

RESEARCH ON THE "MURDER MYSTERY" ELEMENT IN HIGH SCHOOL CHEMISTRY TEST QUESTIONS AND TEACHING METHODS BASED ON EVIDENCE REASONING LITERACY

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ABSTRACT

Evidence reasoning is not only a thinking mode that high school students need to possess, but also a specific requirement of the country for high school students to have the ability. Script Kill "is a popular offline immersive game that combines emotional experience and reasoning to explore answers, favored by young students in recent years. Based on the research on the main process of script kill games in the 2024 Jilin Provincial College Entrance Examination questions, this article designs the teaching of "Chlorine and Its Compounds" in the second section of Chapter 2 of the People's Education Press High School Chemistry Compulsory Course 1. It discusses the necessity and feasibility of applying "Script Kill" teaching in high school chemistry classrooms and integrating "red elements" into teaching, hoping to improve students' evidence-based reasoning ability in the form of "teaching with entertainment".

Keywords: Evidence reasoning, murder mystery, high school chemistry.

1. The Relationship between Murder Script and Evidence Reasoning Literacy

In September 2016, the research results on the development of core competencies for Chinese students were released, and the overall framework of "Core Competencies for Chinese Student Development" was announced. The core competencies for students were divided into 6 aspects and 18 key points, and were defined as "essential qualities and key abilities that students should possess to adapt to their lifelong and social development needs". The 2017 edition (revised in 2020) of the "General High School Chemistry Curriculum Standards" clearly states that the core competencies of high school chemistry consist of five dimensions: macro identification and micro analysis, change concept and balance thinking, evidence reasoning and model cognition, experimental exploration and innovation consciousness, scientific spirit and social responsibility [1]. Evidence reasoning is not only an important component and thinking core of core chemistry literacy, but also an important thinking ability that high school students should possess. Information acquisition and processing are the foundation of the development of the entire chemistry discipline. When analyzing the 2021 college entrance examination chemistry test questions, experts from the Examination Center of the Ministry of Education proposed that "the test questions strengthen the examination of students' logical reasoning ability by creating complex problem scenarios. It can be seen from this that it is imperative to exercise students' abilities in evidence collection, information processing, chart processing, judgment and reasoning through various methods in chemistry teaching and daily training.

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In 2016, starting from the hot broadcast of a domestic detective chase variety show, Script Kill, an offline immersive emotional game, became popular among young people in China. Script Kill "is set against the backdrop of many vivid themes such as ancient times, campuses, suspense, and the Republic of China. It integrates the story background, clue collection, evidence sorting, and inference of the murderer into one, allowing players to immerse themselves in the story plot and character emotions during the game. Through multiple evidence gathering stages, players can sort out evidence and deduce the murderer in the story" [2].

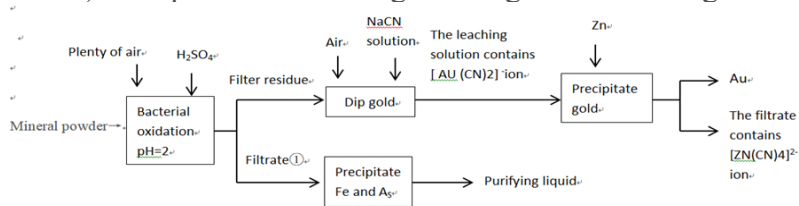
Many chapters in high school chemistry contain a large amount of fragmented knowledge, which requires a lot of time and effort for students to connect and memorize, and is easy to forget [3]. Conducting an entertaining "chemistry murder mystery" after the chapter ends to subtly internalize fragmented knowledge into students' memory would be a feasible approach. In the chemistry questions of the college entrance examination, more and more emphasis is placed on creating story scenarios, allowing students to collect clues from the question stem and images to the maximum extent within a limited time, turn the clues into evidence, and then deduce the answer, which largely overlaps with the game segment of murder mystery. The article will conduct a clue sorting and evidence analysis of a chemistry college entrance examination question in Jilin Province in 2024 years, and use a brief teaching design as an example to demonstrate the degree of conformity between the elements of the question and the script killing, and provide a teaching design reference for chemistry teachers.

2. The phenomenon of "script killing" in the test questions

Many chemistry test questions are based on script killing, providing clues through question stems or pictures, guiding students to synthesize information clues, and inferring answers through research, in order to solidify the foundation, exercise information collection and transformation, and cultivate students' judgment and reasoning abilities during the problem-solving process. Taking the process questions in the 2024 Jilin Province Chemistry College Entrance Examination as an example, illustrate the phenomenon of "script killing" in the questions.

