



Using Generative Artificial Intelligence (Gen AI) as a Study/Support Tool in Chemistry Lab Courses

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Overview

- Generative AI (Gen AI) is a system that can create content. This content can take the form of text, images, audio, video, and code.
- Some equate Gen AI innovation [and its controversy] to the invention of the calculator or the internet.
- Students are curious about Gen AI so I took the opportunity to integrate Chat GPT assignments into two of my chemistry laboratory courses.

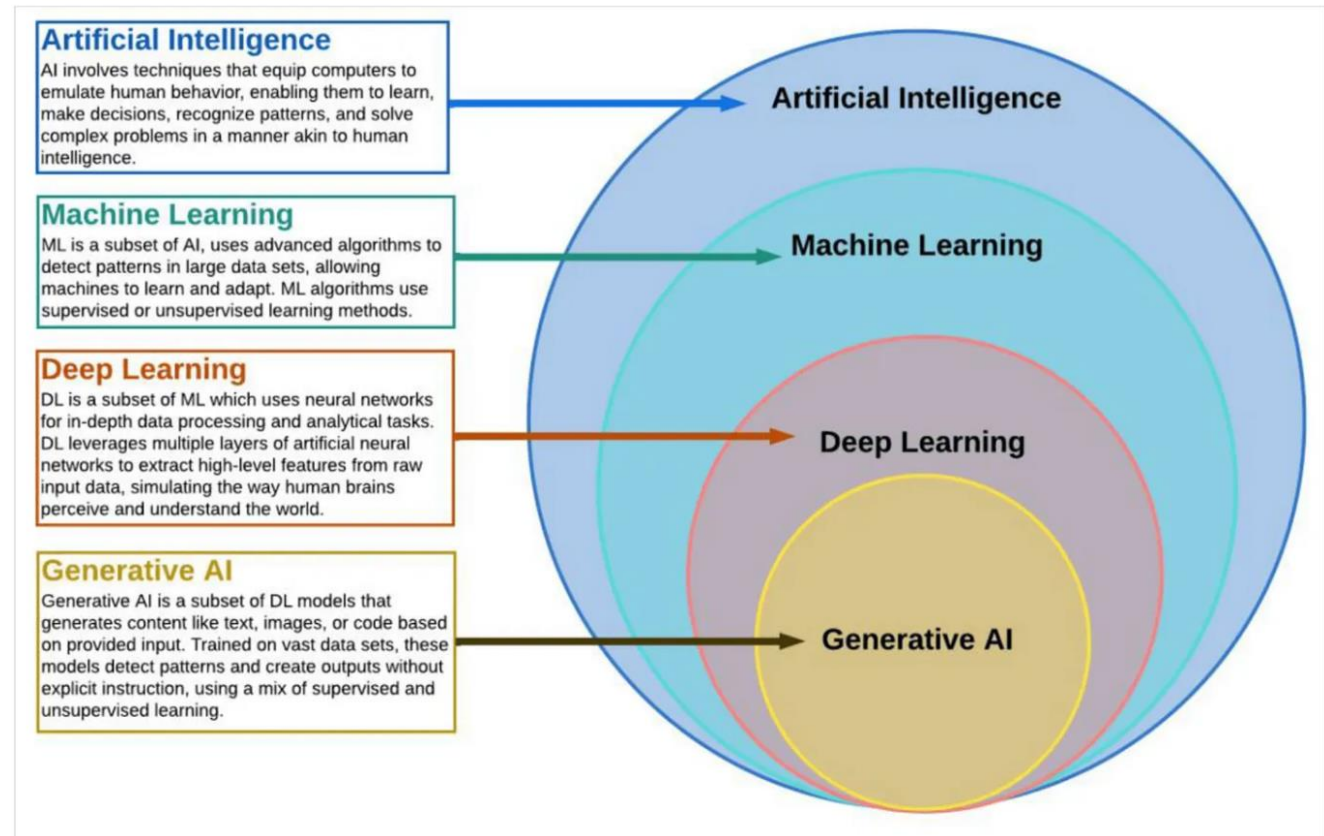


Figure 1. Diagram putting into perspective where Gen AI falls within the realm of artificial intelligence.¹

Chat GPT Assist – Course Concepts

- One concept in Chem 261 chemistry lab is called net ionic equations (NIEs). NIE chemical reactions showcase the chemical species that participate in reactions and eliminate chemical species that don't.
- Students can use Chat GPT in multiple ways to strengthen their understanding of NIEs.
- Students who may find it difficult to follow the Faculty teaching style, can ask Chat GPT to explain concepts, generate practice problems, and assist in confirmation a solution.

