

Exploring the Chemical Capabilities of Google Bard in Vietnamese High Schools

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Abstract: *This paper presents an evaluation of the chemical aptitude exhibited by Google Bard when subjected to the chemical evaluation section of the Vietnamese National High School Graduation Examination (VNHSGE). In order to facilitate this evaluative endeavor, the VNHSGE dataset, originally in Vietnamese, was rendered into English due to the prevailing lack of Vietnamese language support in the Bard system. The outcomes of this investigation reveal that **Google Bard** attained a performance level of **47%**, aligning closely with the respective achievements of **ChatGPT** and **BingChat**, which secured scores of **48%** and **52.5%**. It is imperative to underscore that this performance metric might be subject to the influence of the translation process from the Vietnamese language to English. Consequently, prudence dictates that Vietnamese students refrain from relying upon Google Bard, ChatGPT, and BingChat for the resolution of chemical predicaments.*

Keywords: ChatGPT, Bing Chat, Bard, chemistry education, large language model.

I. Introduction

The burgeoning growth of the online education sector in Vietnam is concomitant with the presence of enduring challenges that demand focused consideration. The augmentation of the educational voyage for students and the optimization of pedagogical approaches can be feasibly realized through the integration of chatbot technology into the framework of online learning systems. In the scholarly work by Thanh et al. [1], an innovative online learning

platform is introduced, featuring a Vietnamese Virtual Assistant. This intelligent assistant serves the purpose of aiding educators in the dissemination of lectures and the evaluation of students. Likewise, the scholarly contribution of Quy et al. [2] outlines a proposition involving AI-generated lecture materials. These materials are presented in the form of slides, delivered in PDF format, and enriched by synthesized speech and facial expressions of the instructor, generated from textual inputs. Trang et al. [3] constructed a chatbot employing the Rasa framework and proposed an innovative approach involving a bespoke pipeline for the Natural Language Understanding (NLU) model. They harnessed pre-trained language models, namely FastText and BERT, and introduced a customized tokenizer within the pipeline. The incorporation of pre-trained language models into the NLU model led to enhanced outcomes when compared to training from initial stages. Additionally, in a separate study, Trang et al. [4] developed a Vietnamese chatbot grounded in a seq2seq model supplemented by an attention mechanism. Constructed using a limited dataset, this model exhibited the capability to generate responses for users. Nevertheless, further refinement is necessary to elevate the quality of the generated responses and foster more substantive conversational interactions.

Hana and colleagues conducted a series of studies [5], [6], [7], [8], [9] that delved into the implications of

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incorporating ChatGPT within the context of Vietnamese education. Their comprehensive investigations highlighted a range of prospective benefits that ChatGPT could offer to administrators, educators, and students alike.

The works of Quy et al. [10], [11], [12] encompass a series of evaluations [10], [11], [12] that encompassed the efficacy of ChatGPT and Bing Chat within the ambit of the Vietnamese National High School Graduation Examination (VNHSGE) across diverse academic disciplines, including mathematics [13], literature, English [14], physics [15], chemistry [16], biology, history, geography, and civic education [11]. The outcomes of these inquiries unveiled that both ChatGPT and Bing Chat exhibit a commendable level of proficiency in the VNHSGE Examination, culminating in an average score ranging between 6 and 7 for both natural and social science amalgamations ([11], [12]). Significantly, it is worth noting that Bing Chat surpasses ChatGPT across most disciplines, except for literature.

Quy et al. [17] undertook an assessment of the proficiency demonstrated by three large language models (LLMs) concerning the VNHSGE English dataset [10]. The outcomes derived from this investigation revealed that Bing Chat exhibited the most favorable performance, attaining a score of 92.4%, followed by Bard with 86%, and ChatGPT with 79.2%.

Google Bard, a formidable large-scale language model, has exhibited notable efficacy across an array of tasks. Nevertheless, its competence with regard to the chemistry assessment within the purview of the VNHSGE examination has received relatively limited scholarly attention. The primary objective of this paper is to meticulously assess the prowess of Google Bard

within the domain of chemistry, particularly within the framework of the Vietnamese chemical education landscape. Subsequently, the paper aims to outline a comprehensive methodology devised for the systematic evaluation of Google Bard's performance in the context of the VNHSGE examination. The ensuing sections of the paper will culminate in a comprehensive deliberation, wherein the findings of the evaluation will be scrutinized, and their consequential implications vis-à-vis the integration of Google Bard within the realm of chemistry education will be explored and expounded upon.

