system, teacher qualifications, etc. to ensure student safety. In addition, it is also a great test for teachers. Teachers need to eliminate dangers in experiments in advance, conduct quantitative experiments on experimental supplies in advance, and test teachers' organizational skills.

5.3.2 Recommendations for Future Research

Considering some limitations of this study, the researcher have the following suggestions for further research.

Compared with other teaching methods in chemistry teaching, the use of experimental methods is more effective in stimulating students' interest and is also very effective in improving students' academic performance. It is recommended that other chemistry teachers try using experimental methods to teach chemistry. Whether the experiments mentioned in this article are required to be completed in the textbook or experiments designed by guiding students, the important thing is to choose experiments that are suitable for the site, meet the students' experimental level, and are related to the course or topic being studied, and provide appropriate guidance. Combining chemistry experiments with students and life. In addition, ensure the operability and safety of the experiment.

For classrooms that use experimental methods, it is recommended that an evaluation system be added to evaluate activity performance, experimental procedures, teacher satisfaction, etc., because experiments and teaching in the course can effectively promote students' development in knowledge, skills, process methods, emotional satisfaction, etc. Comprehensive development.

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APPENDICES

APPENDIX A

LETTER OF APPROVAL

RSU มหาวิทยาลัยรังสิต RANGSIT UNIVERSITY

มหาวิทยาลัยรังสิต เมืองเอก ถ.พหลโยธิน จ.ปทุมธานี 12000
Rangsit University Muang-Ake, Paholyothin Rd. Pathumthani 12000, Thailand
T. (66) 2997 2200-30 F. (66) 2791 5757 E. info@rsu.ac.th

STC. 4800/03858
8 November 2023
Subject: Request for Permission to Collect Data for a Master's Thesis at Yinchuan Foreign Language Experimental School

Director
Yinchuan Foreign Language Experimental School

Dear Sir/Madam,

Miss Yuxing Niu student number 6306064, a student in the Master of Education (Curriculum and Instruction) at Suryadhep Teachers College, Rangsit Pathum Thani, Thailand. She is now planning to collect the data for her thesis in Year 1 High School Students. Three instruments will be used for her thesis entitled **"The Development of Larning Achievement in Chemistry on Chemical for Year 1 High School Students using an Experimental Method"**.

The objectives of the research are: To compare high school year 1 students 'learning achievement in Chemistry using an experimental method., and to study high school year 1 students 'satisfaction towards using an experimental method in chemistry.

"All procedures will be conducted in accordance with the ethical principles of human research. Please rest assured."

After completion, this study will be taken as partial fulfillment of the requirements for the Degree of Master of Education in Curriculum and Instruction. It is hoped that the research findings will be useful for all the parties concerned to use for their benefits. Thus, I would like to seek for your kind permission for the student, Miss Yuxing Niu , Student ID: 6306064 to collect the data in Yinchuan Foreign Language Experimental School.

On behalf of Rangsit University, I truly appreciate all the help and support you can give in Miss Yuxing Niu's thesis endeavor.

Sincerely yours,

Assistant Professor Nipaporn Sakulwongs, Ed.D.
Master of Education in Curriculum and Instruction Program Director
Suryadhep Teachers College, Rangsit University

Permission to Collect Data from Authorized Person

Name: 胡青

☑ I consent to allow your student to collect data under the principles research ethics.
☐ I do not consent to allow your student to collect data.

Signature: 胡青
2023/11/10

三外国语实验学校

Note: When the expert signs the acceptance form, the student should submit the form in the fourth step of the thesis submission process to the Graduate School.

APPENDIX B

EXPERTS WHO VALIDATED RESEARCH INS

No.	Name	Position/Title	Institutes
1	Lu Manling	PhD in organic chemistry	Southwest University for Nationalities
2	Zhang Qi	high school chemistry teacher	Southwest University for Nationalities
3	Baiyun Li	Professor of Education	Sichuan University of Media and Communication

APPENDIX C

IOC OF LESSON PLANS

IOC OF LESSON PLANS

Item No	Attributes	Expert 1	Expert 2	Expert 3	Average	congruence
1	Lesson plan 1	+1	+1	+1	+1	Congruent
2	Lesson plan 2	+1	+1	+1	+1	Congruent
3	Lesson plan 3	+1	+1	+1	+1	congruent
4	Lesson plan 4	+1	+1	+1	+1	congruent
5	Lesson plan 5	+1	+1	+1	+1	congruent
6	Lesson plan 6	+1	+1	+1	+1	congruent
7	Lesson plan 7	+1	+1	+1	+1	congruent
8	Lesson plan 8	+1	+1	+1	+1	congruent
Overall Average		1				congruent

APPENDIX D

IOC FOR TEST QUESTIONS BY THE EXPERTS

IOC OF TEST QUESTIONS						
S1NO.	Items	Expert1	Expert2	Expert3	Average	Congruence
1	Multiple choice Question 1	+1	+1	+1	1.00	congruent
2	Multiple choice Question 2	+1	+1	+1	1.00	congruent
3	Multiple choice Question 3	+1	+1	+1	1.00	congruent
4	Multiple choice Question 4	+1	+1	+1	1.00	congruent
5	Multiple choice Question 5	+1	+1	+1	1.00	congruent
6	Multiple choice Question 6	+1	+1	+1	1.00	congruent
7	Multiple choice Question 7	+1	+1	+1	1.00	congruent
8	Multiple choice Question 8	+1	+1	+1	1.00	congruent
9	Multiple choice Question 9	+1	+1	+1	1.00	congruent
10	Multiple choice	+1	+1	+1	1.00	congruent

	Question 10					
11	Multiple choice Question 11	+1	+1	+1	1.00	congruent
12	Multiple choice Question 12	+1	+1	+1	1.00	congruent
13	Multiple choice Question 13	+1	+1	+1	1.00	congruent
14	Multiple choice Question 14	+1	+1	+1	1.00	congruent
15	Multiple choice Question 15	+1	+1	+1	1.00	congruent
16	Multiple choice Question 16	+1	+1	+1	1.00	congruent
17	Multiple choice Question 17	+1	+1	+1	1.00	congruent
18	Multiple	+1	+1	+1	1.00	congruent

	choice Question 18					
19	Multiple choice Question 19	+1	+1	+1	1.00	congruent
20	Multiple choice Question 20	+1	+1	+1	1.00	congruent
21	Multiple choice Question 21	+1	+1	+1	1.00	congruent
22	Multiple choice Question 22	+1	+1	+1	1.00	congruent
23	Multiple choice Question 23	+1	+1	+1	1.00	congruent
24	Multiple choice Question 24	+1	+1	+1	1.00	congruent
25	Multiple choice Question 25	+1	+1	+1	1.00	congruent

26	Multiple choice Question 26	+1	+1	+1	1.00	congruent
27	Multiple choice Question 27	+1	+1	+1	1.00	congruent
28	Multiple choice Question 28	+1	+1	+1	1.00	congruent
29	Multiple choice Question 29	+1	+1	+1	1.00	congruent
30	Multiple choice Question 30	+1	+1	+1	1.00	congruent
Overall Average		1.00				congruent

Note:

Expert 1: LuManling

Expert 2: BaiYunli

Expert 3: ZhangQi

APPENDIX E

IOC OF QUESTIONNAIRE BY EXPERTS

IOC FOR QUESTIONNAIRE BY THE EXPERTS

IOC OF QUESTIONNAIRE						
S1NO.	Items	Expert1	Expert2	Expert3	Average	Congruence
PART A: INTEREST & MOTIVATION						
A1.	The process of using the chemical experimental method is very interesting	+1	+1	+1	1.00	Congruent
A2.	Learning chemistry using experimental methods makes chemistry more meaningful	+1	+1	+1	1.00	Congruent
A3.	Learning chemistry by experimental methods can develop my interest in chemistry	+1	+1	+1	1.00	Congruent
A4.	The experimental method can encourage me to have more confidence in my chemistry study	+1	+1	+1	1.00	Congruent
Overall Average		1.00				Congruent
	PART B: ENGAGEMENT					

B1	All the activities related to the experimental method are very interesting	+1	+1	+1	1.00	Congruent
B2	All of the activities related to the experimental methods are very meaningful	+1	+1	+1	1.00	Congruent
B3	All the activities related to experimental methods can help me remember chemical experimental phenomena	+1	+1	+1	1.00	Congruent
B4	Using experiments can help me understand the abstract concepts of textbooks	+1	+1	+1	1.00	Congruent
B5	I really like participating in classroom activities related to experimental methods	+1	+1	+1	1.00	Congruent
Overall Average		1.00				Congruent

S1NO.	Items	Expert1	Expert2	Expert3	Average	Congruence

PART C: The function of the experimental method on the students						
C1	Using experimental method teaching can improve my chemical experiment ability	+1	+1	+1	1.00	Congrue nt
C2	Using experimental method teaching can improve my understanding of experiment	+1	+1	+1	1.00	Congrue nt
C3	Using experimental method teaching can help me understand abstract conceptual knowledge	+1	+1	+1	1.00	Congrue nt
C4	Using experimental method teaching can help me improve the score of experimental questions	+1	+1	+1	1.00	Congrue nt
C5	Using the experimental method of teaching can help me to improve my overall chemistry performance	+1	+1	+1	1.00	Congrue nt
Overall Average		1.00				Congrue nt

Note:

Expert 1: LuManling

Expert 2: BaiYunli

Expert 3: ZhangQi

APPENDIX F

LESSON PLAN

Verify that the course plan is feasible

การหาค่า E1/E2 โดยเทียบเกณฑ์มาตรฐาน 80/80

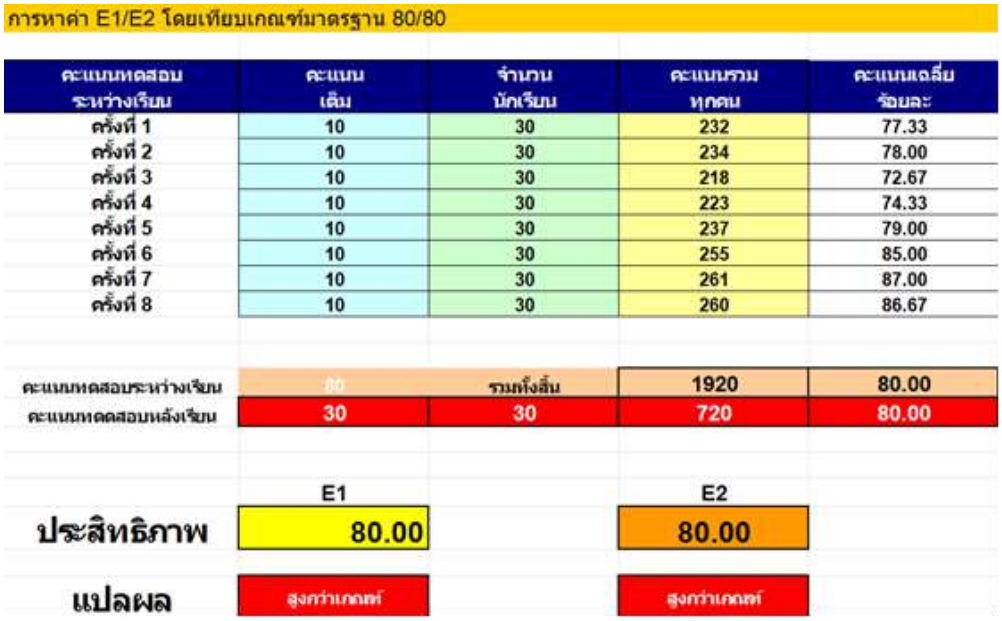
คะแนนทดสอบระหว่างเรียน	คะแนนเต็ม	จำนวนนักเรียน	คะแนนรวมทุกคน	คะแนนเฉลี่ยร้อยละ
ครั้งที่ 1	10	3	21	70.00
ครั้งที่ 2	10	3	16	53.33
ครั้งที่ 3	10	3	17	56.67
ครั้งที่ 4	10	3	17	56.67
ครั้งที่ 5	10	3	18	60.00
ครั้งที่ 6	10	3	16	53.33
ครั้งที่ 7	10	3	17	56.67
ครั้งที่ 8	10	3	17	56.67
คะแนนทดสอบระหว่างเรียน	80	รวมทั้งสิ้น	139	57.92
คะแนนทดสอบหลังเรียน	30	3	56	62.22222222

	E1	E2
ประสิทธิภาพ	57.92	62.2222222
แปลผล	สูงกว่าเกณฑ์	สูงกว่าเกณฑ์

การหาค่า E1/E2 โดยเทียบเกณฑ์มาตรฐาน 80/80

คะแนนทดสอบระหว่างเรียน	คะแนนเต็ม	จำนวนนักเรียน	คะแนนรวมทุกคน	คะแนนเฉลี่ยร้อยละ
ครั้งที่ 1	10	9	60	66.67
ครั้งที่ 2	10	9	56	62.22
ครั้งที่ 3	10	9	63	70.00
ครั้งที่ 4	10	9	69	76.67
ครั้งที่ 5	10	9	64	71.11
ครั้งที่ 6	10	9	69	76.67
ครั้งที่ 7	10	9	65	72.22
ครั้งที่ 8	10	9	72	80.00
คะแนนทดสอบระหว่างเรียน	80	รวมทั้งสิ้น	518	71.94
คะแนนทดสอบหลังเรียน	30	9	201	74.44

	E1	E2
ประสิทธิภาพ	71.94	74.44
แปลผล	ต่ำกว่าเกณฑ์	ต่ำกว่าเกณฑ์



การหาค่า E1/E2 โดยเทียบเกณฑ์มาตรฐาน 80/80

คะแนนทดสอบระหว่างเรียน	คะแนนเต็ม	จำนวนนักเรียน	คะแนนรวมทุกคน	คะแนนเฉลี่ยร้อยละ
ครั้งที่ 1	10	30	232	77.33
ครั้งที่ 2	10	30	234	78.00
ครั้งที่ 3	10	30	218	72.67
ครั้งที่ 4	10	30	223	74.33
ครั้งที่ 5	10	30	237	79.00
ครั้งที่ 6	10	30	255	85.00
ครั้งที่ 7	10	30	261	87.00
ครั้งที่ 8	10	30	260	86.67
คะแนนทดสอบระหว่างเรียน	80	รวมทั้งสิ้น	1920	80.00
คะแนนทดสอบหลังเรียน	30	30	720	80.00

	E1	E2
ประสิทธิภาพ	80.00	80.00
แปลผล	สูงกว่าเกณฑ์	สูงกว่าเกณฑ์

Lesson Plans 1: Session 1

Subject: chemistry **Class**: High school grade 1 **Time**: 45 minutes

Topic: The reaction of sodium and oxygen 1

Theme: Familiarize yourself with the physical properties of sodium and understand the transformation of sodium exposed to oxygen.

