

SI Chemistry - Full Discipline Demo

Beer's Law

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match the electromagnetic sources with the correct wavelength.

Blue Light	$2.05 \times 10^5 - 10^9$ nm	1
Green Light	620 - 760 nm	2
Microwaves	470 - 550 nm	3
Red Light	440 - 470 nm	4
Ultraviolet Light	400 - 10 nm	5
X-rays	1 nm - 1 pm	6

Correct answers:

- 1 Microwaves 2 Red Light 3 Green Light 4 Blue Light
5 Ultraviolet Light 6 X-rays

Match the spectroscopic methods with the appropriate descriptions.

⚡ Circular dichroism	Molecular vibrational, rotational, and other energy states of a molecule	1
⚡ Mass spectrometry	Vaporizes molecules and produces ions to determine the chemical composition of a sample	2
⚡ NMR	The wavelength and intensity of the light absorbed by a sample	3
⚡ Raman	Aligns, spins, and excites chemical isotopes which are used to determine the structure of a protein	4
⚡ UV-Vis	The absorption of polarized light to determine secondary structure of proteins	5

Correct answers:

- 1 Raman 2 Mass spectrometry 3 UV-Vis 4 NMR
5 Circular dichroism

A student prepares 5 calibration standards of a red dye by mixing a stock dye solution ($M = 3.8 \times 10^{-2} \text{ M}$) with water in the volumes presented in the table below. Order the solutions from lowest (1) to highest (5) absorbance.

Tube Label	Volume of Distilled Water (mL)	Volume of Standard Red Dye (mL)	Total Volume (mL)
A	3.0	7.0	10.0
B	0.0	10.0	10.0
C	10.0	0.0	10.0
D	8.0	2.0	10.0
E	5.0	5.0	10.0

❏ 1

❏ 2

❏ 3

❏ 4

❏ 5

▶

A: 3 mL water + 7 mL red dye

B: 0 mL water + 10 mL red dye

C: 10 mL water + 0 mL red dye

D: 8 mL water + 2 mL red dye

E: 5 mL water + 5 mL red dye

1

2

3

4

5

Correct answers:

1 4 2 5 3 1 4 2 5 3

Exploration

A solution is composed of ____ dissolved into a ____.

- |

●

a solute; solvent

✓
- a solvent; solute
- water; solvent
- water; solute

The study of how electromagnetic radiation interacts with atoms and molecules is defined as ____.

- ☒ spectrometry ✓
- ☐ chromatography
- ☐ topography
- ☐ geometry

Absorbance is the measure of light intensity passed through a sample.

- ☐ True
- ☒ False ✓

A ____ is a type of spectrophotometer that measures the light transmitted through a sample at a specific wavelength.

- ☐ multimeter
- ☒ colorimeter ✓
- ☐ microwave
- ☐ cuvette

The constant(s) in Beer's law include ____.

- ☐ absorbance
- ☐ the molar extinction coefficient
- ☐ the path length
- ☒ the molar extinction coefficient and path length ✓
- ☐ All of the above

Exercise 1

Data Table 1: Concentration and Resistance
(SAMPLE ANSWER BELOW)

Test Tube	Concentration of Red Dye in Test Tube (M)	Resistance for W Blank (Ω)	Resistance for Sample (Ω)	Overall Resistance
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B	0.000199	0.6	4.8	8.0
1	0.000179	0.6	4.4	7.3
2	0.000159	0.6	3.9	6.5
3	0.000139	0.6	3.4	5.6
4	0.000119	0.6	3.2	5.3
5	0.0000995	0.6	2.5	4.1
6	0.0000796	0.6	2.0	3.3
7	0.0000597	0.6	1.7	2.8
8	0.0000398	0.6	1.2	2.0
9	0.0000199	0.6	0.9	1.5
CD 1		0.6	4.4	7.3
CD 2		0.6	1.1	1.8
W	0	0.6	0.6	1.0

Data Table 2: Concentration and % Transmittance
(SAMPLE ANSWER BELOW)

Test Tube	Concentration of Red Dye in Test Tube (M)	Resistance for W Blank (Ω)	Resistance for Sample (Ω)	Current for W Blank (A)	Current for Sample (A)	Percent Transmittance (%T)
B	0.000199	0.6	4.8	15	1.9	12.6
1	0.000179	0.6	4.4	15	2.0	13.3
2	0.000159	0.6	3.9	15	2.3	15.3
3	0.000139	0.6	3.4	15	2.6	17.3
4	0.000119	0.6	3.2	15	2.8	18.7
5	0.0000995	0.6	2.5	15	3.6	24.0
6	0.0000796	0.6	2.0	15	4.5	30.0
7	0.0000597	0.6	1.7	15	5.3	35.3
8	0.0000398	0.6	1.2	15	7.5	50.0
9	0.0000199	0.6	0.9	15	10	66.7
W	0	0.6	0.6	15	15	100
CD 1		0.6	4.4	15	2.0	13.3
CD 2		0.6	1.1	15	8.2	54.7

Data Table 3: Concentration and Absorbance
(SAMPLE ANSWER BELOW)

Test Tube	Concentration of Red Dye in Test Tube (M)	Absorbance
B	0.000199	0.903
1	0.000179	0.865

2	0.000159	0.813
3	0.000139	0.753
4	0.000119	0.727
5	0.0000995	0.619
6	0.0000796	0.522
7	0.0000597	0.452
8	0.0000398	0.301
9	0.0000199	0.176
W	0	0
CD1	0.000169	0.865
CD2	0.000324	0.263

Exercise 2

Describe possible sources of error in this experiment.

