PROBEWARE INVESTIGATION 7 • A

Concentration of Solutions

Beer's law states that the amount of light absorbed by a chemical is *directly* related to the concentration of the chemical in a solution. A colorimeter (spectrophotometer) can provide useful qualitative and quantitative information about a chemical sample. This device measures the amount of light your samples absorb. The intensity of the light collected by a photocell is monitored as either an absorbance or a percent transmittance value. The value of this reading depends on the concentration of the coloured material in the solution.

Question

How can Beer's law be used to determine an unknown concentration?

Materials

computer system and interface
colorimeter sensor
cuvette
5 test tubes (20 × 150 mm)
test tube rack
stirring rod
transfer pipette
100 mL of 0.40 M nickel(II) sulfate ($NiSO_4$) solution
100 mL distilled water

Safety Precautions

- Nickel(II) sulfate is harmful if swallowed or inhaled. Nickel compounds are highly toxic by all routes of exposure and are irritants.
- Never pipette by mouth. Always use a pipette bulb or pipette pump.
- Be sure to dispose of materials properly.

Procedure

1. Label the clean, dry test tubes #1 through #5.

2. Pipette 2, 4, 6, 8, and 10 mL of the $NiSO_4$ solution into test tubes #1 through #5 respectively.

3. Pipette 8, 6, 4, and 2 mL of the distilled water into test tubes #1 through #4 respectively.

4. Thoroughly mix the contents of test tubes 1 through 4 with the stirring rod, wiping it clean between stirrings. The following table outlines the volumes and concentrations that will be used:

Test tube #	Volume of $NiSO_4$ (mL)	Volume of water (mL)	Concentration (M)
1	2	8	0.08
2	4	6	0.16
3	6	4	0.24
4	8	2	0.32
5	10	0	0.40

5. Set up the computer system with the colorimeter sensor.

6. Set the recording of data to manual sampling control.

7. Calibrate the colorimeter sensor

8. Display the sensor with a table display of absorbance (A) and concentration (M).

9. Display the sensor with a digits display of absorbance.

10. Turn the wavelength setting of the colorimeter sensor to the RED (625 nm) LED colour.

11. Empty any material in the cuvette, and carefully rinse it with distilled water. Empty the water from the cuvette and dry it well.

12. Rinse the cuvette twice with approximately 1 mL amounts from test tube #1.

13. Fill the cuvette ¾ full of solution from test tube #1 and carefully dry the outside of the cuvette.

14. Place the cuvette in the colorimeter and close the lid.

15. Once the absorbance digits display stabilizes, use the keyboard to save its value.

16. Continue testing each of the test tubes #2 through #5 by repeating steps 11 to 15.

17. Obtain the unknown concentration solution of nickel(II) sulfate from your teacher and repeat steps 11 to 15.

18. Record the absorbance for the unknown concentration solution.

19. Discard the solutions as directed by your teacher. Do not pour anything down the drain.

Analysis

1. Create a graph display of absorbance (A) versus concentration (M).

2. Locate the absorbance value along the vertical axis for the unknown solution, and trace a horizontal line to the plotted line.

3. What is the corresponding horizontal value directly below the plotted line?

Conclusions

4. Write a conclusion to explain how your experimental observations supported your theoretical calculations.

Applications

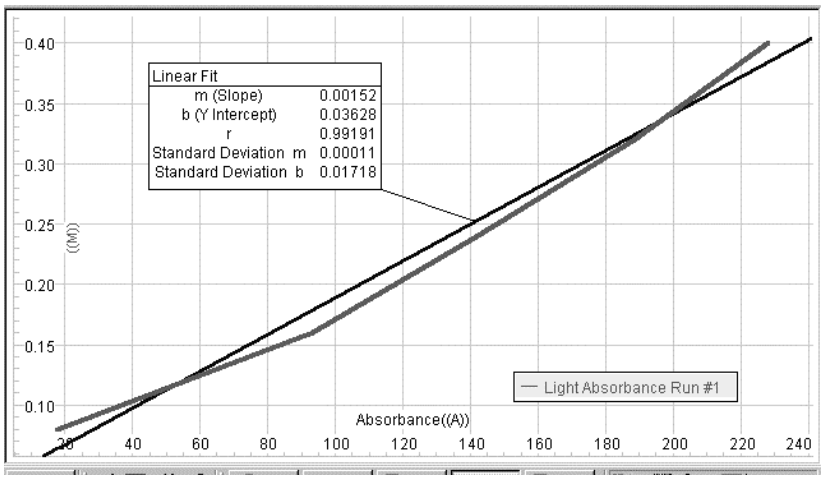
5. How can the use of Beer's law and spectroscopy be useful in industries?

6. What would be the limitations of using this technique in industries?

Teacher Information

Sample Data – Answer Sheet

Observations



Graph 1

Light Absorbance Run #1	
Absorbance ((A))	*Concentration ((M))*
17.440	0.080
93.221	0.160
141.358	0.240
188.216	0.320
228.207	0.400

Table 1

Answers

5. Concentrations of unknown solutions can be measured quickly and easily once the Beer's law graph is determined.

6. It is limited to solutions that are not completely colourless or opaque.