Step 1 Preparation before the experiment		Time
learning objectives	1. Know the physical properties of sodium. 2. understand its existence and uses. 3. Cultivate students' ability to explore, analyze and reason based on experimental phenomena.	
experimental planning	Use tweezers to take out the sodium from the empty container bottle, wipe off the kerosene on the surface with filter paper, cut the sodium with a knife, and observe	

	the changes on the surface of the sodium	
experimental materials and equipment	1. Sodium kept in a kerosene bottle. 2. tweezers 3. Filter paper 4. Knife	
Examination of experimental materials and equipment	1. Check whether the seal of the kerosene bottle is intact. 2. Check whether the tweezers and knife are rusty. 3. Whether the filter paper is clean and meets the standard**.**	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time
Introduction to the lesson	Demonstration of sodium metal stored in liquid in the laboratory. Today we will study the physical properties of sodium and explore the storage and use of sodium	6
Experimental stage	1. Students carefully remove a piece of sodium with tweezers, dry the kerosene on the surface with filter paper, and cut the skin off one end with a knife. Feel the texture of sodium. 2. Observe the gloss and color of the sodium Note the changes in the cut surface	20
Step 3 Presenting the experimental results		Time
Students present experimental results	Students present by explaining the experimental plan, experimental results, and problems encountered in each group's	7

	experiment.	
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	All students discuss the experiment. to the reason why the experimental results are like that or the reason why the experimental results are different from other groups to analyze which step is wrong and work together to find a solution to the problem. Teachers have a role in providing additional feedback. emphasize important points and summarize the principles and concepts obtained from the experiment	6
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	After sodium is cut, it contacts with oxygen, the color of sodium becomes darker, and a chemical product is formed with oxygen, called sodium oxide. The problem that is likely to occur in this experiment is that the instrument is not clean, which leads to errors in the experimental results.	6

Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
Know the physical properties of sodium.		test paper	9-10 points is very good. 6-8 points is a fair level.

understand its existence and uses.	test		0-5 points is the improvement level
Cultivate students' ability to explore, analyze and reason based on experimental phenomena	classroom assessment	Experiment Evaluation Form	Form records are detailed without errors

Recording of learning management results

Topics	Highlight /good	Disadvantages /flaws	Solution /Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			

Test paper: The reaction of sodium and oxygen 1

Learning objectives to assess:

1. know the physical properties of sodium.

2. Understand its existence and uses.

Instructions: Have students choose only one correct answer.

1、Sodium occurs naturally in the form of（）

A、Simple substance B、Oxide C、hydroxide D、normal salt

2、Sodium metal is left in the air for a long time and eventually becomes（）

A. Na_2O B. Na_2O_2 C. NaOH D. Na_2CO_3

3、Put a sodium section into a beaker with kerosene and water, and you can see it（）

A. Sodium floats on the liquid level in the beaker B. Sodium sinks at the bottom of the beaker

C. The kerosene will burn up, producing a very thick black smoke D. Sodium will float down above the junction of water and kerosene

4、The reaction of sodium with water is independent of the following properties of sodium（）

A. Sodium has a low melting point B. Sodium has less density than water

C. The hardness of sodium is small D. The reaction of sodium with water is significantly exothermic

5、When Na catches fire, the substance used to extinguish the fire is

A. H_2O B. kerosene C. foam fire-extinguisher D. sandy soil

6、Where where the sodium should be stored（）

A、 water B、kerosene C、sand D、 in the air

7、The texture of sodium is（）

A、Soft B、hardC、adamancy D、Very soft

8、The color of sodium is（）

A、white B 、blackC、 silvery white D、yellow

9、The newly cut metal sodium changes quickly in the air（）

A、white B 、blackC、 silvery white D、yellow

10、Sodium and what substance do not react（）

Acoal oil B、 ethyl alcohoC、waterD、air

Lesson Plans 1: Session 2

Subject: chemistry

Class: High school grade 1 **Time**: 45 minutes

Topic: The reaction of sodium and oxygen 2

Theme: Master the products formed by the reaction of sodium and oxygen under different conditions

Step 1 Preparation before the experiment		Time
learning objectives	1. Learn about the chemistry of sodium 2. Remember the products generated by the sodium and oxygen reaction under different conditions 3. Learn basic experimental operation methods such as access and heating test drugs.	
experimental planning	Heat a dry crucible, cut a piece of sodium the size of a mung bean, and quickly put it into the crucible。 Keep heating, wait for the sodium to melt and immediately remove the alcohol lamp. Observe the phenomenon。	
experimental materials and equipment	1、sodium preserved in kerosene 2、Crucible 3、tweezers and knife **4**、alcohol lamp	
Examination of experimental materials and equipment	1、Check that the sodium in kerosene is well preserved 2、Check the crucible for cracks 3、Check pocket knives and tweezers for rust **4**、Check whether the alcohol capacity in the alcohol lamp is up to standard	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time

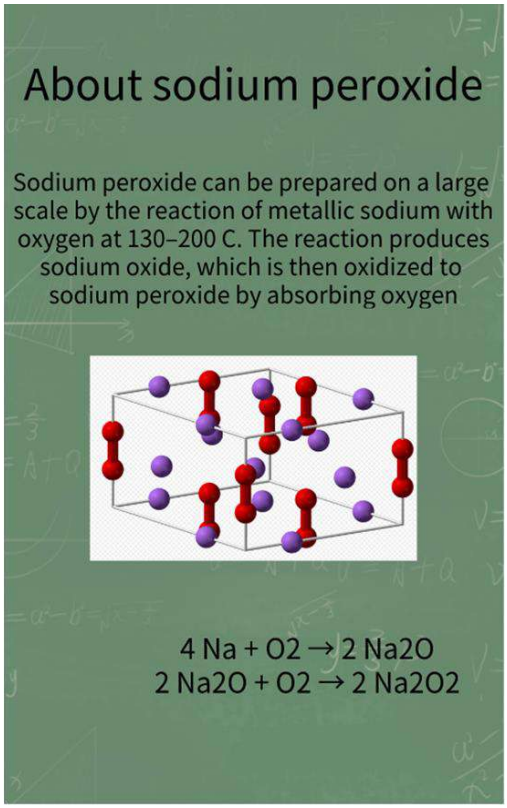
Introduction to the lesson	Explore what substances sodium produces under normal and heated conditions	6
Experimental stage	1. 1. Students use an alcohol lamp to heat a dry crucible, cut a piece of mung bean-sized sodium, and quickly put it into the crucible. 2. Continue heating, wait for the sodium ions to melt, and immediately remove the alcohol lamp. Observe the change in form of sodium and the color of the resulting substance	20
Step 3 Presenting the experimental results		Time
Students present experimental results	the sodium first melts and then burns, and the flame is yellow when burning. The final solid generated is also yellow	7
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	Students discuss what elements the resulting substances are and discuss writing the appropriate equations. The teacher guides the students to explore the reasons why the heating cannot be maintained during the experiment.	6
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	the sodium product is yellow sodium peroxide after combustion 2、$Na+O_2=Na_2O_2$（yellow），The condition is to ignite	6

Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
Learn about the chemistry of metals Remember the products generated by the sodium and oxygen reaction under different conditions	test	test paper	9-10 points is very good. 6-8 points is a fair level. 0-5 points is the improvement level
Learn basic experimental operation methods such as taking and heating test drugs.	classroom assessment	Experiment Evaluation Form	Form records are detailed without errors

Recording of learning management results

Topics	Highlight /good	Disadvantages /flaws	Solution /Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			



Test paper: The reaction of sodium and oxygen 2

Learning objectives to assess:

1. Learn about the chemistry of sodium

2. Remember the products generated by the sodium and oxygen reaction under different conditions

Instructions: Have students choose only one correct answer.

1. Which of the following statements is wrong ( )

A. Sodium fire can be extinguished with foam fire extinguisher

B. Sodium reacts with water to form sodium hydroxide and hydrogen gas

C. High pressure sodium lamps can be used for road lighting

D. Ignite metal sodium in a burning spoon, and quickly put it into the full gas collecting bottle, a large amount of white smoke is produced in the gas collecting bottle, and black particles are produced in the bottle, which proves that it has oxidative properties.

2. Which of the following statements about sodium is incorrect ( )

A. The flame color of sodium is yellow

B. Sodium oxide is formed when sodium burns

C. Sodium is highly reducing

D. Sodium metal can be cut with a knife

3. Which of the following statements about sodium is incorrect ( )

A. Sodium is highly reducing

B. Solids need to be sealed and stored

C. Sodium oxide and sodium peroxide are called allotropes

D. In the laboratory, a small amount of sodium metal is often preserved in kerosene

4. Take a small piece of metallic sodium and heat it in a burning spoon. In the following description of the experimental phenomenon, the correct one is ( )

① Metal sodium melts ② Burns in air, the flame is blue-purple ③ White solid is obtained after burning ④ Flame is yellow when burning ⑤ Light yellow solid is formed after burning

A. ①② B. ①②③ C. ①④⑤ D. ④⑤

5. Which of the following operations does not comply with the experimental safety regulations ( )

A. When extinguishing the alcohol lamp, cover it with the lamp cap

B. Before igniting hydrogen, the purity of the gas must be checked

C. After the experiment is over, throw the sodium metal into the waste tank

D. If hydrochloric acid gets on the skin, immediately rinse with plenty of water and then rinse with a dilute solution

6. Which of the statements about the elemental element of sodium and its compounds is incorrect ( )

A. Sodium is silvery white, soft, relatively low melting point, and less dense than water

B. When a large amount of sodium is on fire, it can be extinguished with sand, and a small amount of sodium should be stored in kerosene

C. Sodium metal is placed in the air for a long time and eventually turns into sodium carbonate

D. Take a piece of sodium metal and heat it in a burning spoon, observe that the sodium metal melts, and a white solid is obtained after burning

7. Which of the following statements about sodium metal is correct? ( )

A. Sodium metal is a silver-white metal with high density and high melting point

B. Sodium metal has low hardness and can be easily cut into small pieces with a knife

C. Sodium metal burns violently when heated in air, producing a yellow flame and a white solid

D. Put metallic sodium into the copper sulfate solution, the sodium reacts rapidly and produces a red solid

8. Sodium is an important metal. Which of the following statements about sodium is incorrect ( )

A. less rigid B. reacts violently with cold water

C. less dense than water D. Burns in oxygen to form a white solid

9.Which of the following statements about sodium and its compounds is correct ( )

A. Sodium is less dense than kerosene

B. Sodium carbonate commonly known as baking soda

C. A sodium fire can be extinguished with a foam fire extinguisher

D. Sodium peroxide will eventually turn into sodium carbonate when it is exposed to the air for a long time

10. For two pieces of sodium of equal mass, the first piece fully reacts with sufficient oxygen under heating conditions, and the second piece fully reacts with sufficient oxygen at normal temperature. Then the following statement is correct ( )

A. The first piece of sodium loses more electrons B. Two pieces of sodium lose the same number of electrons C. The color of the reaction product of the two pieces of sodium is the same D. The mass of the reaction product obtained from the two pieces of sodium is equal

Lesson Plans 2: Session 1

Subject: chemistry **Class**: High school grade 1 **Time**: 45 minutes

Topic: The reaction of sodium to water 1

Theme: Master the experimental operation of the reaction between sodium and water, and understand the disposal method of sodium in daily life after fire。

Step 1 Preparation before the experiment		Time
learning objectives	Know how to deal with sodium fire in daily life Memorize the operation steps of sodium and water experiments	
experimental planning	Add 1 / 2 to the beaker Water, drop 1 to 2 drops of phenolphthalein solution。Use a piece of sodium on filter paper and drain the kerosene on its surface.need	

	Cut a piece of sodium metal the size of a mung bean. Place the rest back to the original bottle. Gently pour a grain of sodium into a beaker filled with water.	
experimental materials and equipment	1、Beaker 2、Phenolphthalein solution 3、Filter paper 4、Sodium preserved in kerosene 5、tweezers and knife	
Examination of experimental materials and equipment	1. Check whether the seal of the kerosene bottle is intact. 2. Check whether the tweezers and knife are rusty. 3. Whether the filter paper is clean and meets the standard**.** 4.check the beaker for cracks 5. Shelf life of phenolphthalein solution	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time
Introduction to the lesson	Demonstrate the reaction of sodium and water in the laboratory, improve the operation of sodium and water experiments, and explore the correct way to deal with sodium fire	6
Experimental stage	1. Students add half of the water to the beaker and drop 1 to 2 drops of phenolphthalein solution. 2. Students put a piece of sodium on the filter paper, then clean up the kerosene on the surface and	20

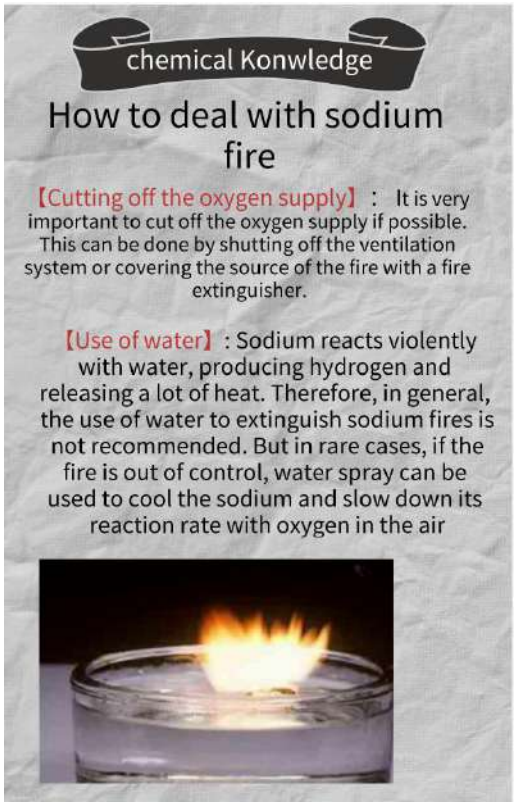
	cut a piece of metal sodium the size of mung bean, and put the rest back on the original bottle. 3. Students gently pour a grain of sodium into the beaker and record the experimental phenomenon. 4. After the experiment, students sort out the experimental operation process	
Step 3 Presenting the experimental results		Time
Students present experimental results	Students present by explaining the experimental plan, experimental results, and problems encountered in each group's experiment.	7
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	The experimental phenomenon is that sodium reacts violently in water. Students will base their analysis on the reaction of sodium and water in the experiment. To explore whether the sodium fire can be extinguished with water	6
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	In the experiment of sodium and water, if the volume of sodium is too large, it will cause too much local heating, which is not conducive to observation, and if it is too small, the reaction will not be obvious.Therefore, when sodium catches fire, water cannot be used to extinguish the fire.	6

Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
Master the reaction of sodium and water	test	test paper	9-10 points is very good. 6-8 points is a fair level. 0-5 points is the improvement level
Know how to deal with sodium fire in daily life			
Memorize the operation steps of sodium and water experiment	classroom assessment	Experiment Evaluation Form	Form records are detailed without errors

Recording of learning management results

Topics	Highlight /good	Disadvantages /flaws	Solution /Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			



Test paper: The reaction of sodium and Water 1

Learning objectives to assess:

1. Master the reaction of sodium and water
2. Know how to deal with sodium fire in daily life

Instructions: Have students choose only one correct answer.