(1) Test questions reproduced, script opened

China was the first country in the world to utilize bacterial metallurgy. It is known that metal sulfides are converted into sulfates during bacterial oxidation. A certain factory uses bacterial metallurgy technology to treat gold ore powder (in which small Au particles are wrapped in FeS_2 and FeAsS) to improve the leaching rate of gold and smelt gold. The process flow is as follows:



Answer the following questions:

1) During the Northern Song Dynasty, multiple mining sites in China utilized bacterial oxidation to form natural "bile water" for copper smelting. The main solute in "bile water" is (filled with chemical formula).

2) The ion equation for the reaction of FeS_2 in bacterial oxidation is _____.

3) When "settling iron and arsenic", it is necessary to add alkali to adjust the pH and generate (fill in the chemical formula) colloids for flocculation, which promotes the settling of As containing particles.

4) Baking oxidation can also improve the efficiency of gold leaching. Compared with roasting oxidation, the advantage of bacterial oxidation is _____(fill in the label).

- A. No need for temperature control ;
- B. Can reduce the production of harmful gases ;
- C. The equipment does not need to withstand high temperatures ;
- D. Does not produce waste liquid or residue .

5) 'True gold is not afraid of fire' indicates that Au is difficult to oxidize by O₂, and the role of NaCN in 'gold immersion' is _____.

6) The role of Zn in "sinking gold" is _____.

7) The equation for the conversion of [Zn (CN)₄]²⁻ to ZnSO₄ and HCN through H₂SO₄ _____; acidification of filtrate _____ can be used to neutralize HCN with alkali to generate a solution, thus achieving recycling.

[Reference answer]

1) CuSO₄

2) $4\text{FeS}_2 + 15\text{O}_2 + 2\text{H}_2\text{O} = 4\text{Fe}^{3+} + 8\text{SO}_4^{2-} + 4\text{H}^+$

3) Fe(OH)₃

4) BC

5) As a chelating agent, providing CN⁻ ligand 2 facilitates the conversion of Au to [Au (CN)₂]⁻ under the action of oxygen

6) As a reducing agent, [Au (CN)₂]⁻ reducible Au

7) $\text{Na}_2[\text{Zn}(\text{CN})_4] + 2\text{H}_2\text{SO}_4 = \text{ZnSO}_4 + 4\text{HCN} + \text{Na}_2\text{SO}_4$; NaCN

(2) Search for evidence and reason to find the culprit

Emphasis is placed on understanding the properties and reaction principles of common inorganic substances such as acids, bases, metal monomers, and metal compounds. Among them, 1), 3), and 6) are relatively simple, with the addition of alkaline substances to "precipitated iron arsenic" and the production of colloids. The colloids that were emphasized in high school are only iron hydroxide colloids; Adding elemental zinc to 'sinking gold' generates elemental gold and a new complex [Zn (CN)₄]²⁻ ion, which naturally leads students to associate displacement and reduction reactions. So none of these three questions require in-depth discussion.

The starting point of the process - the main composition of mineral powder - is inferred from the question stem "Au is encapsulated by FeS₂ and FeAsS", and the theme stem also provides an important clue that "metal sulfides are converted into sulfates during bacterial oxidation". There are also many important clues and evidence in the flowchart, such as the arrow pointing to sulfuric acid and air in the "bacterial oxidation" step, pH=2; Afterwards, filter out the filter residue and filter 2, and combine with the main theme to derive the ion reaction equation for problem 2). The arrow in the "gold leaching" step indicates the introduction of NaCN solution and air. The leaching solution contains [Au (CN)₂]⁻ ions, indicating that the metal Au has reacted with the added NaCN solution and formed a new complex. In addition, each question stem also has important clues for solving the problem. For example, the question stem of question 7 has already given two products of substance reactions. Based on this clue combined with the clue of adding substances in the

flowchart, the chemical reaction equation of this reaction and the substance that can achieve "recycling" can be written. This is the "hidden key" to clearing the game.

In addition to searching for clues and evidence in the problem, students also need to have a certain foundation in biology. 4) The advantage of "bacterial oxidation" is that option A "no temperature control required" is a confusing answer for students. If they cannot associate it with the interdisciplinary knowledge that high temperature reduces bacterial activity, it is highly likely to infer the wrong answer.

(3) Game over, review the script

The material is selected from the example of using bacterial oxygen to extract metal gold in industry, which has high requirements for students' chemical core literacy. The focus is on students' knowledge of elements such as sulfur, iron, copper, and gold, as well as their mastery of redox reactions. Utilize elements such as situational creation, evidence gathering reasoning, and implicit clues in murder mystery to cultivate students' ability to reason based on evidence.