Example prompts:

- 1) *I am a college student learning the concept net ionic equations. Please explain the steps in this process [with an example].*
- 2) *I am a college student and need practice doing net ionic equations. Can you provide three example chemical reactions for me to practice with?*
- 3) *I have a chemical reaction [put reaction here] and need to confirm my net ionic equation for it. What is the net ionic equation for this reaction?*

Chat GPT Assist – Course Concepts Results on NIEs

I am a college student learning the concept net ionic equations. Please explain the steps in the process with an example.



Memory updated

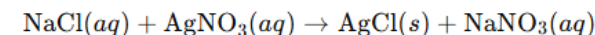
Net ionic equations focus on the species that undergo a chemical change in a reaction. Here's a step-by-step guide to writing net ionic equations with an example:

Steps to Write a Net Ionic Equation

- 1. Write the Balanced Molecular Equation:** Start by writing the balanced chemical equation for the reaction, showing all reactants and products in their molecular form.
- 2. Identify the Strong Electrolytes:** Determine which compounds in the reaction are strong electrolytes (usually soluble salts, strong acids, and strong bases). These will dissociate into ions in solution.
- 3. Write the Complete Ionic Equation:** Break down all strong electrolytes into their constituent ions. Keep weak electrolytes, insoluble salts, and gases in their molecular form.
- 4. Cancel the Spectator Ions:** Spectator ions appear unchanged on both sides of the equation. Cancel these ions to focus only on the species that undergo a chemical change.
- 5. Write the Net Ionic Equation:** The remaining species after canceling spectator ions form the net ionic equation, showing only the ions and molecules directly involved in the reaction.

Example: Reaction Between Sodium Chloride and Silver Nitrate

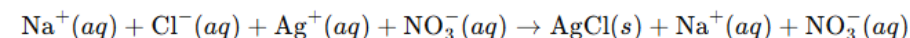
1. Write the Balanced Molecular Equation:



2. Identify the Strong Electrolytes:

- NaCl, AgNO₃, and NaNO₃ are strong electrolytes (soluble in water).
- AgCl is insoluble and precipitates as a solid.

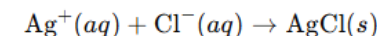
3. Write the Complete Ionic Equation:



4. Cancel the Spectator Ions:

- Na⁺ and NO₃⁻ are spectator ions, appearing unchanged on both sides of the equation.

5. Write the Net Ionic Equation:



This net ionic equation shows that silver ions (Ag⁺) react with chloride ions (Cl⁻) to form solid silver chloride (AgCl).

Would you like to see another example or further clarification on any of the steps?

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Message ChatGPT

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Chat GPT Assist – Course Concepts Results on NIEs

Question 1

Which of the following is the correct net ionic equation for the reaction between hydrochloric acid (HCl) and sodium hydroxide (NaOH)?

- A) $\text{HCl}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l)$
- B) $\text{H}^+(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O}(l)$
- C) $\text{Na}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{NaCl}(aq)$
- D) $\text{H}^+(aq) + \text{Cl}^-(aq) + \text{Na}^+(aq) + \text{OH}^-(aq) \rightarrow \text{Na}^+(aq) + \text{Cl}^-(aq) + \text{H}_2\text{O}(l)$

Question 2

What are spectator ions in the reaction between potassium chloride (KCl) and silver nitrate (AgNO_3)?

- A) K^+ and Ag^+
- B) NO_3^- and Cl^-
- C) K^+ and NO_3^-
- D) Ag^+ and Cl^-

Question 3

Which of the following compounds will remain in molecular form in a complete ionic equation?

- A) $\text{NaCl}(aq)$
- B) $\text{HCl}(aq)$
- C) $\text{AgCl}(s)$
- D) $\text{KNO}_3(aq)$

Would you like to see the correct answers or need further explanations on any of these questions?