1、**The various phenomena that occur when sodium reacts with water are as follows（）**

①Sodium floats on the water surface; ②Sodium sinks to the bottom of the water; ③Sodium melts into small balls; ④The small balls swim rapidly and gradually decrease, and finally Disappeared; ⑤Hissing sound; ⑥The solution was red after dropping phenolphthalein, where the correct set is ()

A. ①②③④⑤ B. all C. ①②③⑤⑥ D. ①③④⑥

2、**What is impossible to observe when a small piece of sodium is dropped into a test tube containing a solution of copper sulphate（）**

A. Sodium lumps melt into shiny little balls B. Sodium swims around on the liquid surface

C. Precipitation of red substance D. blue precipitate

3、**According to the phenomenon of reaction between metal sodium and water (dropped with phenolphthalein), which of the following statements is wrong（）**

A. Sodium melts into shiny little balls, indicating that sodium has a low melting point

B. After the reaction, the color of the solution gradually turned red, indicating that the reaction produced a base

C. 1 mole of electrons is obtained for every mole of sodium consumed in this reaction

D. When a large amount of sodium metal is stored at the fire scene, water cannot be used to extinguish the fire

4、**Which of the following statements about sodium metal is correct?( )**

A. Sodium metal can be stored in a small amount of water B. Sodium burns in air, and the product is Na2O

C. Sodium is a silver-white metal with high hardness and high melting point. D. Na and K alloys can be used as heat conduction agents for atomic reactors

5、**Which of the following experiments is correct( )**

A. Put a sodium block the size of a soybean grain into a beaker filled with water, and observe the phenomenon

B. Preserve sodium in gasoline

C. Heat a small piece of sodium on an asbestos net and observe the phenomenon

D. Break apart a piece of metallic sodium by hand and observe the color of the sodium.

6、**In the experimental inquiry activities, the following are the contents of the experimental report ( )**

① Experiment purpose ② Instruments and reagents ③ Experimental phenomenon ④ Conclusion and explanation ⑤Experimental steps

A. ①②③ B. ②③④ C. ①③④ D. all

7、**Sodium metal is on fire, what can be used to extinguish the fire is ( )**

A. Water B. Wet rag C. Foam fire extinguisher D. Dry sand

8、**Put 2.3 grams of sodium into 100 grams of water, the mass fraction of the solute in the resulting solution is ( )**

A. Equal to 2.3% B. Equal to 4% C. Greater than 2.3% and less than 4% D. Greater than 4%

9、**After checking the data, it was found that metal sodium can not only react with oxygen and water, but also react with a variety of other substances, including the reaction with alcohol at room temperature. To study the similarities and differences between the properties of sodium metal reacting with alcohol and the properties of sodium metal reacting with water, the following research methods are not used ( )**

A. Experiment method B. Observation method C. Classification method D Comparison method

10、**In the experiment of the reaction of sodium and water, the phenomenon that does not occur is（）**

A. sodium sinks below the surface

B. generate gas

C. Drops of phenolphthalein solution turn red

D. Sodium melts into pellets

Lesson Plans 2: Session 2

Subject: chemistry **Class**: High school grade 1 **Time**: 45 minutes

Topic: The reaction of sodium and water 2

Theme: Familiar with the specific phenomena in the reaction process of sodium and water. Check the gas generated during the experiment.

Step 1 Preparation before the experiment		Time
learning objectives	1..Familiar with the specific phenomena in the reaction process of sodium and water 2.Explore the gas composition generated during the experiment 3. Understand the confirmatory experiment process.	
experimental planning	Pour distilled water into the plastic bottle, cut off the lower end of the rubber plug, take out a small piece of sodium and put it into the plug, and inhale the phenolphthalein solution with a syringe. Open the water stop clamp and put in the rubber plug. After the sodium and water react quickly, collect the outflowing water and test it with phenolphthalein solution. And collect the gas and test the gas composition with flame.	
experimental materials and equipment	1. Plastic bottle 2. Rubber plug 3. Phenolphthalein solution 4. Small pieces of sodium 5.flame	
Examination of experimental materials and	1.Check the tightness of plastic bottles and rubber stoppers	

equipment	2.Check the shelf life of phenolphthalein solutions 3.Check Sodium Preservation Status	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time
Introduction to the lesson	Memorize the specific phenomena of the reaction between sodium and water, and explore the gas components produced in the experiment.	6
Experimental stage	1、assemble； 2、Fill the plastic bottles with distilled water to the water surface and rubber The lower end of the plug is cut. Take a small piece of sodium and insert it in the large head On the needle, 1 to 2 mL of phenolphthalein solution was inhaled in a syringe. 3、During the experiment, open the water stop clip and insert the sodium and injection The rubber plug of the launcher is quickly inserted into the mouth of the bottle and plugged tightly.sodium In a violent reaction with the water, the water from the plastic bottle flows in along the catheter cylinder. 4、After the reaction, push the phenolphthalein solution in the syringe	20

	into it Plastic bottles, and the solution turns red. 5、Replace the syringe and extract the gas from the bottle. After pumping Move the syringe into the flame, push the gas at constant speed, the needle Immediately lit up a slender flame	
Step 3 Presenting the experimental results		Time
Students present experimental results	The students presented the experiment by designing the experimental steps, drawing the experimental conclusion and summarizing the problems encountered in the experiment	7
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	Students need to discuss the reasons for designing the experimental procedure and discuss the differences in the experimental results. Work together to find the most suitable experimental procedure. Teachers need to add additional ideas to supplement, emphasize key points, and summarize the principles and concepts obtained from experiments.	6
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	1. According to the reddening of the phenolphthalein solution and the combustion of the gas, the gas produced is hydrogen. 2. Once again, it has been verified that	6

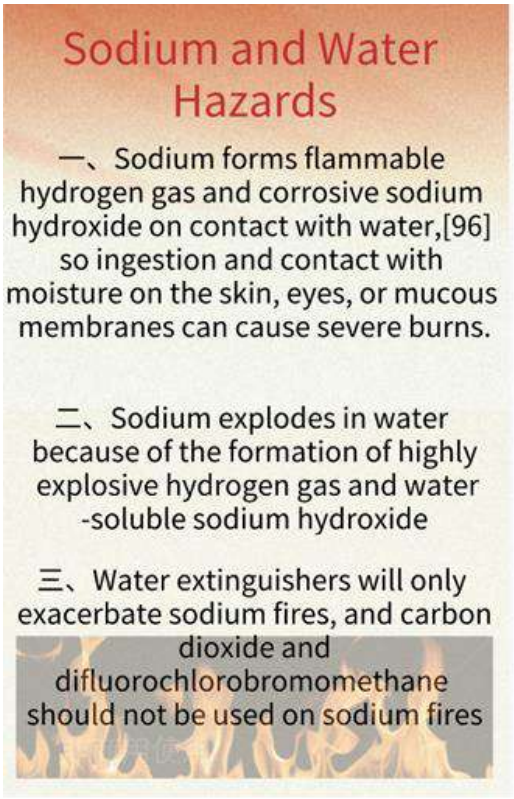
	after sodium fire, water can not be used but sand can be used. 3.The experiment was successful when the airtightness with the collected gas was good and there was no interference from oxygen	

Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
Familiar with the specific phenomena in the reaction process of sodium and water	test	test paper	9-10 points is very good. 6-8 points is a fair level. 0-5 points is the improvement level
Explore the gas composition generated during the experiment			
Learn about the verification experiment process.	classroom assessment	Experiment Evaluation Form	Form records are detailed without errors

Recording of learning management results

Topics	Highlight /good	Disadvantages /flaws	Solution /Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			



Test paper: The reaction of sodium and water 2

Learning objectives to assess:

1.Familiar with the specific phenomena in the reaction process of sodium and water

2.Explore the gas composition generated during the experiment

Instructions: Have students choose only one correct answer.

1. **Which of the following statements is wrong（）**

A. Sodium fire can be extinguished with foam fire extinguisher B. Sodium reacts with water to form sodium hydroxide and hydrogen gas

C. High pressure sodium lamps can be used for road lighting D. Ignite metal sodium in a burning spoon, and quickly insert it into the full gas collecting bottle, a large amount of white smoke will be generated in the gas collecting bottle.

2. **Which of the following statemis incorrect（）**

A. The flame color of sodium is yellow B. Sodium oxide is formed when sodium burns

C. Sodium is highly reducing D. Sodium metal can be cut with a knife

3,**Which of the following statements about sodium is incorrect（）**

A. Sodium is highly reducing

B. Solids need to be sealed and stored

C. Sodium oxide and sodium peroxide are called allotropes

D. In the laboratory, a small amount of sodium metal is often preserved in kerosene

4.In the experiment of the reaction of sodium and water, the phenomenon that does not occur is（）

A. sodium sinks below the surface

B. generate gas

C. Drops of phenolphthalein solution turn red

D. Sodium melts into pellets

5.Which of the following experimental operations in the chemical laboratory is correct（）

A. Hold the solution in a brown narrow-mouth bottle with a rubber stopper

B. Carefully place the sodium lumps left over from the experiment in the trash

C. Use a funnel to add a small amount of alcohol to a burning alcohol lamp

D. When diluting the concentrated sulfuric acid, pour the concentrated sulfuric acid into the water slowly along the inner wall of the beaker and keep stirring with a glass rod

6、Let the sodium react with the solution under the condition of isolating the air. During the experiment, first add kerosene to the large test tube, take three grains of rice-sized metal sodium into the large test tube and plug it with a rubber stopper, and add the solution through the long-necked funnel to make the kerosene dissolve. Liquid level to the rubber stopper, and tighten the spring clip (as shown). The following statement is wrong（）

A. Return the remaining sodium to the original reagent bottle

B. Bubbles are generated in the solution, and white flocculent precipitate appears in the lower layer solution

C. The liquid level in both the large test tube and the long-necked funnel drops

D. The chemical equation for the reaction of sodium with ferrous sulfate solution is $2Na + FeSO_4 + 2H_2O = Fe(OH)_2\downarrow + Na_2SO_4 + H_2\uparrow$

7.After the following groups of substances are mixed and reacted with each other, the final white precipitate is formed（）

① Put sodium metal into MgCl2 solution ② Add excess CO2 to clarified lime water ③ Add a small amount of BaCl2 solution to sodium bisulfate solution ④ Add a small amount of Ca(OH)2 to excess NaHCO3 solution ⑤ Add excess CO2 to saturated Na2CO3 solution

A. ①②④⑤ B. ①②④ C. ②③⑤ D. ①②③

8.Among the following metal elements, the one that can replace copper from CuSO4 solution is（）

A. mercury B. silver C. sodium D. iron

9.Which of the following experiments is correct（）

A. Put a sodium block the size of a soybean grain into a beaker filled with water and observe the phenomenon

B. Store sodium in gasoline C. Heat a small piece of sodium on an asbestos net and observe the phenomenon

10.Put sodium into the water dropped in litmus, which of the following statements about the phenomenon is wrong（）

A. Na floats on the water surface B. Na melts into small balls and swims around on the water surface C. Gas is produced D. The aqueous solution turns red

Lesson Plans 3: Session 1

Subject: chemistry **Class**: High school grade 1 **Time**: 45 minutes

Topic: Reaction of sodium compounds and water 1

Theme: Observe the sodium compounds: sodium oxide, sodium peroxide and water reaction. To study its properties and material use.

Step 1 Preparation before the experiment		Time
learning objectives	1、Master the difference between sodium oxide and sodium peroxide 2、Memorize the reaction products of sodium peroxide and water 3、Master the operation process of sodium peroxide and water experiments	
experimental planning	1、Observe the difference in appearance and shape between sodium oxide and sodium peroxide 2、Put sodium peroxide into the test tube, add 1~2ml of water, put the wooden strip with Mars into the test tube, and test the gas produced	
experimental materials and equipment	1、test tube 2、Sodium peroxide solid 3、Wood	
Examination of experimental materials and equipment	1. Check whether the test tube is broken 2. Check whether the sodium peroxide solid is damp	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time
Introduction to the lesson	Demonstrate the phenomenon of sodium	6

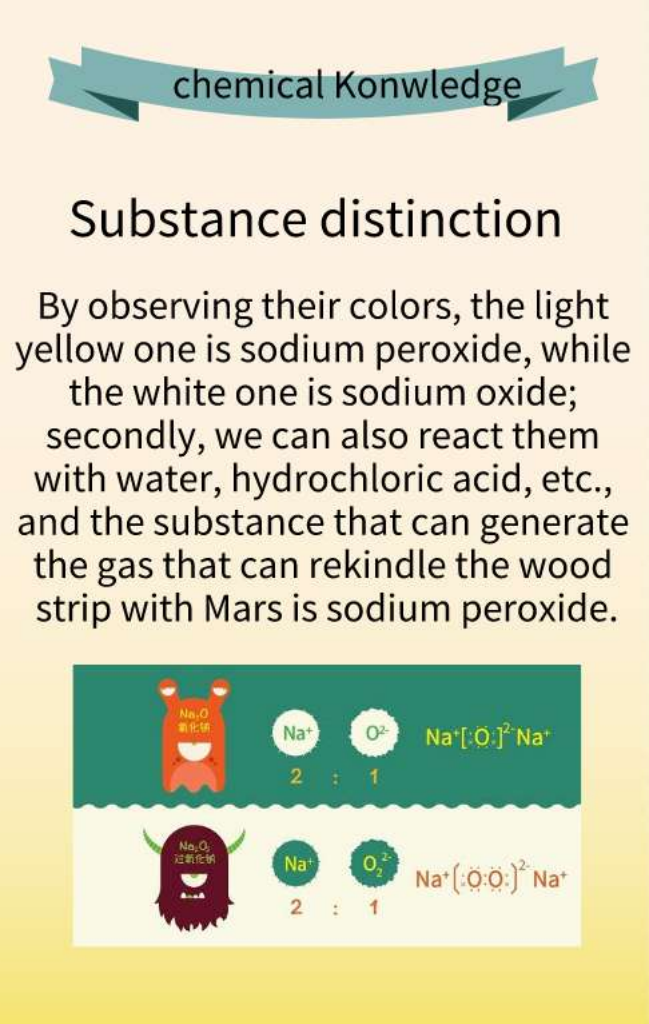
	peroxide and water reaction, and detect the gas produced	
Experimental stage	Put 1 ~ 2 mL of water into a test tube filled with 1~2g sodium peroxide solid, and immediately put the wooden strip with Mars into the test tube to test the generated gas generated. Gently touch the outer wall of the tube with your hand, and the sensation was recorded	20
Step 3 Presenting the experimental results		Time
Students present experimental results	Students present by explaining the experimental plan, experimental results, and problems encountered in each group's experiment.	7
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	Students can verify the success of the experiment by using a wooden stick with rekindled sparks. Under the guidance of the teacher, you will think about what kind of gas makes the stick rekindle, and summarize the main points of the experiment.	6
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	Sodium oxide: white powder Sodium peroxide: Light yellow solid (powder) In the experiment, the re-ignition of the sticks with sparks shows that sodium peroxide and water produce oxygen.	6

Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
Master the difference between sodium oxide and sodium peroxide	test	test paper	9-10 points is very good. 6-8 points is a fair level. 0-5 points is the improvement level
Memorize the reaction products of sodium peroxide and water			
Master the operation process of sodium peroxide and water experiments	classroom assessment	Experiment Evaluation Form	Form records are detailed without errors

Recording of learning management results

Topics	Highlight /good	Disadvantages /flaws	Solution /Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			



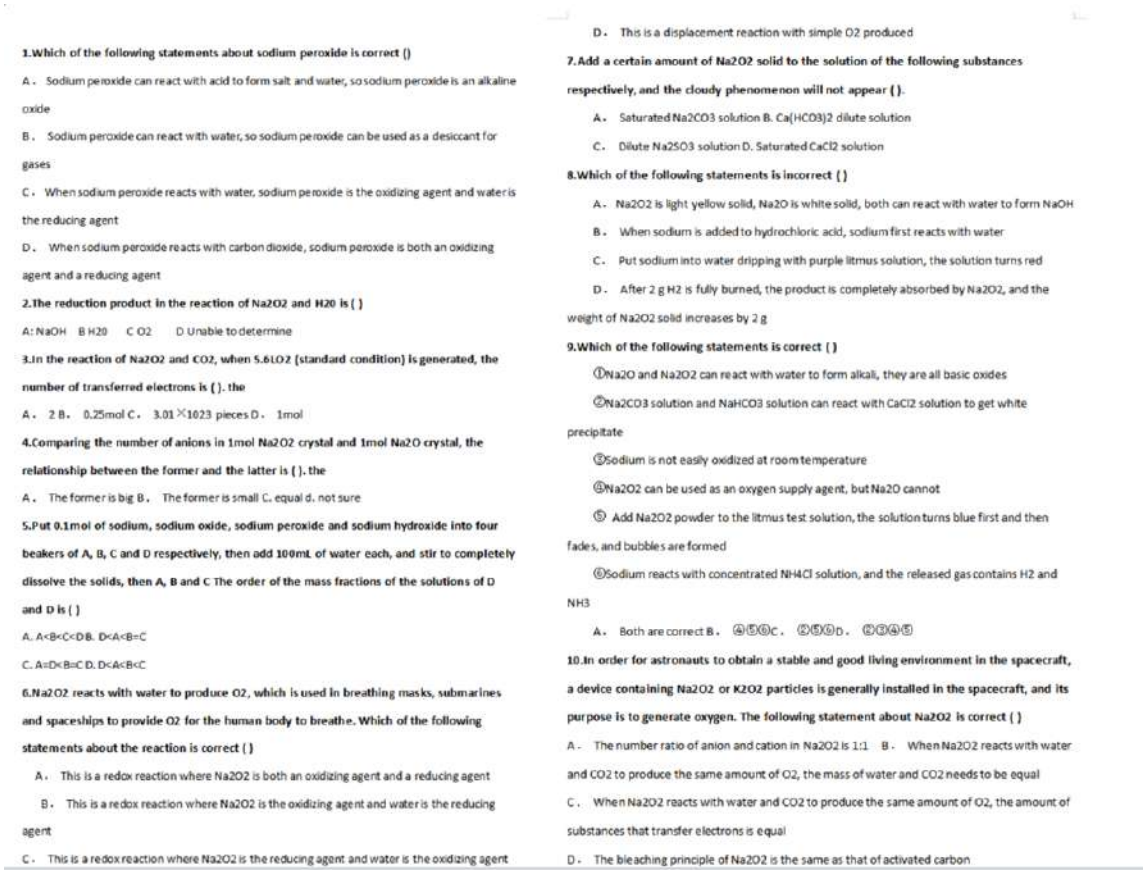
Test paper: The reaction of sodium compounds and water 1

Learning objectives to assess:

1、Master the difference between sodium oxide and sodium peroxide

2、Memorize the reaction products of sodium peroxide and water

Instructions: Have students choose only one correct answer.