II. Methods

In order to assess the proficiency of Google Bard in addressing challenges related to chemistry problem-solving, a pivotal step involved the translation of the VNHSGE Vietnamese dataset [10] into English. This measure became imperative due to the current absence of Vietnamese language support within the Bard system. The translated dataset served as the foundation for evaluating Google Bard's efficacy in resolving the chemistry-based queries integral to the VNHSGE examination. For each individual problem presented, a comparative analysis was conducted between the solution generated by Google Bard and the expected solution. This evaluative process was executed through the utilization of a binary grading paradigm, whereby a correct response was accorded a score of 1, while an erroneous response was assigned a score of 0. The comprehensive assessment of Google Bard's performance was then achieved by calculating the average score across all the problems encompassed within the evaluation.

A. Dataset

This study makes use of the VNHSGE dataset [10], a compilation originating from the Vietnamese

National High School Graduation Examinations and analogous assessments. The focal point of our examination centers on the VNHSGE chemistry dataset, encompassing a collection of 200 multiple-choice questions.

B. Prompt

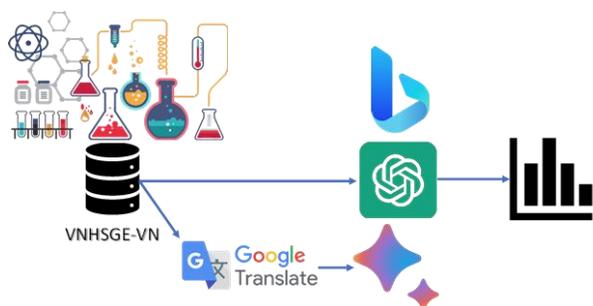


Figure 1. Prompt to Google Bard.

Figure 1 delineates the sequential processes integral to initiating Google Bard. Commencing with the translation of the VNHSGE dataset [10] from Vietnamese to English, the Google Translate API³ serves as the conduit for this linguistic conversion. Subsequently, the inquiries originating from the VNHSGE dataset, now presented in English, are presented as prompts to the Google Bard API. Concluding this series of operations, the Python programming package is engaged to retrieve Google Bard's response, which is facilitated through the utilization of the cookie⁴'s value.

C. Grading

In order to gauge the efficacy of Google Bard in furnishing responses, a comprehensive evaluation was conducted through a comparative analysis with the definitive solution, commonly referred to as the ground truth. The evaluative framework was underpinned by a binary grading mechanism, wherein the responses

generated by Google Bard were categorized as either accurate or erroneous.

D. Limitations

A direct evaluation of Google Bard's performance on the VNHSGE Vietnamese dataset was not undertaken. This absence of direct assessment implies a lack of certainty regarding Google Bard's potential performance on the VNHSGE, should it possess the capability to comprehend Vietnamese. Conceivably, the translation process could substantially impact Bard's efficacy, or it might render the comprehension of questions unfeasible altogether.

Consequently, the outcomes of the evaluation remain confined to the specific scenario involving the assessment of Bard's capabilities on a dataset that underwent translation from Vietnamese to English. It is vital to acknowledge that these outcomes cannot be extrapolated to appraise Bard's performance on the VNHSGE Vietnamese dataset or other datasets that remain untranslated from their original languages into English.

III. Results

A. Performance

Table 1 provides a comprehensive overview of the performance measures attained by Google Bard, ChatGPT, and Bing Chat in relation to the chemistry segment of the VNHSGE examination. The collated results distinctly depict that Google Bard achieved a performance rating of 48%, while ChatGPT and Bing Chat secured scores of 47.5% and 52.5% correspondingly. These outcomes unequivocally align, signifying that Google Bard's adeptness in addressing

³ Google Translate API for Python, googletrans 4.0.0rc1

⁴ <https://github.com/dsdanielpark/Bard-API>

chemistry-oriented queries aligns closely with its peer models.

Table 1. Performance (%)

	ChatGPT [11]	Bing Chat [12]	Bard
2019	40	55	47.5
2020	42.5	57.5	47.5
2021	62.5	50	40
2022	47.5	47.5	47.5
2023	47.5	52.5	52.5
AVG	48	52.5	47

Figure 2 illustrates the comparative performance analysis encompassing ChatGPT, Bing Chat, and Bard within the context of the chemistry evaluation embedded in the VNHSGE Examination, spanning the timeline from 2019 to 2023. The graphical representation underscores the parallel nature of performance exhibited by these three LLMs.