Can you provide a diagram for me for nies?

I can create a diagram to help illustrate the concept of net ionic equations (NIEs). It will visually represent the steps involved, including the molecular equation, the complete ionic equation, and the net ionic equation. Let me generate that for you.

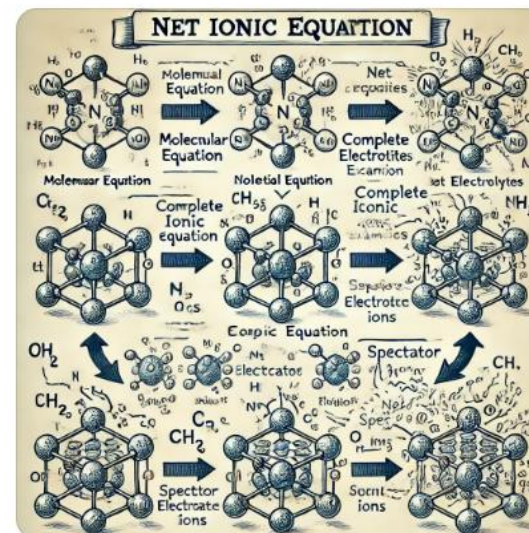


Figure 2. Gen AI is not perfect, here is a hallucination when I asked for a NIE diagram. In a year I'll try this prompt again and am sure the image will be better [old Chat GPT versions did not generate images].



Chat GPT as a Peer Reviewer

- Students in STEM are required to write formal lab reports, akin to a journal article, on specific lab experiments.
- Introduction and background information, experimental procedures, interpreting results, drawing conclusion are all a part of this report.
- Although resources like the Tutoring Center exist, there are students that want a *fast* way to get feedback on their work.
- Chat GPT can analyze the students' text and provide feedback.

Example prompts:

- 1) *I am a college student studying chemistry and need my lab report proofread for correctness of concepts and spelling.*
- 2) *Please review my college level chemistry lab report and offer advice on the background information content, spelling & grammar, chemical reactions, and wording. [students then paste their report text into the prompt box].*
- 3) *Please review the chemistry lab report and offer advice on format, content, wording, and length.*

Chat GPT as a Peer Reviewer - Result

- Note: Chat GPT can deliver one of two things: 1) a list of suggested corrections/revisions (shown) or 2) an entirely revised text of the formal report the student input text (not shown). Shown here are example feedback for introduction section and conclusion section of a formal lab report about paper chromatography.

1. Introduction:

The explanation of Rf could be clearer. Instead of "The Rf Value is composed of the distance the solvent has traveled along with the distance the compound has traveled," try: "The Rf value is the ratio of the distance a compound travels relative to the distance the solvent front travels."

Avoid repeating similar ideas about comparing compounds. Condense it to something like: "Paper chromatography is useful for analyzing compounds based on their polarity and molecular mass."

5. Conclusion:

Rephrase "you could visibly see this in the paper chromatography" to something more formal, like "The separation of the dyes was visually observable in the chromatography."

6. General formatting:

Make sure all tables and figures are titled and referred to properly in the text.

Use consistent terminology (e.g., use "Rf value" throughout).

With these tweaks, your report will be clearer and more polished.

Chat GPT Assist – Review Text to Find Information

- There is a lab experiment students complete that involves deductive reasoning. A narrative of a Sherlock Holmes scenario is presented to students and the chemistry work they complete mirrors this narrative.
- I was curious if Chat GPT could identify the poison that Sherlock Holmes story is based on [and students are trying to determine from their lab work.
- Students asked Chat GPT to analyze the lab's Sherlock Holmes narrative and ID the poison.
*Students used Chat GPT *after* they completed the experiment and made their own conclusion on what the poison is.

Example prompt:

1) Analyze the Sherlock Holmes narrative and determine what the poison is. [students then paste the narrative in the prompt box].

Chat GPT Assist – Review Text to Find Information Result

The Sherlock Holmes Narrative

“Help us, Mr. Holmes,” he said quietly. “My stepfather is screaming.”

“As I said, sir, he’s screaming at everyone and everything around him. Something is very wrong, or he perhaps might be ill.”