1.Which of the following statements about sodium peroxide is correct ()

A． Sodium peroxide can react with acid to form salt and water, so sodium peroxide is an alkaline oxide

B． Sodium peroxide can react with water, so sodium peroxide can be used as a desiccant for gases

C． When sodium peroxide reacts with water, sodium peroxide is the oxidizing agent and water is the reducing agent

D． When sodium peroxide reacts with carbon dioxide, sodium peroxide is both an oxidizing agent and a reducing agent

2.The reduction product in the reaction of Na2O2 and H20 is ( )

A: NaOH B H20 C O2 D Unable to determine

3.In the reaction of Na2O2 and CO2, when 5.6LO2 (standard condition) is generated, the number of transferred electrons is ( ). the

A． 2 B． 0.25mol C． 3.01×1023 pieces D． 1mol

4.Comparing the number of anions in 1mol Na2O2 crystal and 1mol Na2O crystal, the relationship between the former and the latter is ( ). the

A． The former is big B． The former is small C. equal d. not sure

5.Put 0.1mol of sodium, sodium oxide, sodium peroxide and sodium hydroxide into four beakers of A, B, C and D respectively, then add 100mL of water each, and stir to completely dissolve the solids, then A, B and C The order of the mass fractions of the solutions of D and D is ( )

A. A<B<C<D B. D<A<B=C

C. A=D<B=C D. D<A<B<C

6.Na2O2 reacts with water to produce O2, which is used in breathing masks, submarines and spaceships to provide O2 for the human body to breathe. Which of the following statements about the reaction is correct ( )

A． This is a redox reaction where Na2O2 is both an oxidizing agent and a reducing agent

B． This is a redox reaction where Na2O2 is the oxidizing agent and water is the reducing agent

C． This is a redox reaction where Na2O2 is the reducing agent and water is the oxidizing agent

D． This is a displacement reaction with simple O2 produced

7.Add a certain amount of Na2O2 solid to the solution of the following substances respectively, and the cloudy phenomenon will not appear ( ).

A． Saturated Na2CO3 solution B. Ca(HCO3)2 dilute solution

C． Dilute Na2SO3 solution D. Saturated CaCl2 solution

8.Which of the following statements is incorrect ( )

A． Na2O2 is light yellow solid, Na2O is white solid, both can react with water to form NaOH

B． When sodium is added to hydrochloric acid, sodium first reacts with water

C． Put sodium into water dripping with purple litmus solution, the solution turns red

D． After 2 g H2 is fully burned, the product is completely absorbed by Na2O2, and the weight of Na2O2 solid increases by 2 g

9.Which of the following statements is correct ( )

①Na2O and Na2O2 can react with water to form alkali, they are all basic oxides

②Na2CO3 solution and NaHCO3 solution can react with CaCl2 solution to get white precipitate

③Sodium is not easily oxidized at room temperature

④Na2O2 can be used as an oxygen supply agent, but Na2O cannot

⑤ Add Na2O2 powder to the litmus test solution, the solution turns blue first and then fades, and bubbles are formed

⑥Sodium reacts with concentrated NH4Cl solution, and the released gas contains H2 and NH3

A． Both are correct B． ④⑤⑥C． ②⑤⑥D． ②③④⑤

10.In order for astronauts to obtain a stable and good living environment in the spacecraft, a device containing Na2O2 or K2O2 particles is generally installed in the spacecraft, and its purpose is to generate oxygen. The following statement about Na2O2 is correct ( )

A． The number ratio of anion and cation in Na2O2 is 1:1 B． When Na2O2 reacts with water and CO2 to produce the same amount of O2, the mass of water and CO2 needs to be equal

C． When Na2O2 reacts with water and CO2 to produce the same amount of O2, the amount of substances that transfer electrons is equal

D． The bleaching principle of Na2O2 is the same as that of activated carbon

Lesson Plans 3: Session 2

Subject: chemistry **Class**: High school grade 1 **Time**: 45 minutes

Topic: Reaction of sodium compounds and water 2

Theme: Familiar with the use of sodium carbonate and sodium bicarbonate, master the products of sodium carbonate, sodium bicarbonate and water reaction.

Step 1 Preparation before the experiment		Time
learning objectives	1. Familiar with the use of sodium carbonate and sodium bicarbonate 2. Master the reaction products of sodium carbonate, sodium bicarbonate and water 3. Master the operation process of comparative experiments	
experimental planning	Prepare two test tubes, add a small amount of sodium carbonate and sodium	

	bicarbonate respectively, add water and phenolphthalein solution to the test tubes in turn, and observe the phenomenon.	
experimental materials and equipment	1. Test tube 2.Sodium carbonate and sodium bicarbonate 3. Phenolphthalein solution	
Examination of experimental materials and equipment	1.Check whether the test tube is broken 2.Check the shelf life of sodium carbonate and sodium bicarbonate 3.Check the phenolphthalein solution	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time
Introduction to the lesson	Show the difference in appearance and color between sodium carbonate and sodium bicarbonate. 2.Grasp the difference between the reaction of sodium carbonate, sodium bicarbonate, water and phenolphthalein solution through comparative experiments.	6
Experimental stage	1.A small amount of sodium carbonate and sodium bicarbonate (about 1g each) 2.added to the two tubes to observe the difference between appearance, 3. Add 5ml of water to the two test tubes and observe the phenomenon 4. Continue to drop the phenolphthalein solution into the two test tubes and observe the phenomenon	20

Step 3 Presenting the experimental results		Time
Students present experimental results	Students will compare the differences between two substances through the different phenomena exhibited in the two test tubes	7
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	Through comparison, students will use tables to show the different phenomena of the reactions of sodium carbonate, sodium bicarbonate, water, and phenolphthalein solutions. On this basis, the teacher will guide students to make a summary.	6
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	1.After adding a small amount of water in sodium carbonate, sodium carbonate clumps into crystals, and there is an exothermic phenomenon 2.After adding a small amount of water to sodium bicarbonate, sodium bicarbonate dissolution and heat absorption phenomenon. 3.Both are alkaline by the phenolphthalein solution test	6

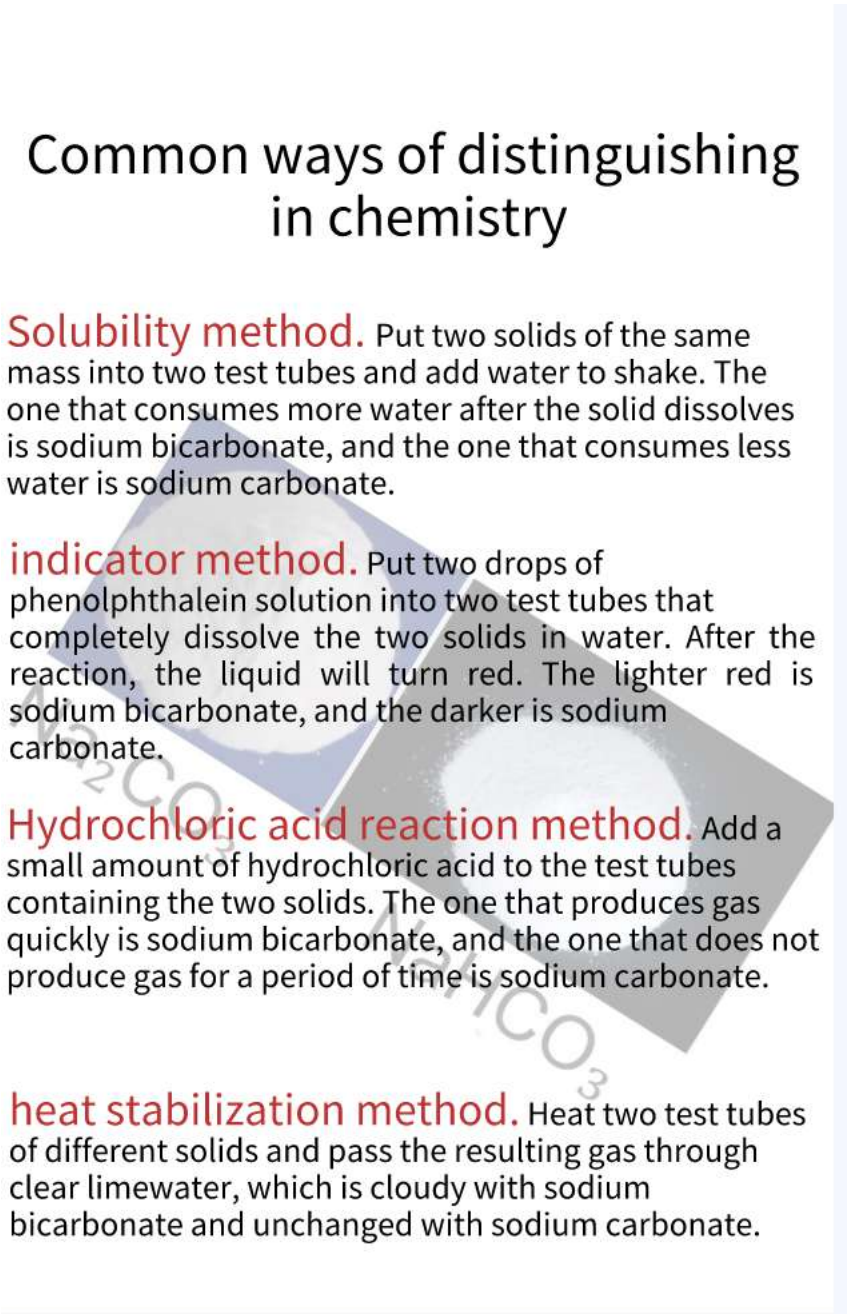
Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
Familiar with the use of sodium carbonate			9-10 points is very good.

and sodium bicarbonate.	test	test paper	6-8 points is a fair level. 0-5 points is the improvement level
Master the reaction products of sodium carbonate, sodium bicarbonate and water			
Master the operation process of the comparative experiment	classroom assessment	Experiment Evaluation Form	Form records are detailed without errors

Recording of learning management results

Topics	Highlight /good	Disadvantages /flaws	Solution /Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			



Test paper: The reaction of sodium compounds and water 2

Learning objectives to assess:

1. Familiar with the use of sodium carbonate and sodium bicarbonate

2. Master the reaction products of sodium carbonate, sodium bicarbonate and water

Instructions: Have students choose only one correct answer.

1、In order to identify the two white solids Na2CO3 and NaHCO3, 4 students have designed the following four different methods, among which the ones that are not feasible are ( )

A、Take samples separately to form a solution, add 1 mol/L hydrochloric acid solution drop by drop, and observe the speed of bubble generation

B、Take samples separately and heat them in test tubes, pass the gas that may be generated into clarified lime water, and observe whether there is white turbidity

C、Take samples separately to form a solution, add BaCl2 solution dropwise, and observe whether there is white precipitation

D、Make solutions respectively, dip the solution with platinum wire and burn it on the flame of alcohol lamp, observe the color of the flame

2、Chemistry is closely related to life. Which of the common names and chemical formulas of the following common substances is correct ( )

A、Soda ash - $NaOH$ B. baking soda - $NaHCO_3$

C、Limestone - CaO D. marble - $CaSO_4$

3、Which of the following statements is incorrect ( )

A、"Ascorbic acid" vitamin C has reducing properties

B、In Yang Wanli's "Playing Pen", it is written that "the wild chrysanthemum and wild moss cast money separately, and the golden, copper and green compete for beauty". The main component of the patina is basic copper carbonate, and Cu2(OH)2CO3 belongs to the basic salt

C、Add dilute hydrochloric acid dropwise to the sodium carbonate solution, first without bubbles then with bubbles

D、Food spoilage, stalactite formation, and plant photosynthesis are all related to redox reactions

4、Which of the following is wrong about the properties of Na2CO3 and NaHCO3 ( )

A、Ba(OH)2 solution can be used to identify Na2CO3 and NaHCO3

B、To remove a small amount of NaHCO3 mixed with Na2CO3 solid, use heating method

C、Introduce enough CO2 into the Na2CO3 saturated solution, and NaHCO3 crystals will precipitate

D、Add phenolphthalein dropwise to equal concentrations of Na2CO3 and NaHCO3 solutions, the former will be darker in red

5、Which of the following statements is incorrect ( )

A、Thermal stability: Na2CO3 is more stable than NaHCO3

B、Solubility: Na2CO3 is more soluble in water than NaHCO3

C、Na2CO3 and NaHCO3 of the same quality react with sufficient hydrochloric acid respectively, and NaHCO3 releases more CO2

D、Na2CO3 and NaHCO3 solutions with the same concentration of substances react with hydrochloric acid of the same concentration respectively, and Na2CO3 produces gas faster

6、Which of the following statements about the reaction between sodium and water is incorrect? ( )

A、Put a small piece of sodium into the water dripping with litmus test solution, the solution turns blue after the reaction

B、Put sodium into dilute hydrochloric acid, sodium reacts with water first, then with hydrochloric acid

C、When sodium is added to water, a large amount of hydrogen gas will be produced

D、Sodium is put into the aqueous solution dripping with phenolphthalein, the solution in the beaker turns red