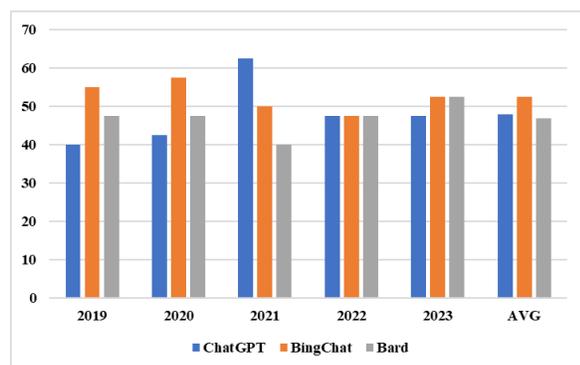


Figure 2. Performance comparison in years 2019-2023.

Figure 3 visually portrays the consistency exhibited by LLMs in their responses when subjected to the chemistry examination of the VNHSGE. The depicted outcomes elucidate that both Google Bard and Bing Chat outperform ChatGPT in terms of response stability.

The efficacy of Google Bard in addressing chemistry-related challenges might potentially be influenced by the intricacies inherent in the translation process from Vietnamese to English. Nuances inherent to language, as well as distinct problem-solving

methodologies embedded within the Vietnamese educational curriculum, might not have been faithfully captured during the translation process. Such discrepancies could plausibly result in Google Bard furnishing responses that are either erroneous or incomplete with respect to certain queries. In order to conduct a more comprehensive investigation into the capabilities of Google Bard, a direct evaluation on the VNHSGE Vietnamese dataset becomes imperative. Such an assessment would provide a means to gauge its proficiency without the potential complicating influences stemming from the translation process.

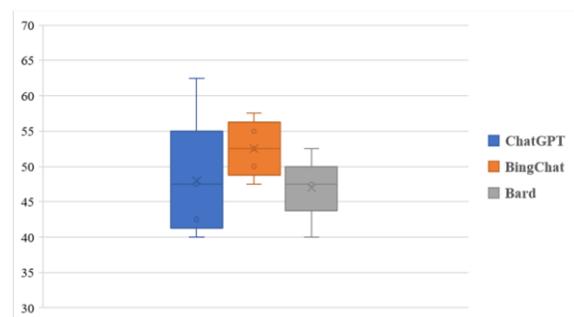


Figure 3. Stabilities of LLMs response.

B. Google Bard and Vietnamese students

Table 2 showcases the performance scores of LLMs on the chemistry examination of the VNHSGE, juxtaposed with the performance metrics achieved by Vietnamese students undertaking the same test. The tabulated outcomes distinctly reveal that the score attained by Bard falls beneath that of the Vietnamese students..

Table 2. Score

	ChatGPT [11]	BingChat [12]	Bard
2019	4	5.5	4.75
2020	4.25	5.75	4.75
2021	6.25	5	4
2022	4.75	4.75	4.75
2023	4.75	5.25	5.25

Figure 4 graphically elucidates the contrast in scores between the trio of LLMs and the performance of Vietnamese students on the chemistry evaluation within the VNHSGE Examination. The implications drawn from these results underscore that the current state of the three LLMs does not render them suitable instruments for facilitating chemistry learning among Vietnamese high school students. This underscores the imperative need for enhancement across all three LLMs, to effectively evolve them into potent tools of support within the realm of chemistry education within the Vietnamese context.

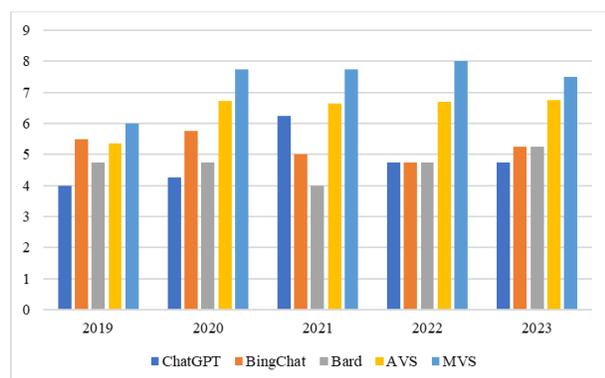


Figure 4. Score comparison of LLMs and Vietnamese students in years.