“Did you notice any possible symptoms of a medical problem beside this unusual rage?” I interjected.

“Well yes, Doctor. He appears to have acquired a stomach problem since I have noticed him clutching his middle, and once I found him doubled up in a chair in agony!” “Excellent!” cheered Holmes. “Can you tell me about his eating habits?”

“Some, Mr. Holmes,” Robin replied. “My mother and grandmother cook for him. Oh, he likes a variety of things: cobblers, fowls of any sort, mincemeat, and quite recently, gooseberries. None of the rest of us like them.”

[The victim’s residence: a flat on Charles Street where Robin lives with his mother, grandmother, and stepfather

-- Mr. Wooley. After a brief consultation with family members, Holmes leaves the flat carrying a fresh dish of bright gooseberries. Watson stays with the family overnight and Holmes returns in the morning. As Holmes and Watson leave the flat, Holmes reveals to Watson what he has discovered.]

“I had my suspicions, Watson, and in confirmation, I took some of the gooseberry juice, diluted it with water to mask the green color, and added **ammonia** solution to it. A **deep blue color** resulted. Mark that, Watson, it is critical. Moreover, **upon acidification** the dark blue solution became **nearly colorless again**. Treatment then with

potassium ferrocyanide gave a distinct **red precipitate**.”

At this point in our walk, Holmes grabbed my arm and pulled me into a small, but busy grocery market. We proceeded to the back of the store and quickly found a large display of jars of frighteningly green gooseberries for sale to the public.

Holmes grabbed the closest jar and forced it open. He inserted his steel spoon and began to crush and stir the contents of the jar with his **steel spoon**. To my amazement when the steel spoon was removed from the jar, it had been transformed, as if by the magic of alchemy, to a **shiny bronze** like metal.

Holmes smiled and turned to me. “Our poisoning is solved, Watson.”

The Chat GPT results about the poison ID.

In this narrative, Holmes uses chemical tests and observations to identify the poison. Here’s how the clues point to the poison:

1. Chemical Tests:

- **Gooseberry Juice Test:** Holmes added ammonia to the gooseberry juice, resulting in a deep blue color, which indicates the presence of copper. The solution turning nearly colorless upon acidification and forming a red precipitate with potassium ferrocyanide further confirms this.
- **Steel Spoon Reaction:** When Holmes stirred the gooseberries with a steel spoon, the spoon was transformed to a shiny bronze-like metal, which suggests the formation of a copper coating on the spoon.

2. Symptoms:

- The stepfather shows symptoms of severe stomach pain and unusual rage, which can be associated with heavy metal poisoning, particularly copper.

3. Conclusion:

- The combination of the chemical tests and the symptoms leads Holmes to conclude that the gooseberries are contaminated with **copper salts**, likely **copper sulfate** or another copper compound. The reaction with the steel spoon suggests that copper ions in the gooseberries were deposited on the spoon, forming a layer of metallic copper.

The poison is **copper contamination**, probably introduced through the preparation or storage of the gooseberries, leading to copper poisoning in the stepfather.

Summary

- Generative AI, in particular Chat GPT, has been used as a study tool and support system for students in Chem 261 and 272 lab courses. Students can not only write a prompt and get feedback, interact and ask for additional output styles of their query [if they ask for a concept review, they can add another prompt asking for practice problems with/without solutions for example].
- Students use Chat GPT to re-phrase and re-explain course concepts, generate practice problems, analyze text, and peer review formal lab reports.
- Something beyond the scope of this lightning round but important, Faculty must present information to students on how to use the Gen AI tool(s), pros & cons of the tool(s), and guidance for in text prompt generation *before* assigning students Gen AI assignments. Input = output.



References and Thank You!

References

¹Singh, P. *Generative AI: Unveiling a New Era of Artificial Creativity*. <https://pushpendrasingh28.medium.com/generative-ai-unveiling-a-new-era-of-artificial-creativity-df6b36cb33f0> (accessed August 24, 2024)

²Chat GPT <https://chatgpt.com> (accessed December 1, 2024)

THANK YOU!

If you would like to earn certification in Teaching with Gen AI for professional development, check out:

[Institute at Macmillan Learning – Teaching and Generative AI Course](#)

[EdX](#)