7、A dry powder may be composed of one or more of Na2O, Na2O2, Na2CO3, NaHCO3, and NaCl. When the powder is reacted with a sufficient amount of hydrochloric acid, the gas X will escape, and X will shrink in volume after passing through a sufficient amount of NaOH solution (measured at the same temperature and pressure). If the original mixed powder is heated with an alcohol lamp in the air, gas will also be released, and the mass of the residual solid matter after heating is greater than that of the original mixed powder. Which of the following inferences is correct ( )

A、There must be no Na2O in the powder B. Gas X only CO2

C、The powder must not contain NaHCO3, NaCl D. Unsure whether the powder contains Na2CO3 and NaCl

8、There are currently two bottles of Na2CO3 and NaHCO3 colorless solutions of the same concentration that have lost their labels. Which of the following identification methods is unreasonable ( )

① Check with dry pH test paper, the one with the highest pH is Na2CO3

② Take the same amount of solution in two test tubes, heat it, and the bubbles will be NaHCO3

③ Take the same amount of solution in two test tubes, add dilute hydrochloric acid drop by drop, at the beginning the gas will be released as NaHCO3

④ Take the same amount of solution in two test tubes, add Ba(OH)2 solution dropwise, the white precipitate is Na2CO3

⑤ Take the same amount of solution in two test tubes, add BaCl2 solution dropwise, the white precipitate is Na2CO3

A、①⑤ B、③⑥ C、②④ D、②⑤

9、Which of the following statements is correct ( )

A、When Na2O2 meets wet purple litmus paper, the litmus paper eventually turns blue

B、When Na2O2 reacts with CO2 to generate 0.1mol O2, it transfers 0.4mol of electrons

C、When Na2O2 is put into CuCl2 solution, there will be blue precipitate and bubbles

D、Add 2g Na2O2 to the saturated caustic soda solution, after fully reacting, the number of Na+ in the solution remains unchanged

10、Which of the following statements about Na2O is incorrect ( )

A、Belongs to basic oxides B. Can react with water to form the corresponding base

C、Can react with acid to form salt and water d. Can react with CO2 to form salt and oxygen

Lesson Plans 4: Session 1

Subject: chemistry **Class**: High school grade 1 **Time**: 45 minutes

Topic: flame reaction 1

Theme: Master the flame color when sodium and potassium burn, and understand the experimental process of flame reaction

Step 1 Preparation before the experiment		Time
learning objectives	1. Master the flame reaction of sodium and potassium 2. Understand the experimental process of flame reaction	
experimental planning	Observe the sodium and potassium flame colors through the experimental video. And sort out the operation steps of the flame experiment	
experimental materials and equipment	Video about sodium and potassium flame reaction	
Examination of experimental materials and equipment	Check playing video device	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time
Introduction to the lesson	Video Demonstration Flame Experiment Process	6
Experimental stage	the video experiment- -video demonstrating the flame reaction of sodium and potassium.	20
Step 3 Presenting the experimental results		Time
Students present experimental results	Through group discussion, the experimental process and the required	7

	instruments are obtained, and the students show the results and modify them under the guidance of the teacher	
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	Students are required to sort out the experimental steps and required instruments according to the experimental video, and improve the experimental process under the guidance of the teacher	6
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	The sodium burning flame is yellow and the potassium burning flame is purple. 2、The experimental equipment has glass rod, iron wire, alcohol lamp and blue cobalt glass	6

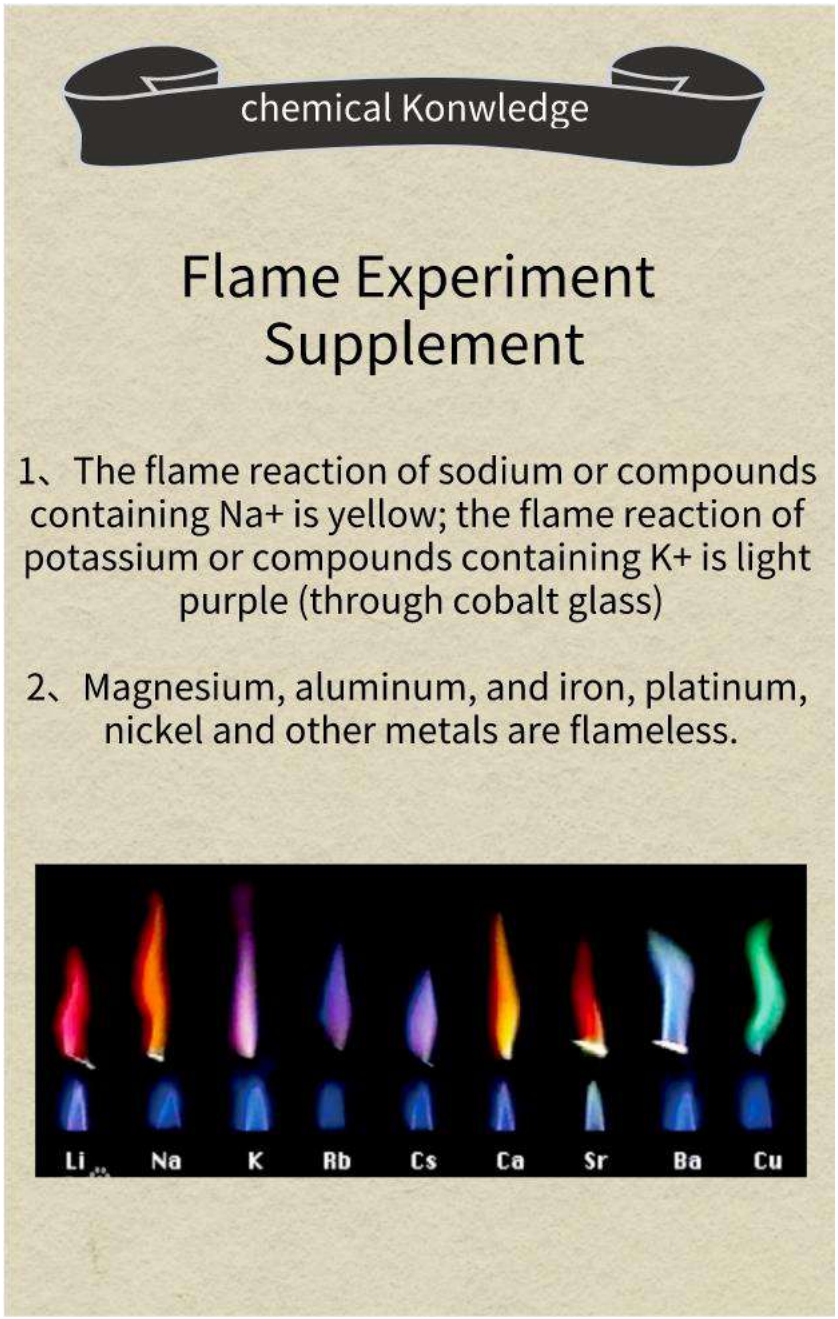
Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
. Master the flame reaction of sodium and potassium.	test	test paper	9-10 points is very good. 6-8 points is a fair level. 0-5 points is the improvement level
Understand the experimental process of flame reaction			

Recording of learning management results

Topics	Highlight	Disadvantages	Solution

	/good	/flaws	/Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			



Test paper: flame reaction 1

Learning objectives to assess:

1. Master the flame reaction of sodium and potassium
2. Understand the experimental process of flame reaction

Instructions: Have students choose only one correct answer.

1. For the platinum wire used in the flame reaction experiment, each sample must be ( )

A. Wash with water 2-3 times before use

B. After washing with hydrochloric acid, rinse with distilled water before use

C. Dry with filter paper before use

D. After washing with hydrochloric acid, burn it on the flame of an alcohol lamp until it has no color before it can be used

2. Which of the following changes is a chemical change ( )

A. Flame test b. Corrosion of steel c. Gasoline volatilizes D. wrought metal

3. Which of the following statements is correct ( )

A. Colorless test solution flame color reaction is purple (observed through blue cobalt glass), then the test solution is a potassium salt solution

B. Before and after each flame reaction experiment, the platinum wire should be cleaned with dilute hydrochloric acid

C. The experimental operation for the flame reaction is shown in the figure:

D. If there is no platinum wire, the sample can be directly dipped in a glass rod for flame reaction

4. In the experiment of flame reaction of sodium element, the unnecessary instruments or medicines are ( )

A. Platinum wire rod

B. alcohol lamp

C. blue cobalt glass

D. Dilute hydrochloric acid

5. When doing flame reaction experiments in the laboratory, the platinum wire must be cleaned for each experiment. This reagent is ( )

A. sulfuric acid washing

B. Dilute hydrochloric acid washing

C. water washing

D. Acetic acid washing

6. In the description about the experimental operation of the flame reaction of sodium chloride, the incorrect one is ( )

A. Take a platinum wire washed with hydrochloric acid and burn it on the flame of an alcohol lamp until it is colorless

B. Dip a small amount of sodium chloride solution with a burnt platinum wire and burn it on the flame of an alcohol lamp

C. The flame of burning sodium chloride is yellow when observed through a blue cobalt glass sheet

D. After the experiment, the platinum wire should be washed with hydrochloric acid

7. The following instructions on the precautions for the operation of the flame reaction experiment, the correct one is ( )

①The flame color of potassium should be observed through blue cobalt glass. ②First burn the platinum wire to the same color as the original flame, and then dip in the substance to be tested. ③After each experiment, the platinum wire should be washed with hydrochloric acid ④~⑤ It is best to choose a flame with a weaker color in the experiment ⑤ There is no platinum wire, and it can also be replaced by smooth and rust-free iron wire

A. Only ② is incorrect

B. Only ④ is incorrect

C. Only ⑤ is incorrect

D. all right

8. There are the following steps when performing flame reaction to test potassium ions, and the correct operation sequence is ( )

① Dip the solution to be tested ② Put it on the flame of an alcohol lamp and burn it ③ Observe through the blue cobalt glass ④ Wash the platinum wire with dilute hydrochloric acid

A. ④②①③⑤

B. ①②③④

C. ④①③②

D. ②①③④

9. Which of the following statements about the flame reaction experiment is correct ( )

A. Copper wire can be used instead of platinum wire for experiments

B. Observe the flame reaction of potassium through blue cobalt glass

C. After the experiment, the platinum wire should be washed with sodium carbonate solution

D. Flame reaction refers to the special color of the flame when the metal is heated and burned, which is the chemical property of the substance

10. Which of the following experimental operations and precautions related to flame reaction is correct ( )

A. The flame reaction can only be carried out if the salt is prepared as a solution

B. During the experiment, directly dip the medicine with platinum wire and burn it on the alcohol lamp

C. Iron wire can be used instead of platinum wire for flame reaction

D. After the experiment, the platinum wire should be washed with dilute sulfuric acid

Lesson Plans 4: Session 2

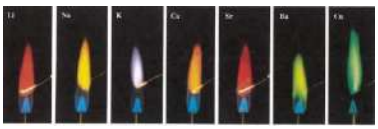
Subject: chemistry **Class**: High school grade 1 **Time**: 45 minutes

Topic: flame reaction 2

Theme: Memorize the flame colors of various metals and master the operation process of flame experiments

Step 1 Preparation before the experiment		Time
learning objectives	1. Master the flame color of common metals 2. Memorize the process of flame test 3. Master the principles of using various instruments in the flame test	
experimental planning	Place the wire soldered on the glass rod in an alcohol flame until it is the same color as the original flame. Dip a steel wire in a sodium carbonate solution, burn it on an external flame, and observe the color of the flame. After cleaning the platinum wire (or iron wire) with hydrochloric acid, burn it on an external flame until it becomes colorless, and then immerse it in potassium carbonate to carry out the same experiment	
experimental materials and equipment	1. Glass rod 2. Alcohol lamp 3. Sodium carbonate solution and potassium sulfate 4. Hydrochloric acid 5. Iron wire	
Examination of experimental materials and	1. Check that the glass rod is not broken 2. Check the capacity of the alcohol lamp	

equipment	3. Check that the iron wire is not rusted 4. Check the storage of reagents	
student grouping	Divide the students into two groups of 15 students each.	
Step 2 Experimental procedure		Time
Introduction to the lesson	Familiar with the flame experiment process of sodium and potassium, and memorize the flame colors of common compounds	6
Experimental stage	Place the wire welded on the glass rod in the alcohol flame until it is the same color as the original flame. Dip the sodium carbonate solution with wire and burn on the outer flame to observe the color of the flame. After washing the platinum wire (or iron wire) with hydrochloric acid, burn on the outer flame until there is no color 3、dip in potassium carbonate to do the same experiment. At this time, observe the color of the flame through the blue cobalt glass	20
Step 3 Presenting the experimental results		Time
Students present experimental results	Students explain the flame color change of the flame in the experiment, and they need to pay attention to whether there are different experimental results from other groups	7
Step 4 Discussion and conclusion		Time
Students discuss based on experimental phenomena	All students discuss the experiment. to the reason why the experimental results	6

	are like that or the reason why the experimental results are different from other groups to analyze which step is wrong and work together to find a solution to the problem. Teachers have a role in providing additional feedback. emphasize important points and summarize the principles and concepts obtained from the experiment	
Step 5 Stage of learning evaluation		Time
The teacher summarizes the conclusion of the experiment, the details of the experiment	blue cobalt glass sheet can filter out the yellow light, leaving the purple light, easy to observe the flame color of potassium Because metal chloride is easy to vaporize and volatilization, it can remove a small amount of impurities after burning to colorless 	6

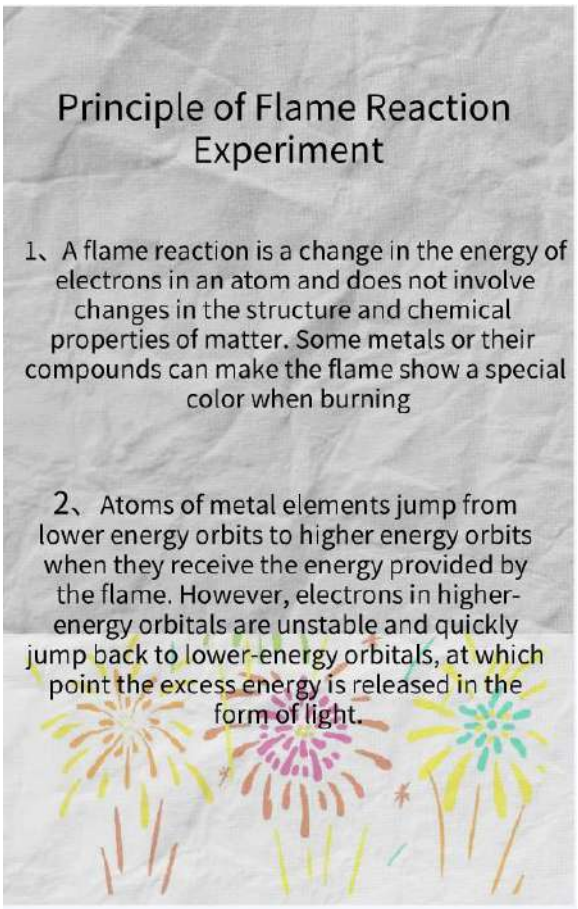
Measurement and evaluation

Learning Objectives to Assess	Assessment method	Assessment tool	Evaluation criteria
Master the flame color of common metals	test	test paper	9-10 points is very good. 6-8 points is a fair level. 0-5 points is the improvement level
Memorize the process of flame test			

Master the principles of using various instruments in the flame test	classroom assessment	Experiment Evaluation Form	Form records are detailed without errors

Recording of learning management results

Topics	Highlight /good	Disadvantages /flaws	Solution /Development
Learning Activities			
teacher's teaching behavior			
student behavior			
learning outcomes			



Test paper: flame reaction 2

Learning objectives to assess:

1. Master the flame color of common metals
2. Memorize the process of flame test

Instructions: Have students choose only one correct answer.