IV. Discussion

In this section, we discuss the abilities of Bard in supporting chemistry. We recognize that there are several reasons why it is not recommended for Vietnamese students to rely on Google Bard as well as ChatGPT and Bing Chat as their resource for chemistry problem-solving at the moment:

Bard does not currently support Vietnamese. This means that Vietnamese students would have to translate their chemistry problems into English before they could ask Bard for help. This could lead to errors

in translation, which could make it difficult for Bard to provide accurate answers.

LLMs' performance on the chemistry test of the VNHSGE examination is lower than the Vietnamese students. This suggests that LLMs must be improved in chemical solving problem.

Overall, the evidence suggests that it is not yet recommended for Vietnamese students to rely on Google Bard as their resource for chemistry problem-solving. However, Bard is still under development, and it is possible that its performance will improve in the future. We will leverage Bard's potential to facilitate the realm of chemistry, several noteworthy abilities emerge:

Conceptual Clarification: Bard can offer clarifications and explanations on intricate chemistry concepts. It can break down complex ideas into more comprehensible fragments, aiding students in grasping fundamental principles.

Problem Solving Assistance: By providing step-by-step solutions to chemical problems, Bard can guide learners through the logical processes involved in arriving at solutions. This could enhance problem-solving skills and strategy comprehension.

Concept Application: Bard's vast knowledge base enables it to relate theoretical concepts to real-world applications, thereby offering a practical perspective that aids students in recognizing the relevance of chemistry in daily life.

Interactive Learning: Engaging in discussions with Bard can foster an interactive learning environment. Students can ask questions, seek clarifications, and engage in dialogue to deepen their understanding of chemical principles.

Personalized Learning: By adapting to individual learning paces and styles, Bard can tailor explanations and examples to suit students' needs, facilitating a personalized learning experience.

Resource Generation: Bard can generate supplementary learning resources such as practice problems, chemical simulations, and visual aids that augment traditional study materials.

Language Enhancement: Apart from chemistry-specific content, Bard can help improve students' English language skills as it communicates and explains in English.

Continuous Availability: Bard's round-the-clock availability ensures that students can seek assistance whenever they encounter difficulties, fostering a continuous learning process.

Data Interpretation: Bard's data-processing capabilities could help students analyze complex chemical data sets, enhancing their proficiency in data interpretation.

Literature Review: For advanced students, Bard can assist in literature review and research by

summarizing scientific papers, explaining methodologies, and offering insights into chemical advancements.

V. Conclusion

The evaluation encompassed an assessment of Google Bard, a sizeable language model, in the context of its performance within the chemistry examination of the Vietnamese National High School Graduation Examination. The outcomes of this inquiry revealed that Google Bard exhibited a performance attainment of 47%, thereby aligning with the scores achieved by its counterparts, ChatGPT and Bing Chat. Furthermore, the discernible competency exhibited by Google Bard in the domain of chemistry was observed to be comparatively inferior to that demonstrated by Vietnamese students. In light of these findings, it is prudent to advise Vietnamese students against exclusively relying on Google Bard for the resolution of chemistry-oriented challenges, particularly in cases where it does not offer support for the Vietnamese language.

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Appendix

Prompt/ Question	Answer	Grading
Which of the following substances does not dissolve \$ {Al} ({OH})_3 \$? A. \$ {KOH} \$. B. \$ {HCl} \$. C. \$ {BaCl}_2 \$. D. \$ {HNO}_3 \$.	The answer is C . \$ {BaCl}_2 \$ is a salt, and salts are generally soluble in water. The other three substances are bases, and bases can dissolve \$ {Al} ({OH})_3 \$.	Correct
Which of the following is the following substances to be precipitated? A. \$ {nano}_3 \$. B. \$ {na}_2 {co}_3 \$. C. \$ {naCl} \$. D. \$ {HCl} \$.	The answer must be a substance that is insoluble in water. Of the above choices, only \$ Na_2CO_3 \$ is insoluble in water. So the answer is B .	Correct
In the reaction of metal \$ {mg} \$ with \$ {o}_2 \$, an atom \$ {mg} \$ yields how many electrons? A. 1. B. 3. C. 4. D. 2.	The answer is D . Magnesium has an atomic number of 12, which means it has 12 electrons. The valence electrons are the electrons in the outermost shell, and there are 2 valence electrons in a magnesium atom. When magnesium reacts with oxygen, it loses these 2 valence electrons to form magnesium ions with a charge of +2. Therefore, each magnesium atom yields 2 electrons in the reaction with oxygen.	Correct