The material may be selected from the master's thesis "Thermophilic bacteria pretreatment of complex and difficult to treat gold ore - gold extraction experimental research" by Northeastern University Haifeng^[4]. Combined with other literature and papers, it can be concluded that bacterial single tank oxidation pretreatment of ore can greatly improve the subsequent cyanide leaching rate of gold and silver.

It was found that this question focuses on allowing students to analyze and answer the connections between the stem information of each question, the hidden clues in the flowchart, and interdisciplinary knowledge, with a particular emphasis on testing students' judgment, reasoning, and information conversion abilities. For example, 2) Write the ion reaction equation for the reaction of FeS_2 in "bacterial oxidation". The first key clue to solving the problem is to find the various substances added in the bacterial oxidation step and the types of products generated after the reaction in the flowchart. Then, combined with the theme "metal sulfides turn into sulfates during" bacterial oxidation", it can be inferred that in addition to FeS_2 , there is also oxygen in the air participating in the reaction; After the reaction, Fe forms $\text{Fe}_2(\text{SO}_4)_3$; And important information such as acidic reaction environment can be used to write the ion reaction equation that the questioner wants based on this information.

3. Teaching Design Festival of "Chemistry Script Kill" --- Taking "Chlorine and Its Compounds" as an Example

(1) Teaching background

① Standard analysis

The High School Chemistry Curriculum Standards (2-7 Year Edition) aim to develop core competencies in the field of chemistry. The requirements for this lesson in the curriculum standards are: 4. List, describe, and identify important physical and chemical properties and experimental phenomena of typical substances. Can accurately represent the main chemical properties of typical substances using chemical equations and ion equations. Can explain the transformation path of matter from the perspective of material categories and changes in elemental valence states^[3].

②Material analysis

The section is located in Chapter 2 of the first volume of the compulsory course. Before studying the content of this chapter, students have already completed the study of substances and their changes in Chapter 1. Students have established important perspectives for studying the properties and uses of inorganic substances during their secondary school years, including substance classification, ion reactions, and redox reactions. The next chapter requires students to use their already learned understanding of iron and its compounds to study complex transformations. In the arrangement of such chapters, the study of the content of the article is hoped that students can consolidate their understanding, clarify their thinking, and gradually improve their ability to study material properties from the perspectives of material classification, oxidation-reduction reactions, etc. through the study of two specific elements and their compound properties.

③Analysis of learning situation

At this stage, students have limited knowledge of chlorine and its compounds, and only chloride ions and silver ions can form white precipitates. After studying in the previous chapter, students have acquired the ability to study the properties of inorganic substances from macro, micro, redox, and other perspectives. However, their accumulation of oxides and reducing substances is limited, and their observation and analysis of changes in elemental compounds are not sharp enough, making it difficult to systematically understand and study two substances from multiple perspectives. Therefore, teachers should not only provide students with a certain amount of independent learning space, but also provide timely and targeted guidance to students' difficulties.

(2) Teaching key and difficult points

- ①Key points: properties of chlorine gas, composition and properties of water 2, conversion between chlorine and its compounds.
- ②Difficulty: Recognizing Chlorine 2 from a Microscopic Perspective.

(3) Script background

①Information

The unemployed youth "Chlorine" in the apartment mysteriously disappeared from his home, but the apartment surveillance did not capture anyone entering or leaving Mr. Chlorine's room. Please help find the missing Mr. Chlorine!

②Sir's Memoirs

During this period, the German army used chlorine gas on a large scale for the first time in the Battle of Ypres in Belgium. Faced with the pungent yellow green gas rushing towards them, the British and French defenders quickly collapsed, and some soldiers covered their mouths and noses with wet towels and fled to higher places, surviving.


[Task 1] Please write a "personal profile" for Mr. Chlorine based on his personal pictures and past records.

(4) Evidence search process**① Rotating search for evidence - medical records of chlorine gas**

Medical record book

Symptoms: Irritable and irritable outdoors

☆ Family genetic history: The chlorine element family exists in the form of chemicals in nature

☆ Structure: Cl 

Doctor's advice: Do not come into contact with the following categories of substances for too long. (The handwriting below is covered by other substances and cannot be seen clearly)

② First round of discussion

1) Analyze medical records and try to explain why chlorine exists in the form of compounds in nature?

2) Classify chlorine gas, consider which substances have similar properties to chlorine gas, and predict which categories of substances are missing from the medical record?

[Students answer the questions] The outermost layer of chlorine has 7 electrons, making it easy to obtain one electron and transform into an 8-electron stable structure. It has strong oxidizing properties and therefore exists in the form of compounds in nature. Chlorine gas and bromine gas have similar properties, and the missing substance in the medical record is a reducing substance.

③ Second round of evidence search - experimental verification and speculation

Watch the experimental video of the reaction between chlorine gas and sodium, iron, copper, and hydrogen gas, observe and record the experimental phenomena, collect evidence, and analyze it.