1、Take sodium chloride for flame reaction experiment, the flame is yellow, the reason for the color is ( )

A. Sodium chloride volatilizes with heat B. Sodium chloride decomposes on heating

C. Electron transitions in sodium ions D. Electron transitions in chloride ions

2、The flame reaction reflects ( )

A. Elementary properties B. properties of compounds

C. properties of ions D. properties of elements

3、Which of the following understandings about "flame reaction" is correct ( )

A. Only metal element has flame reaction B. Only metal compounds have flame reaction

C. Only certain metals or their compounds have flame reaction D. All metal elements have a flame reaction

4、Which of the following statements is correct ( )

A. The flame reaction is yellow, indicating that the substance must contain sodium

B. The purple flame can be directly observed when potassium carbonate is burned on the alcohol lamp

C. As long as it contains metal elements, there must be a flame reaction when burning

D. A flame reaction is a chemical change

5、The fireworks show in the program was brilliant and amazing. Which of the following statements about flame reaction is correct ( )

A. Metals and their compounds have color when they burn

B. All flame reactions should be observed through blue cobalt glass

C. Sodium chloride and sodium carbonate have the same flame color when burned

D. When the flame reaction shows a yellow flame, the burning substance must be sodium or sodium salt

6、Flame reaction can be used to test ( )

A. the presence of all elements B. The existence of all elemental metals

C. The presence of certain metal elements or metal ions D. Presence of all non-metallic elements

7、When a substance burns, the flame reaction is yellow, which of the following is correct ( )

A. The substance must be a sodium compound B. The substance must contain sodium

C. The substance must be sodium metal D. This substance does not contain potassium

8、The main component of plant ash is potassium carbonate, and its flame reaction is ( )

A. Green B. Purple C. red D. Yellow

9、Flame reaction is not yellow ( )

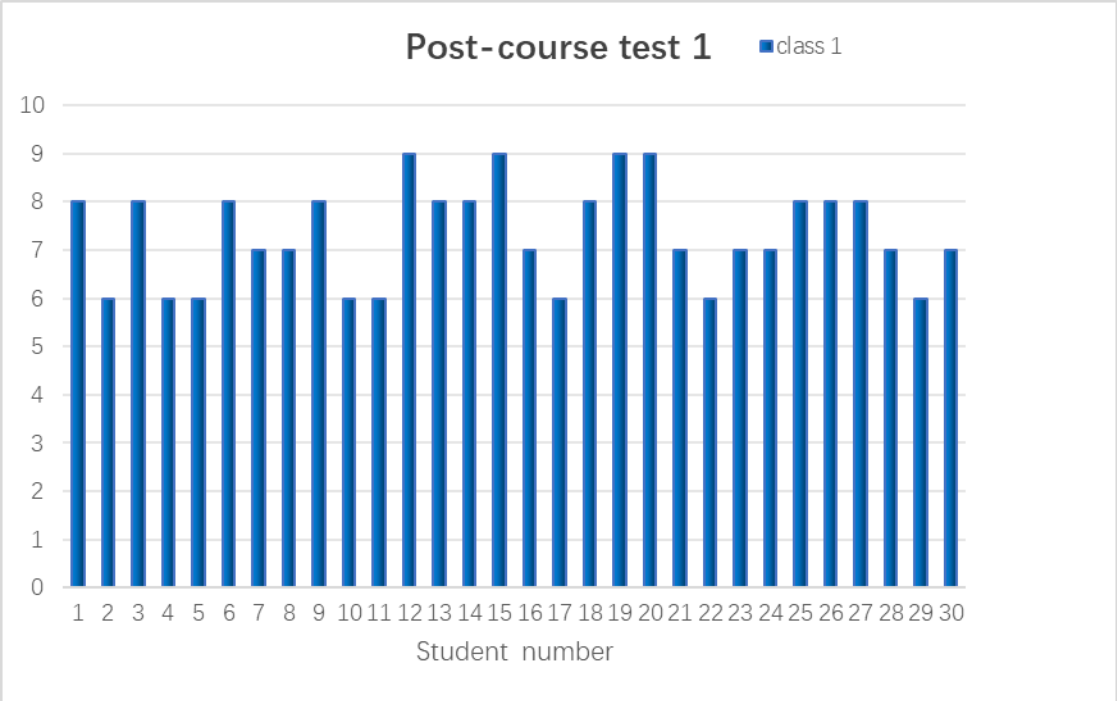
A. Sodium chloride B. sodium peroxide C. sodium hydroxide D. Potassium hydroxide

10、The color of sodium flame reaction is ( )

A. Brick red B. Purple C. yellow D. green

APPENDIX G

CLASS TEST SCORE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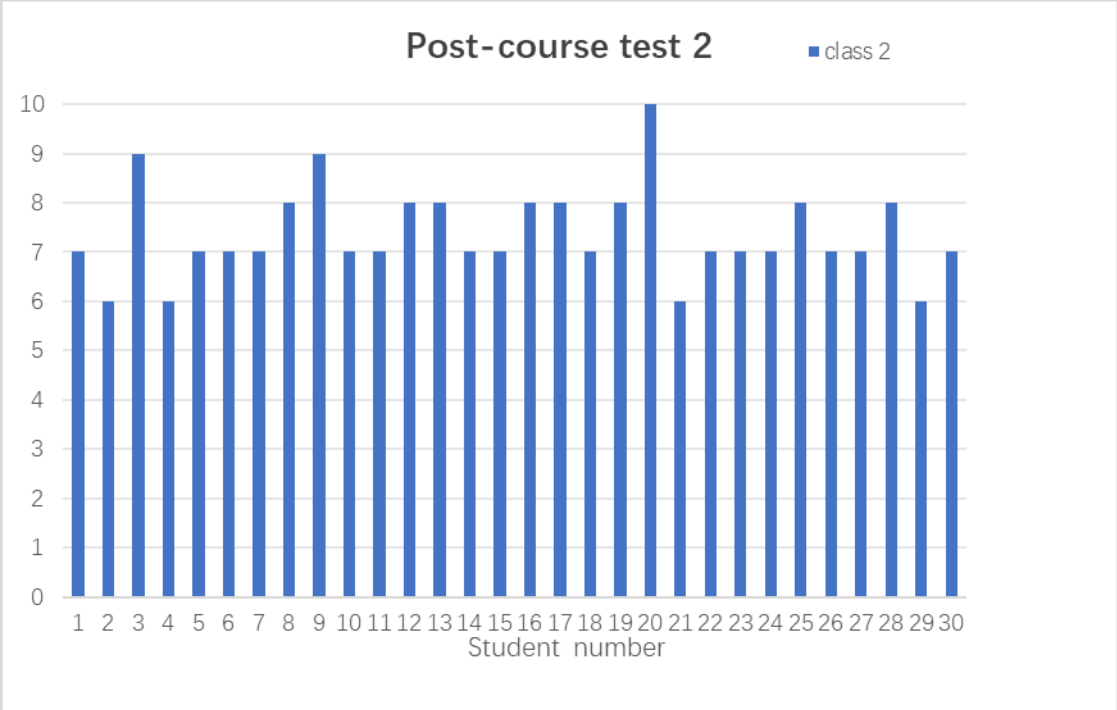
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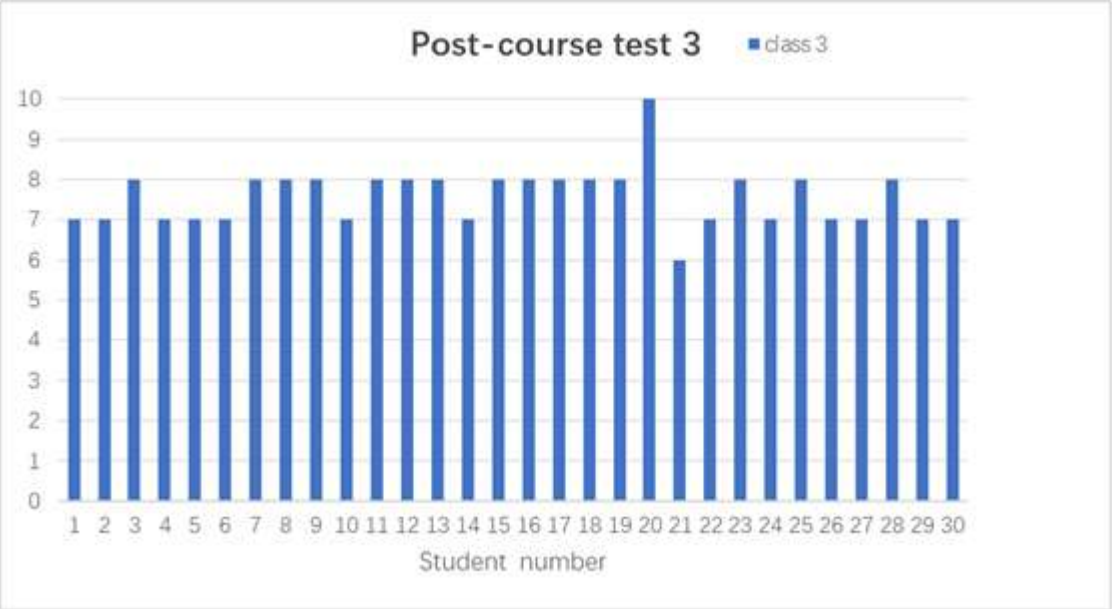
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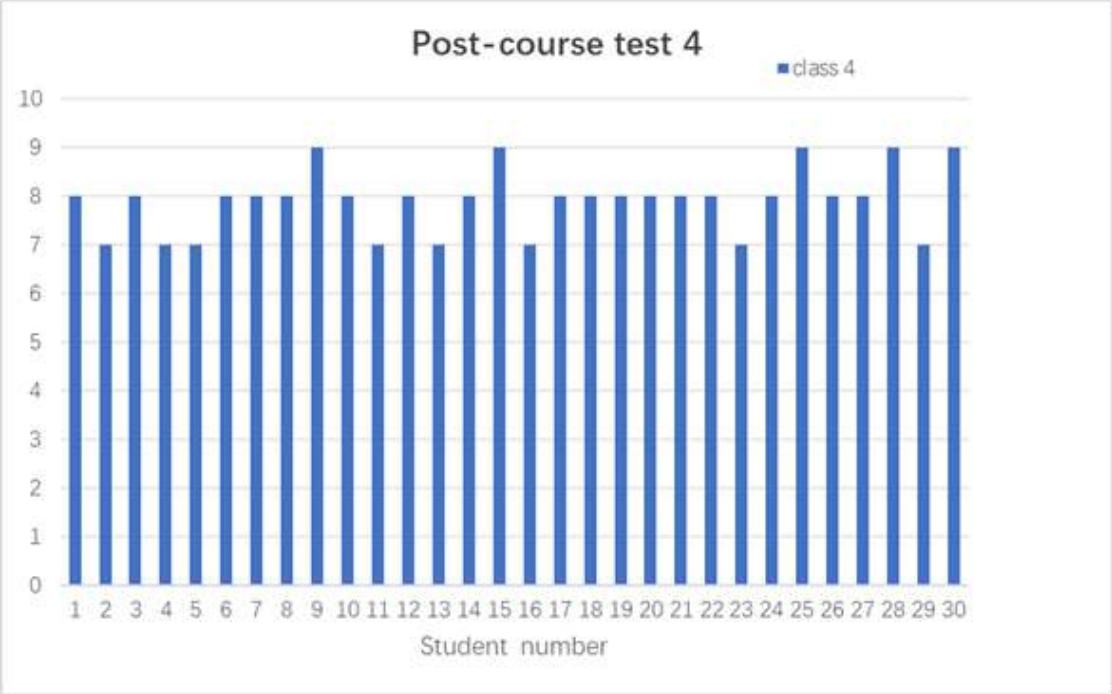
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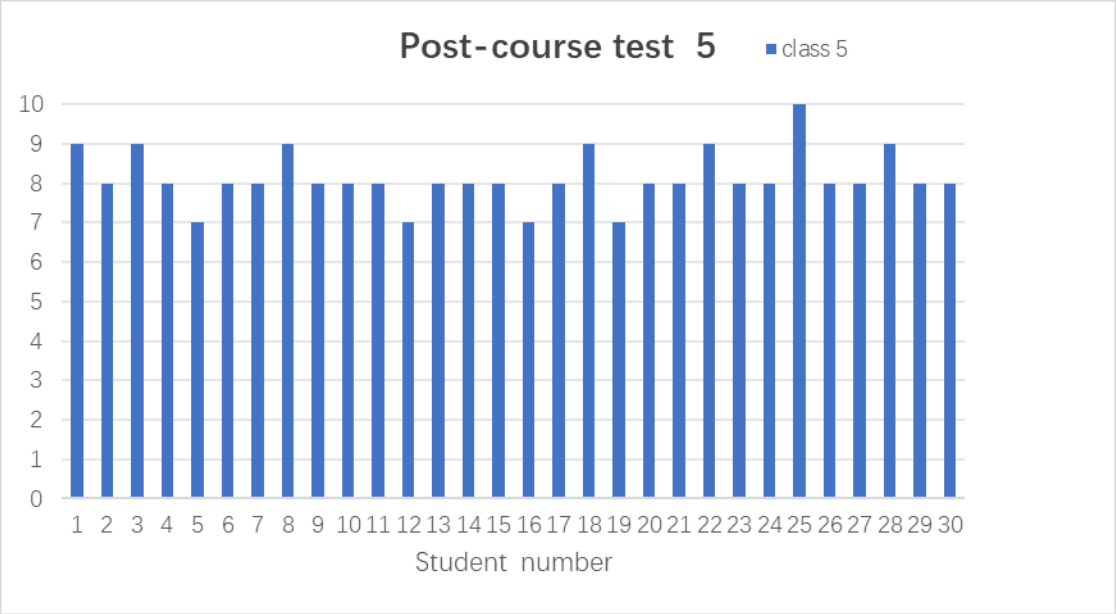
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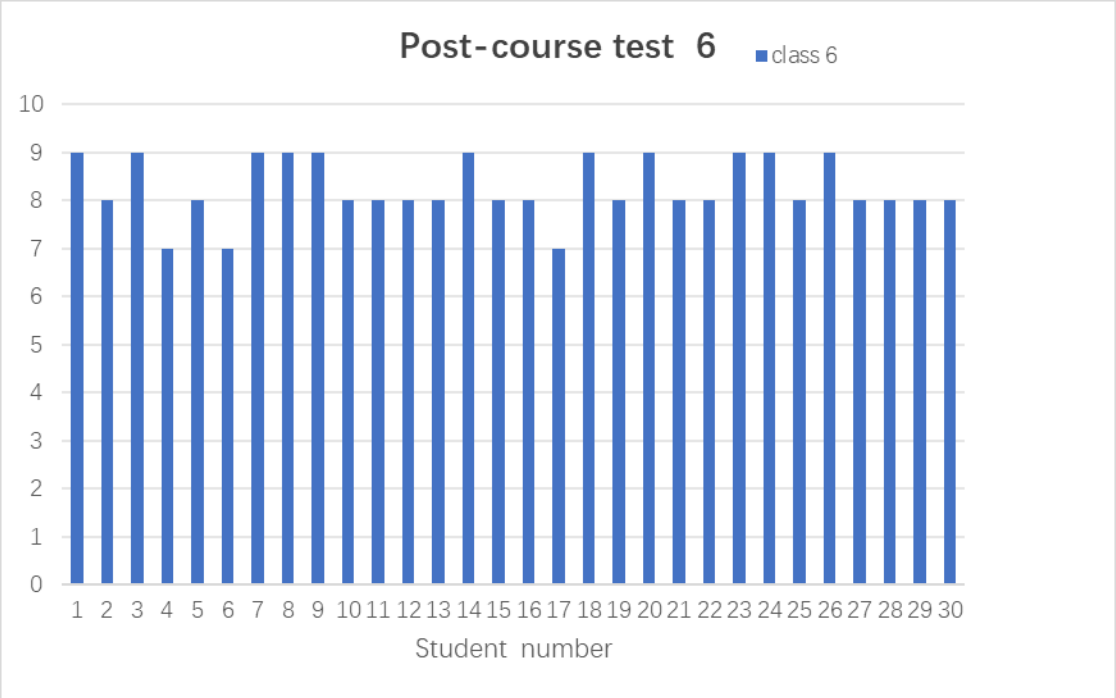
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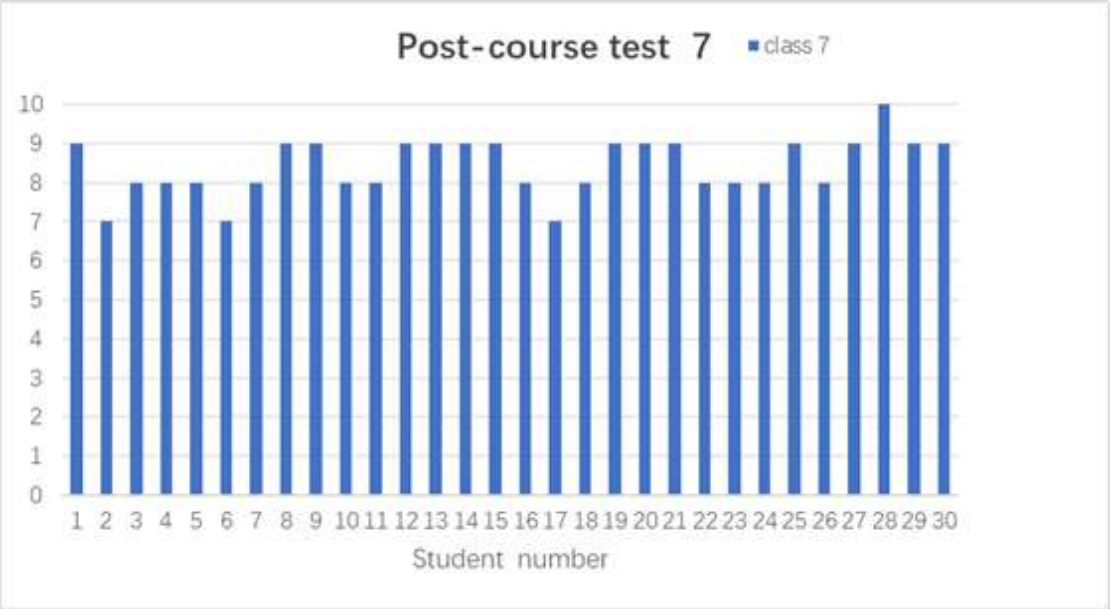
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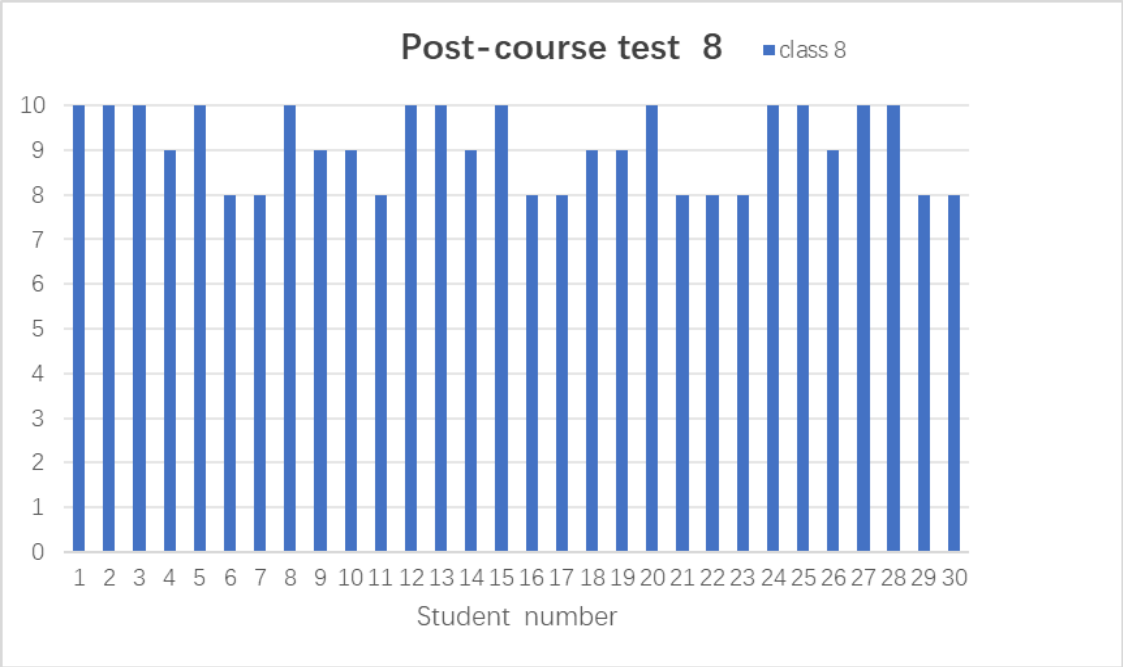
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Student number