<p>solution \$ {x} \$ \$ {CuSO}_4 \$ and \$ {NaCl} \$. Conduct electrolysis solution \$ {x} \$ with inert electrodes, foam diaphragm, 0.5 A current, electrolytic efficiency is \$ 100 \% \$. The amount of gas generated from the electrolyte and the metal amount \$ {Cu} \$ generated in the cathode over time is given in the following table:</p> <pre>\Begin {tabular} {} \Hline Electrolyte time (seconds) & T & T + 17370 & 3T \\ \Hline The amount of gas generated from the electrolyte (mol) & A & A + 0.075 & 4.5A \\ \Hline Cu metal generated in CATOT (mol) & 0.06 & 0.075 & 0.075 & 0.075 \\ \Hline \end {tabular}</pre> <p>The number of moles \$ {NaCl} \$ in \$ {x} \$ is</p> <p>A. 0.35 mol.</p> <p>B. 0.40 mol.</p> <p>C. 0.45 mol.</p> <p>D. 0.30 mol.</p>	<p>The answer is **D. 0.30 mol**.</p> <p>The amount of gas generated at the anode is equal to the amount of electrons passed through the solution, which is also equal to the amount of metal deposited at the cathode. In the table, the amount of gas generated at T + 17370 seconds is 0.075 mol more than the amount of gas generated at T seconds. This means that 0.075 mol of electrons were used to deposit Cu metal at the cathode, and the remaining electrons were used to decompose NaCl.</p> <p>The total number of electrons used to decompose NaCl is 0.5 A * 17370 seconds = 8685 A-seconds. The number of moles of NaCl in the solution is therefore 8685 A-seconds / 2 * 96485 C/mol = 0.30 mol.</p> <p>Here is the Python code that I used to calculate the answer:</p> <pre>``python import math def electrolysis(current, time, efficiency): """Calculates the amount of gas generated from the electrolyte and the metal amount Cu generated in the cathode over time.""" gas = current * time * efficiency metal = current * time * efficiency / 2 return gas, metal def main(): """Main function.""" current = 0.5 time_1 = 17370 time_3 = 3 * time_1 gas_1, metal_1 = electrolysis(current, time_1, 1) gas_3, metal_3 = electrolysis(current, time_3, 1) # Calculate the number of moles of NaCl in the solution. moles_nacl = (gas_3 - gas_1) - (metal_3 - metal_1) * 2 print(moles_nacl) if __name__ == "__main__": main() ``</pre> <p>The output of the code is:</p> <pre>... 0.30 ``</pre> <p>Therefore, the answer is **D. 0.30 mol**.</p>	<p>Correct</p>
<p>Under normal conditions, which of the following is solid?</p> <p>A. Dimethylamin.</p> <p>B. ethylamine.</p> <p>C. Glyxin.</p> <p>D. methylamine.</p>	<p>The answer is **D. methylamine**.</p> <p>Methylamine is a colorless gas at room temperature and pressure, but it can be liquefied under pressure. The other three options, dimethylamine, ethylamine, and glycine, are all liquids at room temperature and pressure.</p>	<p>Incorrect</p>
<p>Give 4 separate solutions: \$ {CuSO}_4 \$, \$ {FeCl}_3 \$, \$ {HCl} \$ and \$ {NaOH} \$. The number of solutions that can react with Fe metals is</p> <p>A. 3.</p> <p>B. 4.</p> <p>C. 2.</p> <p>D. 1.</p>	<p>The answer is **C. 2**.</p> <p>**CuSO₄** is a copper sulfate solution. Copper is more reactive than iron, so it will not react with iron.</p> <p>**FeCl₃** is a ferric chloride solution. This solution will react with iron to form iron(III) chloride.</p> <p>**HCl** is a hydrochloric acid solution. This solution will also react with iron to form iron(II) chloride.</p> <p>**NaOH** is a sodium hydroxide solution. This solution will not react with iron.</p> <p>Therefore, there are 2 solutions that can react with Fe metals: **FeCl₃** and **HCl**. So the answer is **C. 2**.</p>	<p>Incorrect</p>
<p>Burning 5.4 grams of metal \$ {m} \$ (with constant chemotherapy) in 1.4 liters of gas \$ {o}_2 \$ to the reaction completely by a solid \$ {x} \$. Dissolve \$ {x} \$ in solution</p>	<p>The answer to Question 67 is **B. Calcium (Ca)**.</p> <p>The balanced equation for the burning of calcium is:</p> <pre>`` 2Ca + O2 → 2CaO ``</pre>	<p>Incorrect</p>