④ Second round of discussion

What does it mean that members of the chlorine gas family have been living peacefully in iron houses for many years?

[Students answer the questions] In a room temperature and dry environment, chlorine gas does not react with metallic iron.

⑤ Third round of evidence search - job application form for chlorine gas

Job application form

☆ Application company: Chemical dry cleaning shop

☆ Interview project: Place a damp red cloth strip into a chlorine gas bottle; Put the dry red cloth strip into a chlorine gas bottle

☆ Personal strengths: able to effectively bleach clothes

[Task 2] Please reproduce the interview project and explain why Mr. Chlorine failed the interview?

[Students answer the questions] Because chlorine gas does not bleach in dry environments.

[Task 3] Complete the experimental recording of chlorine gas and dry and wet colored paper strips, collect evidence and analyze it.

[Task 4] Based on the data card, combined with the valence state and composition of elements, predict other ions generated by the reaction between chlorine gas and water and design experimental evidence.

Material archives
• Hypochloric acid
Property 1: Bleach (please oxidize)

[Detective inquiry] Chlorine water has bleaching properties, why is it still considered that Mr. Chlorine's interview result is not qualified?

[Students answer the questions] Because chlorine gas and chlorine water are not the same substance. Chlorine gas does not have bleaching properties, and chlorine water contains hypochlorous acid that has bleaching properties.

⑥ Fourth round of evidence search - bathtub hot water

Please explain why the detective believes Mr. Chlorine disappeared in the bathtub, taking into account the condition of hot water in the bathtub and the properties of chlorine gas?

Exposure to light or heat



(5) Closing review

The teacher leads the students to summarize the physical and chemical properties of chlorine gas, starting from the properties, and combines macroscopic substances with microscopic particles to analyze the changes of chlorine gas in hot water.

Chlorine gas is a yellow green gas with a pungent odor at room temperature and pressure. It has a higher density than air and is soluble in water. Chlorine water contains hypochlorous acid, which has bleaching properties. Chlorine gas itself does not have bleaching properties. Chlorine gas has strong oxidizing properties and undergoes redox reactions with reducing substances. Under ignition conditions, it can react with metals.

(6) Incorporating 'red elements' into the script story

① The necessity of creating a "red" chemistry script

Since the 20th National Congress of the Communist Party of China, General Secretary Xi Jinping stressed that we must always attach great importance to the ideological and political education of the young generation, innovate the content, methods and organizational forms of ideological and political education, and ensure that the young generation can become qualified socialist builders and successors. Integrating chemistry classes into ideological and political education fully meets the requirements emphasized by General Secretary Xi Jinping to innovate the content and methods of ideological and political education, while also implementing the popular concept of "playing and learning while playing" into specific courses^{[5][6]}.

② Feasibility of creating a "red" chemistry script

Since ancient times, there have been countless stories of patriotism and dedication. Whether in ancient or modern times, there are countless heroes who bravely love their country and are willing to dedicate themselves. Their stories are worth telling in a new way in chemistry classes. Since

the popularity of murder mystery in the youth market, there has been an endless stream of background stories, including some "red" scripts that incorporate patriotism. Players can immerse themselves in the emotional development of their characters, gain relevant knowledge of social development background, deepen their understanding of historical facts, and enrich their understanding of the history of the Party and the development of socialism with Chinese characteristics; During the process of playing, one also examines the relationship between the character and oneself through the emotional derivation of the role. By immersing oneself in the life of the historical character, one can appreciate the unwavering ideals and beliefs of the revolutionary martyrs, thereby influencing one's worldview, outlook on life, and values, establishing correct ideals and beliefs, and playing the role of ideological and political education. When choosing the script background for instructional design, in addition to the popular "red" elements such as the War of Resistance Against Japan, the Long March of the Red Army, and other war story backgrounds, examples of modern scientists in the field of science and technology resisting various interference factors and resolutely returning to China to serve the country after learning advanced technology from abroad are also expected to be chosen by chemistry teachers.

3 CONCLUSION

Evidence reasoning "is a thinking model that high school students should master in the process of chemistry learning, and it is also an ability that the country should possess for high school students. It is necessary and feasible to incorporate educational and resonant "red" elements into the design and implementation of chemistry teaching, and to carry out educational and learning activities in the form of innovative "murder mystery" games that young students love. Integrating "murder mystery" into high school chemistry teaching not only meets the psychological and cognitive needs of high school students, but also conforms to the national requirements for students' ideological and political innovation education. Therefore, high school teachers can apply the element of "murder mystery" in teaching to improve teaching effectiveness and make high school chemistry classrooms more charming!

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