APPENDIX H

ACHIEVEMENT TESTS (PRE-TEST AND POST-TEST)

ACHIEVEMENT TEST IN CHEMISTRY SUBJECT
: REACTION OF SODIUM

Subject: chemistry **Total Marks:** 30

Name: …… **ID Number:** …….

Instructions: Choose only one correct answer. (1 point each)

1. A student drops a small piece of sodium into water with phenolphthalein. The experiment shows that sodium has one of the following properties.
① Sodium density is smaller than water
② Sodium has a lower melting point
③ Sodium releases heat when it reacts with water
④ The solution was alkaline after the sodium reaction with water.
A. ①④ B. ①②④ C. ①③④ D. ①②③④

2．The phenomenon of sodium reaction with water and the following properties of sodium are irrelevant.
A．Sodium has a lower melting point. B．Sodium has a smaller hardness.
C．Sodium is less dense than water. D．Sodium has strong reduction.

3．A student drops a small piece of sodium into water with pholphthalein. The experiment proved one of the four properties of the sodium.
① Sodium is lighter than water ② Sodium has a lower melting point
③ Sodium releases heat when it reacts with water ④ The solution was alkaline after the sodium reaction with water.
A. ①④ B. ①②④ C. ①③④ D. ①②③④

4．Take a large test tube, add 20 mL of saturated clarified lime water (ρ = 1.6 gcm 3), add 5 mL benzene (ρ = 0.87 gcm 3), and slowly add soy particle size sodium block (ρ = 0.97 gcm 3). The observed phenomenon is.

① The sodium reacts at saturation to clarify the lime water layer and walks around

②There is gas produced ③ Clear lime water becomes turbid

④ Sodium reacts at the interface between lime water and benzene and beats up and down

⑤ Sodium stays in the phenyl layer unreactive ⑥ Sodium blocks finally disappear

A．①②⑥ B．②③④⑥ C．⑤ D．①②③⑥

5．Put a small piece of metal sodium into CuSO4 solution.

A．Blue precipitate was generated in the solution. B．There is gas generation.

C．There is a red matter breaking out. D．The sodium melts into a small ball and floats on the liquid surface

6．The following statement is true of this statemen.

A．One of the reasons why sodium is stored in kerosene is that it is very prone to react with oxygen.

B．Aluminum burns very easily in the air

C．The oxide film on the aluminum surface is loose and cannot protect the inner metal

D．The main component of the rust is the Fe3O4.

7．The following account of the reaction between sodium and water is incorrect.

① A small particle of sodium is poured into water with purple core solution, and the solution turns red after the reaction

② A small particle of sodium is put into dilute Hic acid, which reacts with water and then with HCl

③ Sodium burns when reacted in water vapor due to a high temperature

④ When two small particles of metal sodium of equal mass, one directly into the water, the other with aluminum foil, and then into the water, the two release the hydrogen of equal mass.

A. ①② B. ②③ C. ②③④ D. ①②③④

8．Various phenomena produced when sodium reacts with water are as follows.

① Sodium floats on the surface; ② Sodium sinks to the bottom;

③ The sodium melts into a pellet, and finally disappears; ⑤ Make a hissing sound

A. ①②③④⑤ B. all C. ①②③⑤⑥ D. ①③④⑤⑥

9．After adding a small piece of sodium metal to the copper sulfate solution, the observed phenomenon were.

①Sodium floats on the liquid surface

②Melt into small balls

③A hissing noise and a gas

④The blue precipitate around the sodium turns black

⑤There is a blue precipitate produced

⑥Large lot of red copper

⑦The small ball floats in the solution

⑧The ball moves on the liquid surface and gradually becomes smaller until it disappears．

A. ①②③④⑤⑥ B. ①②③④⑤⑧ C. ①②③⑥⑧ D. ②⑥⑦

10．Put a small piece of sodium into water with a purple litmus test solution, and the following description is wrong.

A．Sodium floats on the liquid surface B．There are colorless and odorless gas produced.

C．The aqueous solution changes to blue. D．There was a loud sound.

11．Drop 1~2 drops of phenolphthalein solution into the beaker of appropriate cold water, and take a piece of metal sodium the size of mung bean grain into the water. The following experimental phenomenon, analysis and conclusion are correct.

option	experimental phenomenon	Analysis and conclusion
A	Sodium is put into the water, first sinks to the bottom and then rises to the surface	Sodium has less density than water
B	Melt into bright balls	The reaction is exothermic, with a low boiling point of sodium
C	The ball swam around the water with a hissing sound	The gas is uneven, pushing the ball to swim around and react violently
D	The solution becomes red	An alkaline substance was produced：$Na+2H_2O═NaOH+H_2↑$

A．A　B．B　C．C　D. D

12．Put a small piece of sodium metal into a beaker with ethanol, the following incorrect description of the experimental phenomenon is.

A．Sodium sinks at the bottom of the ethanol.

B．Sodium does not melt into pellets.

C．Sodium swam around in the ethanol.

D．Gas is released on the sodium surface.

13．Is incorrect in the following narrative(　　)

A．Na2O2It's a light yellow solid，Na2O Is a white solid, and both can react with water to form NaOH

B. Na and O2 react upon heating to generate Na2O2, and then generate Na2O at room temperature

C．Na2O and CO2 to generate Na2CO3, and Na2O2 replaces CO2 to replace O2

D．After sufficient combustion of 2 g H2, the product is fully absorbed by Na2O2, and the Na2O2 solid weighs by 2g

14．The amount of metal sodium of the following experiment, of which hydrogen is the most(　　)

A．Place the sodium into enough dilute hydrochloric acid

B．Put the sodium into enough water

C．Place the sodium into the copper sulfate solution

D．Wrap the sodium in aluminum foil and punch the holes in the water

15．The following statement of sodium is incorrect(　　)

A．Metal sodium and oxygen reaction, the conditions are different, the product is different

B．The sodium is placed in the air for a long time and will eventually become sodium carbonate

C．The chemical nature of sodium is more lively, and a small amount of sodium can be stored in kerosene

D．When the sodium is on fire, it can be extinguished with water

16. When doing flame reaction experiments in the laboratory, the platinum wire must be cleaned for each experiment. This reagent is ( )

A．sulfuric acid washing　　B．Dilute hydrochloric acid washing

C．water washing　　D．Acetic acid washing

17. In the essential experiment of flame reaction, the unnecessary instruments or medicines are ( )

A．Platinum wire rod　B．alcohol lamp　C．blue cobalt glass　D．Dilute hydrochloric acid

18.Which of the following descriptions about the flame reaction operation is correct ( )

A． Take a clean thin iron wire and burn it on an alcohol lamp until it is colorless, then dip a small amount of NaCl solution for flame reaction

B． When observing the flame reaction, it is necessary to pass through the blue cobalt glass sheet, so as to isolate the interference of the yellow light of the sodium element

C． After finishing the flame reaction of the sodium chloride solution, the platinum wire was washed with dilute sulfuric acid, then dipped in a small amount of K2SO4 solution, and the above experiment was repeated.

D． Dip a certain solution with a clean platinum wire, burn it on the flame, and observe a yellow flame, which proves that there must be Na+ in the solution and no K+

19.There are the following steps when carrying out the flame reaction test K+, and the correct operation sequence is ( )

① Dip the solution to be tested ② Put it on the flame of an alcohol lamp and burn it ③ Observe through the blue cobalt glass ④ Wash the platinum wire with dilute hydrochloric acid

A． ④②①②③ B． ①②③④ C． ④①②③ D． ②①③④

20.The correct one is ( ) for the following instructions on the precautions for the operation of the flame reaction experiment

①The flame color of potassium should be observed through blue cobalt glass. ②First burn the platinum wire to the same color as the original flame, and then dip in the substance to be tested. ③After each experiment, the platinum wire should be washed with hydrochloric acid④④ It is best to choose a flame with a weaker color in the experiment ⑤ There is no platinum wire, and it can also be replaced by smooth and rust-free iron wire

A． Only ③ is incorrect B． Only ④ is incorrect C． Only ⑤ is incorrect

D． all right

21.In the military, it is often made by using the principle of flame reaction ( )

A . Molotov cocktail B . signal flare C . flare D . smoke bomb

22.Among the following solutions, the group that must be identified by flame reaction is ( )

A . Na2CO3, KCl B . NaCl, KCl C . CaCl2, NaCl D . K2CO3, CaCl2

23.A group of substances that can only be identified by flame reaction is ( )

A . NaCl, CuCl2 B . NaCl, Na2CO3 C . Na2CO3, K2CO3 D . NH4Cl, Ba(NO3)2

24.The color of sodium flame reaction is ( )

A . Brick red B . Purple C . yellow D . Green

25.Flame reaction is not yellow ( )

A . NaCl B . Na2O2 C . NaOH D . KOH

26.When a substance burns, the flame reaction is yellow, which of the following is correct ( )

A . The substance must be a sodium compound

B . The substance must contain sodium

C . The substance must be sodium metal

D . This substance does not contain potassium

27.Take sodium chloride for flame reaction experiment, the flame is yellow, the reason for the color is ( )

A . Sodium chloride volatilizes with heat

B . Sodium chloride decomposes when heated

C . Electron transitions in sodium ions

D . Electron transitions in chloride ions

28.The flame reaction reflects ( )

A . Elementary properties B . properties of compounds

C . properties of ions D . properties of elements

29.Which of the following understandings about "flame reaction" is correct ( )

A . Only metal element has flame reaction

B . Only metal compounds have flame reaction

C . Only certain metals or their compounds have flame reaction

D . Only metal ions have flame reaction

30.Flame reaction can be used to test ( )

A . the presence of all elements

B . The existence of all elemental metals

C . The presence of certain metal elements or metal ions

D . Presence of all non-metallic elements

31.Which of the following statements is correct ( )

A . The flame reaction is yellow, indicating that the substance must contain sodium

B . The flame reaction of a certain substance does not show purple (it does not pass through the blue cobalt glass), indicating that there must be no potassium element in the substance

C . As long as it contains metal elements, there must be a flame reaction when burning

D . A flame reaction is a chemical change

32.Which of the following statements about flame reaction is incorrect ( )

A . Flame reaction is the color of the flame when the metal element is burning

B . Not all metal elements have flame reaction

C . When K2CO3 burns on the alcohol lamp, the purple flame can be directly observed

D . When the flame reaction shows a yellow flame, the burning substance may be sodium or sodium salt

33.The fireworks show in the program was brilliant and amazing. Which of the following statements about flame reaction is correct ( )

A . Flame reaction is a property of metal compounds

B . NaCl and Na2CO3 have the same flame color when burning

C . All flame reactions should be observed through blue cobalt glass

D . The flame of all metals and their compounds has color when burned

34.Brown smoke is produced when the following reactions occur

A . Sodium metal burns in Cl2 B. Iron burns in chlorine

C . Hydrogen burns in chlorine D. sulfur burns in oxygen

35.Under the same state, the volume ratio of the gas is equal to the ratio of the number of molecules, and the existing 20 mL of A2 gas and 30 mL of B2 gas just completely react to produce 20 mL of a certain gas X, then the chemical formula of gas X can be deduced as ( )

A . AB2 B . AB3 C . A2B3 D . A3B2

36.Which of the following statements about the flame test is correct ( )

A . The different characteristic colors produced by metals and their compounds when burned are caused by chemical changes

B . Flame test is suitable for the inspection of all metal elements

C . When a solution is tested for flame color, the flame turns yellow, indicating that the solution must contain sodium and must not contain potassium.