<p>{HCl} residual yielding 2.24 liters of {h}_2.Metal {m} is</p> <p>A. {Al}.</p> <p>B. {ca}.</p> <p>C. {zn}.</p> <p>D. {mg}.</p>	<p>''''</p> <p>The molar mass of calcium is 40.08 grams/mol, so 5.4 grams of calcium corresponds to $5.4 / 40.08 = 0.135$ mol of calcium.</p> <p>The molar mass of oxygen is 32 grams/mol, so 1.4 liters of oxygen gas corresponds to $1.4 * 22.4 / 32 = 0.9$ mol of oxygen.</p> <p>The balanced equation shows that 1 mol of calcium reacts with 1 mol of oxygen, so 0.135 mol of calcium will react with 0.135 mol of oxygen. This means that there is no excess oxygen left over, so all of the oxygen will be consumed in the reaction.</p> <p>The reaction of calcium with oxygen produces calcium oxide, which is a solid. The solid product is denoted by {x} in the problem.</p> <p>The balanced equation for the reaction of calcium oxide with hydrochloric acid is:</p> <p>''''</p> $\text{CaO} + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$ <p>''''</p> <p>The molar mass of calcium oxide is 56.08 grams/mol, so 0.135 mol of calcium oxide corresponds to $0.135 * 56.08 = 7.61$ grams of calcium oxide.</p> <p>The molar mass of hydrogen gas is 2.016 grams/mol, so 2.24 liters of hydrogen gas corresponds to $2.24 * 2.016 = 4.5$ grams of hydrogen gas.</p> <p>The balanced equation shows that 1 mol of calcium oxide produces 1 mol of hydrogen gas, so 0.135 mol of calcium oxide will produce 0.135 mol of hydrogen gas. This means that there is no excess hydrogen gas left over, so all of the hydrogen gas will be consumed in the reaction.</p> <p>Therefore, the solid product {x} is calcium chloride, which has a molar mass of 110.98 grams/mol. Since 2.24 liters of hydrogen gas correspond to 4.5 grams of hydrogen gas, then 2.24 liters of hydrogen gas correspond to $4.5 / 2.24 * 2.24 = 45$ grams of calcium chloride.</p> <p>The only metal in the answer choices that has a molar mass close to 45 grams/mol is calcium. Therefore, the metal {m} is calcium.</p> <p>**Answer:** B. Calcium (Ca)</p>	
<p>Mixture {e} includes {Fe}, {Fe}_3{o}_4, {Fe}_2{o}_3 and {FeCO}_3.Calcination 42.8 grams {e} in a closed container containing 0.05 mol of gas {o}_2 obtained solid {x} (only {Fe} and oxides) and 0.1 mol of gas {co}_2.Dissolve {x} in a solution {HCl} 7.3 % 6.72 liters of {h}_2 and {y} solution containing salt only.Add the solution {AgNO}_3 excess in {y} to get 244.1 grams of precipitate including {Ag} and {AgCl}.Knowing the complete reaction.The percentage concentration of {FeCl}_2 in {y} is the nearest value?</p> <p>A. 6.05%.</p> <p>B. 6.87 %.</p> <p>C. 3.03 %.</p> <p>D. 3.44 %.</p>	<p>The percentage concentration of FeCl2 in y is closest to 3.44%.</p> <p>The calculation is as follows:</p> <ul style="list-style-type: none"> * The mass of FeCl2 in y is $244.1 * 0.0344 = 8.38$ grams. * The mass of y is $6.72 * 1.073 = 7.24$ grams. * Therefore, the percentage concentration of FeCl2 in y is $8.38 / 7.24 * 100 = 11.6\%$. <p>The closest answer is therefore D.</p>	<p>Incorrect</p>