



## Science Objectives

- Students will make a serial dilution of a  $\text{NiSO}_4$  standard solution.
- Students will use a Colorimeter to measure the absorbance value of each standard solution.
- Students will find the relationship between absorbance and concentration of a solution.
- Students will use the results of this experiment to determine the unknown concentration of another  $\text{NiSO}_4$  solution.

## Vocabulary

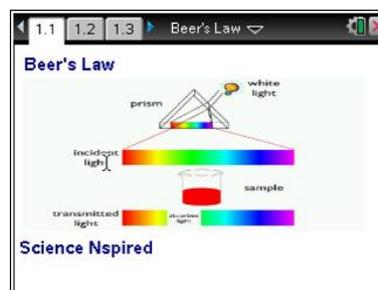
- absorbance
- Colorimeter
- correlation coefficient
- slope
- transmittance
- y-intercept

## About the Lesson

- This lesson involves absorbance data for solutions of various concentrations.
- As a result, students will:
  - Prepare five (5)  $\text{NiSO}_4$  standard solutions.
  - Use a Colorimeter to measure the absorbance value of each standard solution.
  - Find the relationship between absorbance and concentration of a solution.
  - Use the results of this experiment to determine the unknown concentration of another  $\text{NiSO}_4$  solution.

## TI-Nspire™ Navigator™ System

- Send *Beers\_Law.tns* file to students.
- Use Screen Capture to monitor student progress.
- Collect and grade *Beers\_Law.tns* file.



## TI-Nspire™ Technology Skills:

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Use DataQuest App

## Tech Tip:

Access free tutorials at

<http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>

## Lesson Files:

*Student Activity*

- Beers\_Law\_Student.pdf
- Beers\_Law\_Student.doc

*TI-Nspire document*

- Beers\_Law.tns



### **Activity Materials**

- TI-Nspire™ Technology
- TI Lab Cradle or EasyLink
- Vernier® Colorimeter
- Two burettes
- Double burette clamp
- Ring stand
- Wash bottle & distilled water
- One cuvette
- Test tube rack & five (5) 20X150 mm test tubes
- Stirring rod
- KimWipes or tissues (preferably lint-free)
- 5 mL of “NiSO<sub>4</sub>” unknown solution (for example-55 mL of “stock” solution and 45 mL of water-0.22 M)
- 8-9 drops of green food coloring per liter of water to mimic 0.40 M NiSO<sub>4</sub>. (Nickel is a carcinogen, so the green food coloring is an excellent substitute.) Check the absorbance of this stock solution to be certain it falls in the range of 0.40 to 0.80.

### **Activity Overview**

- Please print the student worksheet and make available to students before beginning the lab. Lab background information as well as lab procedures are included only in the student worksheet. Always remember to review any safety precautions thoroughly with your students prior to starting the lab.
- Students may answer the questions posed in the .tns file and submit for grading with TI-Nspire Navigator (optional) or students may answer directly on the student worksheet
- Ensure that students collect data on the 5 known substances and look at the graph before they actually measure the absorbance of the unknown solution. This will allow them to make predictions and to look at the graph of the data first.



## Discussion Points and Possible Answers

### TI-Nspire Navigator Opportunity

Use the TI-Nspire™ Navigator™ System to monitor student progress using screen capture.

#### Pre-lab Information and Questions.

Have students answer the pre-lab questions directly on their student worksheets or on Pages 1.4 – 1.10 prior to starting the lab procedure. Students will need to have read the background information presented in the Student Worksheet.

1. The wavelength of light used by the colorimeter should be \_\_\_\_\_ by the colored solution.

**Answer:** absorbed

2. The  $\text{NiSO}_4$  solution used in the experiment has a deep \_\_\_\_\_ color.

**Answer:** green

3. For this experiment, the LED of the colorimeter needs to be set to \_\_\_\_\_.

**Answer :** red

4. A higher concentration of solution absorbs \_\_\_\_\_ light.

**Answer:** more

5. The relationship between absorbance and concentration is \_\_\_\_\_.

**Answer:** direct

6. The linear relationship between absorbance and concentration is called \_\_\_\_\_ Law.

**Answer:** Beer's

7. The concentration of the unknown can be determined by using the \_\_\_\_\_ of the regression line on the graph.

**Answer:** slope



### Lab Set-Up and Procedures

Please note that detailed lab procedures are outlined in the Student Worksheet, and key steps are included here for convenience.

#### Move to page 2.2.

After students have read through the lab set up and procedures on the handout, they can see a picture of the equipment set up on Page 2.2. Calibrating the colorimeter is a critical step in obtaining accurate data during the experiment.



### Analyze the Data

Students will perform calculations to determine the concentration of the unknown  $\text{NiSO}_4$  solution by interpolating along the regression line to convert the absorbance value of the unknown to concentration.

### Data Table (Sample Data)

| Trial                    | Concentration (mol/L)      | Absorbance         |
|--------------------------|----------------------------|--------------------|
| 1                        | <b>0.080</b>               | <b>0.089</b>       |
| 2                        | <b>0.16</b>                | <b>0.186</b>       |
| 3                        | <b>0.24</b>                | <b>0.281</b>       |
| 4                        | <b>0.32</b>                | <b>0.374</b>       |
| 5                        | <b>0.40</b>                | <b>0.463</b>       |
| 6                        | <b>Unknown number ____</b> | <b>0.308</b>       |
| Concentration of unknown |                            | <b>0.265 mol/L</b> |

**Tech Tip:** If students have not done an Interpolation before, you may encourage them to watch the TechTip video available with this activity. It will walk them step by step through this process.

### Post-lab Assessment

Have students respond to the questions (below) directly on their student worksheets (or on Pages 3.1 through 3.4) once they have completed the lab.



8. As the concentration of the nickel(II) sulfate solution increased, the absorbance \_\_\_\_\_.

**Answer:** increased

9. The closer the value of \_\_\_\_\_ was to zero, the better your data.

**Answer:** b

10. The closer the value of  $r$  is to \_\_\_\_\_, the better your data.

**Answer:** 1

11. To find the concentration of the unknown, you need to \_\_\_\_\_ your graph.

**Answer:** interpolate

**TI-Nspire Navigator Opportunity**

Use the TI-Nspire™ Navigator™ System to collect, grade, and save the .tns file to the Portfolio. Use Slide Show to view student responses.

---

**Wrap Up**

Upon completion of the lab and discussion, the teacher should ensure that students are able to understand:

- The importance of accurately preparing solutions for the lab.
- How to gather and analyze data.
- The relationship between the absorbance and concentration of a solution.

**Assessment**

Students can complete the embedded multiple choice questions in the *Beers\_Law.tns* file. In addition, students can answer questions on the student activity sheet.