Lesson Plan: Beer-Lambert Law and Earth's Atmosphere

A teacher-contributed lesson plan by Dr. Pragya Gahlot and Dr. Rekha Yadav, Sri Venkateswara College (University of Delhi), India.

As an **undergraduate Chemistry** teacher, you can use this set of computer-based tools to teach the **Beer-Lambert Law** and its **application in atmospheric radiation absorption** studies.

This lesson plan will enable students to learn about the Beer-Lambert Law and understand its application for studying the molar absorptivity of greenhouse gases.

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in **Chemistry**.

Use this lesson plan to help your students find answers to:

- What is the Beer-Lambert Law? How is it expressed in an equation?
- Define the molar absorptivity of a chemical medium.
- How is the intensity of transmitted light affected by the molar absorptivity of the medium?
- How does the path length affect the absorbance of transmitted light?
- How would increasing concentrations of atmospheric greenhouse gases affect the absorbance of sunlight?

About the Lesson Plan

Grade Level: Undergraduate

Discipline: Chemistry

Topic(s) in Discipline: Beer-Lambert Law, Molar Absorptivity, Absorbance of Incident Light, Transmittance of Incident Light, Intensity of Transmitted Light, Greenhouse Gases, Molar Absorption Coefficient, Molar Extinction Coefficient

Climate Topic: Climate and the Atmosphere, The Greenhouse Gas Effect

Location: Global

Access: Online

Language(s): English

Approximate Time Required: 55-60 min

1 Contents

1. **Reading (~30 min)**

A reading that introduces the Beer-Lambert Law and derives the expression for the law. It also includes several examples to show the application of the Beer-Lambert Law for absorbance of transmitted light in medium, under different conditions.

This can be accessed at:

https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Electronic_Spectroscopy/Electronic_Spectroscopy_Basics/The_Beer-Lambert_Law

2. Reading (~10 min)

A reading that uses the Beer-Lambert Law to explain the increasing global warming potential of Earth's atmosphere due to the higher concentrations of greenhouse gases, in recent times.

This can be accessed at:

https://www.chemedx.org/blog/chemical-connections-climate-change

3. Visualisation (~15 min)

A simulation to explore the effects of the change in concentration of medium and path length on the absorbance of transmitted light.

This can be accessed at:

https://phet.colorado.edu/en/simulation/legacy/beers-law-lab

4. Suggested questions/assignments for learning evaluation

- What is the Beer-Lambert Law? How is it expressed in an equation?
- Define the molar absorptivity of a chemical medium.
- How is the intensity of transmitted light affected by the molar absorptivity of the medium?
- How does the path length affect the absorbance of transmitted light?
- How would increasing concentrations of atmospheric greenhouse gases affect the absorbance of sunlight?

2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Topic introduction and discussion

Use chapter reading, 'The Beer-Lambert Law' by LibreTexts™, to introduce the topic of light transmittance through a medium and Beer-Lambert's Law. Explain how light transmitted through a medium is affected by its concentration. Also, discuss the importance of the path length for light transmittance through a medium. Use the reading to derive an expression for the Beer-Lambert's Law. Emphasize on the non-linear (exponential) relation between transmittance and concentration of medium. Thus, define its molar absorptivity or molar absorption coefficient or molar extinction coefficient (ε). Use the examples given in the text, to teach students to use the Beer-Lambert's Law to calculate values for the concentration, pathlength, and molar absorptivity of a given medium.

This can be accessed at:

https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Electronic_Spectroscopy/Electronic_Spectroscopy_Basics/The_Beer-Lambert_Law

2. Extend the understanding

Use the reading, 'Chemical Connections to Climate Change' by Tom Kuntzleman, Chemical Education Xchange (ChemEd X), to teach students how the Beer-Lambert Law can be used to study the transmittance of sunlight through the atmosphere. Discuss the composition of the atmosphere and list out the gases that make up the atmosphere. Extend the understanding of the Beer-Lambert Law to evaluate the absorbance values of individual gases in the atmosphere. Use the text to initiate a discussion about the absorption potential of greenhouse gases such as carbon dioxide and methane. Discuss how this results in warming on Earth due to the greenhouse effect. Finally, use the reading to explain how this greenhouse gas effect is exacerbated by increasing concentrations of greenhouse gases in the atmosphere.

This can be accessed at:

https://www.chemedx.org/blog/chemical-connections-climate-change

3. Explore the topic further

Use the simulation, 'Beer's Law Lab' by PhET Interactive Simulations, University of Colorado, to allow students to explore the Beer-Lambert's Law for absorbance/transmittance of incident light through a solution. Encourage the students to note the absorbance/transmittance values of incident light when the simulation is run. Direct the students to run the simulation for different solution concentrations, pathlengths and wavelengths of incident light. Use the data generated to observe the correlations between these varying parameters (concentration of solution, pathlength and wavelength of incident light) and absorbance/transmittance values. Initiate an enquiry-based discussion for further understanding of these correlations eg how much does the absorbance value change when the concentration of a solution is doubled.

This can be accessed at:

https://phet.colorado.edu/en/simulation/legacy/beers-law-lab

4. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

- What is the Beer-Lambert Law? How is it expressed in an equation?
- Define the molar absorptivity of a chemical medium.
- How is the intensity of transmitted light affected by the molar absorptivity of the medium?
- How does the path length affect the absorbance of transmitted light?
- How would increasing concentrations of atmospheric greenhouse gases affect the absorbance of sunlight?

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- derive the expression for Beer-Lambert Law
- define molar absorptivity/molar absorption coefficient/molar extinction coefficient of a medium
- calculate the effect of concentration of a chemical species and path length on the intensity of transmitted light
- understand the effect of increasing concentrations of atmospheric greenhouse gases on absorbance of incident sunlight

4 Additional Resources

If you or your students would like to explore the topic further, this additional resource will be useful.

1. Video micro-lecture

A video micro-lecture, 'Spectrophotometry introduction', by Sal Khan, Khan Academy, that gives an introduction of spectrophotometry, transmittance, absorbance, and the Beer-Lambert Law for light incident on a medium.

This can be accessed at:

https://www.khanacademy.org/science/chemistry/chem-kinetics/spectrophotometry-tutorial/v/spectrophotometry-introduction

5 Credits/Copyrights

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ownership details for each tool by following the individual links provided.
We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. **Reading; "The Beer-Lambert Law"**

By LibreTexts™

2. **Reading; "Chemical Connections to Climate Change"**

Blog by Tom Kuntzleman, Chemical Education Xchange (ChemEd X)

3. **Simulation; "Beer's Law Lab"**

Created by PhET Interactive Simulations, University of Colorado

4. **Additional Resources**

Video micro-lecture, "Spectrophotometry introduction" by Sal Khan, Khan Academy