D . Necessary instruments and reagents for flame test: platinum wire or clean and rust-free iron wire, alcohol lamp or gas lamp, hydrochloric acid

37.In order to identify the two white solids Na2CO3 and NaHCO3, 4 students have designed the following four different methods, among which the ones that are not feasible are ( )

A . Take samples separately to form a solution, add 1 mol/L hydrochloric acid solution drop by drop, and observe the speed of bubble generation

B . Take samples separately and heat them in test tubes, pass the gas that may be generated into clarified lime water, and observe whether there is white turbidity

C . Take samples separately to form a solution, add BaCl2 solution dropwise, and observe whether there is white precipitation

D . Make solutions respectively, dip the solution with platinum wire and burn it on the flame of alcohol lamp, observe the color of the flame

38. . For the platinum wire used in the flame reaction experiment, each sample must be ( )

A . Wash with water 2-3 times before use

B . After washing with hydrochloric acid, rinse with distilled water before use

C . Dry with filter paper before use

D . After washing with hydrochloric acid, burn it on the flame of an alcohol lamp until it has no color before it can be used

39.Which of the following changes is a chemical change ( )

A . Flame test b. Corrosion of steel c. Gasoline volatilizes D. wrought metal

40.Which of the following statements about sodium metal is incorrect ( )

A . Silvery white metallic luster B . Combustion in air produces Na2O2

C . kept in kerosene D . Can not react with oxygen at room temperature

41.Which of the following statements about sodium is incorrect ( )

A． Sodium is highly reducing

B． Sodium peroxide is formed when sodium burns

C． Sodium ions are highly oxidizing

D． The outermost shell of a sodium atom has only 1 electron

42.A classmate put metal sodium dew in the air, and observed the following phenomena: silvery white → grayish gray → white → liquid droplets appear → white solid, the substance that cannot be produced during the metamorphic process is ( )

A． Na2O2　　B． NaOH　　C． Na2CO3　　D． Na2O

43.Put a piece of metallic sodium into a beaker filled with cold water dripping with purple litmus test solution, student A believes that the following phenomena can be observed, among which the correct one is ( )

① When sodium is put into water, it first sinks to the bottom and then emerges to the surface. ② Sodium immediately reacts with water and produces gas. ③ After the reaction, the solution turns red.

④Sodium melts into shiny balls ⑤The balls swim around on the water surface ⑥ There is a "hissing" sound.

①②③④B． ②③④⑤C． ②④⑤⑥D． ③④⑥

44.Put a small piece of sodium metal into the following solution, the correct statement is ( )

A． Saturated NaOH solution: hydrogen gas is released, and the concentration of the solution increases after returning to room temperature

B． Water dripped with litmus solution: hydrogen gas is released and the solution turns red

C． MgCl2 solution: hydrogen gas is released and white precipitate is formed

D．Dilute CuSO4 solution: hydrogen gas is released, and purple-red copper is precipitated

45.Put sodium metal into a small beaker containing the following solutions, both gas and white precipitates are produced (regardless of the temperature change of the solution) ( )

① MgSO4 solution ②Dilute Na2SO4 solution ③ Saturated clarified lime water

④CuSO4 solution ⑤ Saturated NaCl solution ⑥ FeCl3 solution

A．①④⑥B．②④⑤C．③④⑥D．①③⑤

46.Which of the following statements about sodium oxide and sodium peroxide is correct ( )

A．The solution obtained after dissolving in water has the same composition

B．Oxygen has the same valence

C．The number ratio of anion and cation is different

D．are basic oxides

47.Which of the following statements about Na2O and Na2O2 is correct ( )

A．Na2O2 is more stable than Na2O

B．Both Na2O and Na2O2 are strong oxidizing agents

C．Both Na2O and Na2O2 are basic oxides

D．Na2O2 and Na2O are allotropes of each other

48.Which of the following statements about Na2O2 is correct ( )

A．can be used as bleach

B．The number ratio of cations to anions is 1:1

C．are basic oxides

D．For every 1 mol of O2 produced by reacting with water, NA e-

49. Na_2CO_3 and $NaHCO_3$ with the same amount of substances are fully reacted with enough hydrochloric acid of the same concentration respectively, where ( )

A . Na_2CO_3 emits more CO_2 B . $NaHCO_3$ emits more CO_2

C . Na_2CO_3 releases CO_2 fast D . $NaHCO_3$ releases CO_2 fast

50.Regarding Na_2CO_3 solution and $NaHCO_3$ solution, which of the following statements is correct ( )

A . Differentiate between two solutions by heating

B . Use clarified lime water to distinguish the two solutions

C . At the same concentration, the pH of the Na_2CO_3 solution is greater

D . At the same concentration, the pH of the two solutions is equal

51.Which of the following statements about the properties and uses of sodium peroxide is correct ( )

A . Sodium peroxide is a light yellow solid with very active properties

B . Sodium peroxide needs to be kept airtight because it reacts with everything in the air

C . The reaction of sodium peroxide with carbon dioxide is very slow and endothermic

D . Sodium peroxide is an alkaline oxide that reacts with acids to form salt and water

52.Which of the following statements is incorrect ( )

A . Both Na_2O_2 and Na_2O are basic oxides

B . $2Na_2O_2+2H_2O=4NaOH+O_2\uparrow$, when 2 molecules of H_2O participate in the reaction, 1 molecule of O_2 is generated

C . Add excess sodium peroxide powder to the purple litmus solution, oscillate, the solution turns blue first and then fades

D . Add a few drops of water to the absorbent cotton covered with Na_2O_2 powder, and the absorbent cotton burns violently, indicating that the reaction between Na_2O_2 and H_2O is exothermic

3."Comparison" is one of the basic methods for chemical research on the properties of substances. Please use the comparative method to answer the following questions: It is known that under certain conditions, sodium peroxide can react with almost all common gaseous non-metallic oxides. Such as: 2Na2O2+2CO2═2Na2CO3+O2, Na2O2+CO═Na2CO3. Then the chemical equation of the reaction between Na2O2 and SO2 is ( )

A．$SO_2+Na_2O_2═Na_2SO_4$ B．$2SO_2+2Na_2O_2═2Na_2SO_3+O_2$

C．$SO_2+Na_2O_2═Na_2SO_3$ D．$SO_2+Na_2O_2═Na_2SO_4+O_2$

54.Put sodium peroxide into ferrous chloride solution, the observed phenomenon is ( )

A． Eventually a white precipitate is formed B. Eventually a reddish-brown precipitate is formed

C． A yellow-green gas is produced D. no change

55.Na2O2 is a commonly used oxygen supply agent in submarines. Which of the following statements about Na2O2 is wrong ( )

A． The number ratio of anions and cations in Na2O2 is 1:2

B． Na2O2 reacts with H2O and CO2 respectively, and when the same mass of O2 is produced, the number of H2O and CO2 molecules consumed is equal

C． When Na2O2 is used as an oxygen supply agent, it not only generates O2 but also "fixes" CO2

D． Add a sufficient amount of Na2O2 solid to the copper sulfate solution, and the solution turns from blue to colorless after standing, indicating that sodium peroxide has bleaching properties

56.Which of the following statements about sodium compounds is incorrect ( )

A． The same mass of sodium reacts completely, regardless of the formation of sodium oxide, sodium peroxide or their mixture, the number of electrons transferred is the same

B． Caustic soda is NaOH, soda is NaHCO3, soda is Na2CO3

C . When sodium metal is on fire, do not use water to extinguish the fire

D . Na, Na2O, Na2O2, and NaOH are placed in the air for a long time, and they will eventually become Na2CO3

57.Burning sodium compounds, the flame is ( )

A . red b . blue C . yellow D . Purple

58.To identify the following groups of substances, only the flame test can be used ( )

A . K2SO4 and NaCl B. NaCl and KCl

C . NaCl and MgCl2 D. KCl and CaCO3

59.Colorful fireworks displays add a lot of festive atmosphere to various festivals. Studies have shown that the color of fireworks is related to the presence of sodium, potassium, calcium, barium, copper, strontium and other metal elements in fireworks. Which of the following statements is incorrect ( )

A . There is no chemical change in the flame test of metal elements

B . Sodium can be preserved in kerosene

C . The color of the flame is different when KCl and KNO3 burn

D . The flame test for potassium and its compounds requires penetration through blue cobalt glass

60.Which of the following statements about sodium carbonate and sodium bicarbonate is incorrect ( )

A . Sodium carbonate is more thermally stable than sodium bicarbonate

B . Sodium carbonate is more soluble than sodium bicarbonate at the same temperature

C . At the same temperature and the same concentration of substances, the alkalinity of sodium carbonate solution is higher than that of sodium bicarbonate solution

D． Sodium bicarbonate can be converted into sodium carbonate under certain conditions, but sodium carbonate cannot be converted into sodium bicarbonate

note

The difficulty value is calculated from the formula P=r/n

The discriminant power value is calculated from the formula： Item Total Correlation

The precision value is calculated with the formula KR-20

Precision value (Reliability) = 0.9450

The results of the analysis of the discriminant power values of each item of the criterion-referenced test.

Point number	B-index	Interpret results	Point number	B-index	Interpret results
1	0.8077	available	31	0.5962	available
2	0.5192	available	32	-0.0577	discard
3	0.8077	available	33	0.6923	available
4	0.3077	available	34	0.1154	discard
5	0.5577	available	35	0.7692	available
6	0.2308	available	36	0.4423	available
7	0.8462	available	37	0.1731	discard
8	0.7308	available	38	0.2885	available
9	0.4808	available	39	0.4038	available
10	0.6346	available	40	0.3654	available
11	0.5577	available	41	0.3654	available
12	0.5962	available	42	0.4038	available
13	0.5192	available	43	0.3269	available
14	0.8077	available	44	0.2308	available
15	0.4423	available	45	0.5962	available
16	0.4808	available	46	0.5577	available
17	0.2692	available	47	0.2308	available
18	0.7692	available	48	0.2885	available

19	0.4808	available	49	0.1346	discard
20	0.8077	available	50	0.3077	available
21	0.8077	available	51	0.2885	available
22	-0.0577	discard	52	0.0962	discard
23	-0.0962	discard	53	0.4231	available
24	0.4808	available	54	0.1538	discard
25	0.2308	available	55	0.2885	available
26	0.2308	available	56	0.1731	discard
27	0.1538	discard	57	0.0000	discard
28	0.5962	available	58	0.3077	available
29	0.3077	available	59	0.1923	discard
30	0.2692	available	60	0.3269	available

Note

B-index > 0.2 means available

B-index < 0.2 means throw away

Summary of the results of analysis of criterion-based examinations.

examination		quantity
1	Exams that pass the criteria	48
2	Exams that do not pass the criteria	12
together		60
Bmin=		-0.0962
Bmax=		0.8462
Lowest precision		0.9758

Table Score difference between Pretest and Posttest.

STUDENT NO.	PRETEST	POSTTEST	IMPROVEMENT SCORE	% Different Scores
1	16	20	4	13%
2	12	16	4	13%
3	20	22	2	7%
4	14	16	2	7%

5	15	18	3	10%
6	14	17	3	10%
7	15	19	4	13%
8	15	20	5	17%
9	18	22	4	13%
10	11	16	5	17%
11	14	18	4	13%
12	17	20	3	10%
13	14	16	2	7%
14	15	17	2	7%
15	14	18	4	13%
16	13	16	3	10%
17	15	18	3	10%
18	15	18	3	10%
19	16	20	4	13%
20	18	23	5	17%
21	15	19	4	13%
22	12	16	4	13%
23	14	17	3	10%
24	12	16	4	13%
25	16	19	3	10%
26	15	19	4	13%
27	18	20	2	7%
28	17	22	5	17%
29	13	17	4	13%
30	14	18	4	13%

APPENDIX I

QUESTIONNAIRE

QUESTIONNAIRE

SATISFACTION QUESTIONNAIRE FOR THE DEVELOPMENT
OF LEARNING ACHIEVEMENT IN CHEMISTRY ON THE REACTION
OF SODIUM WITH AN EXPERIMENTAL TEACHING METHOD.

The questionnaire will be distributed to first-year high school students as the sample group for this study. The questionnaire was designed to examine students' perception of the use of experimental methods in the chemistry class. The questionnaires completed by the participants will be kept confidential and used only for this study.

Part I: Demographic Data

Direction: Please tick ✓ in the box ☐ that corresponds to your information.
Age: ☐ Between 14-15 ☐ Between 15-16 ☐ 16 and above
Gender: ☐ Male ☐ Female
Years of learning : ☐ 1 years ☐ 2 years ☐ more than 2 years

Part II: Students' Satisfaction

Mark your level of opinion from 1-5 against each statement. The description of each scale 1-5 is as follows:

Level 5 means most satisfied.
Level 4 means very satisfied.
Level 3 means moderately satisfied.
Level 2 means less satisfaction.
Level 1 means least satisfied.

Students' Satisfaction

No.	Items	Opinion level				
		5	4	3	2	1
PART A: INTEREST & MOTIVATION						
A1	The process of using the chemical experimental method is very interesting					
A2	Learning chemistry using experimental methods makes chemistry more meaningful					
A3	Learning chemistry by experimental methods can develop my interest in chemistry					
A4	The experimental method can encourage me to have more confidence in my chemistry study					
PART B: ENGAGEMENT						
B1	All the activities related to the experimental method are very interesting					
B2	All of the activities related to the experimental methods are very meaningful					
B3	All the activities related to experimental methods can help me remember chemical experimental phenomena					
B4	Using experiments can help me understand the abstract concepts of textbooks					
B5	I really like participating in classroom activities related to experimental methods					
PART C: The function of the experimental method on the students						

No.	Items	Opinion level				
		5	4	3	2	1
C1	Using experimental method teaching can improve my chemical experiment ability					
C2	Using experimental method teaching can improve my understanding of experiment					
C3	Using experimental method teaching can help me understand abstract conceptual knowledge					
C4	Using experimental method teaching can help me improve the score of experimental questions					
C5	Using the experimental method of teaching can help me to improve my overall chemistry performance					

Additional Suggestions:

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…….

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…….

…….

Thank you for your cooperation.

BIOGRAPHY

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