There are multiple possible sources of error in this experiment, including: the rounding of significant figures of the concentration, the measurement of the samples with the graduated cylinder, the drift of the multimeter, the optical matching of the test tubes, and incident light present in the colorimeter

Create a Beer's law plot and best fit line using the data in Table 2. Upload an image of the graph into Graph 4. Use the following data:

Questions 2 - 5 are based upon the following scenario:

A testing laboratory has been hired by a company called "Drug Company Q" to analyze a series of over-the-counter drugs that the company produces. In all of these over-the-counter drugs, the active ingredient is called "Active Ingredient M." The laboratory technician collected the data from samples with known concentrations of Active Ingredient M. The data is shown below in Table 2.

Table 2. Known Concentrations of Active Ingredient M Drug

Sample Identification Code	Sample Concentration (M)	Absorbance
Q5000	4.00×10^{-4}	0.750
Q5001	3.20×10^{-4}	0.602
Q5002	2.40×10^{-4}	0.447
Q5003	1.60×10^{-4}	0.299
Q5004	8.00×10^{-5}	0.150

The technician also collected absorbance readings for 5 over-the-counter drugs for review. The data collected for the 5 over-the-counter drugs is shown in Table 3.

Table 3. Absorbance Data for Over-the-counter Drugs

Sample Identification Code	Absorbance
M21050-1	0.359
M21050-2	0.356
M21050-3	0.339
M21050-4	0.376
M21050-5	0.522

Use the Beer's law plot and best fit line to determine the concentrations for samples: M21050-1, M21050-2, M21050-3, M21050-4, M21050-5.

The concentration for M21050-1 is 1.92×10^{-4} M. The concentration for M21050-2 = 1.90×10^{-4} M. The concentration for M21050-3 = 1.81×10^{-4} M. The concentration for M21050-4 = 2.01×10^{-4} M, and the concentration for M21050-5 = 2.79×10^{-4} M.

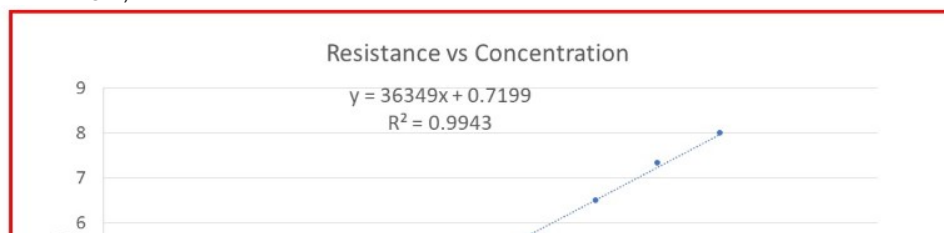
The company reported that sample M21050-2 has an M concentration of 0.0003 M. Assuming that the results in Question 3 are 100% accurate and without error, is the company's statement accurate? What is the percent error between the reported concentration and the concentration calculated in Question 3?

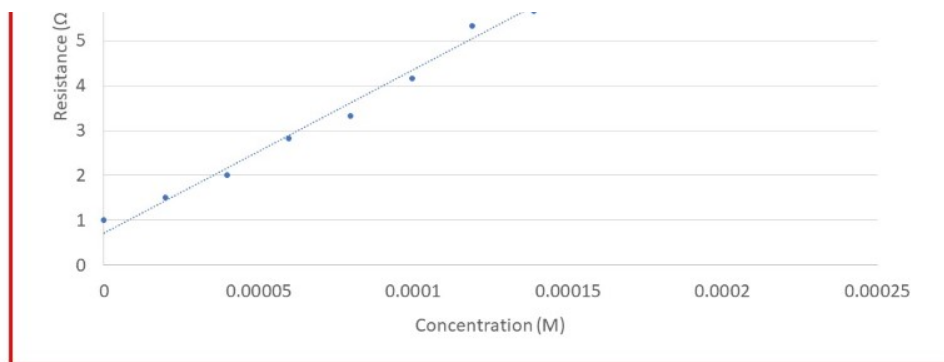
Assuming that the company reported that M21050-2 has an M concentration of 0.0003 M, the company is not providing accurate data, as concentration for M21050-2 = 1.90×10^{-4} .
% error = $(0.000300 \text{ M} - 0.000190 \text{ M}) / 0.000190 \text{ M} \times 100\% = 57.9\%$

By law, Drug Company Q must have an M concentration between 2.85×10^{-4} M and 3.15×10^{-4} M. Do all samples analyzed meet the legal requirements? Use the information from Question 3 to explain your answer.

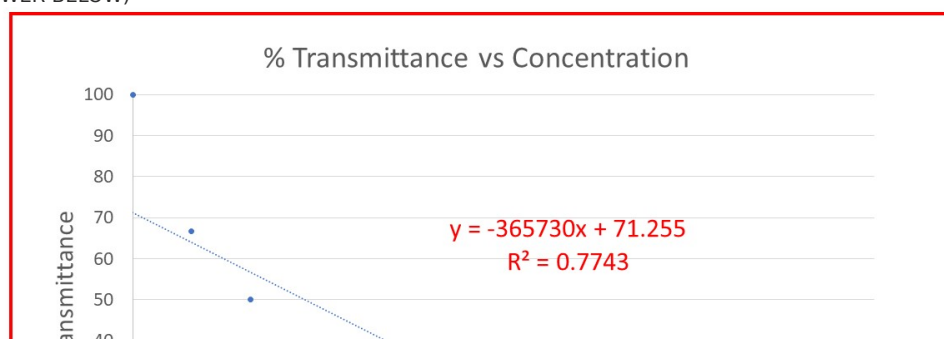
All of the analyzed samples have concentrations that are too low to meet legal requirements.

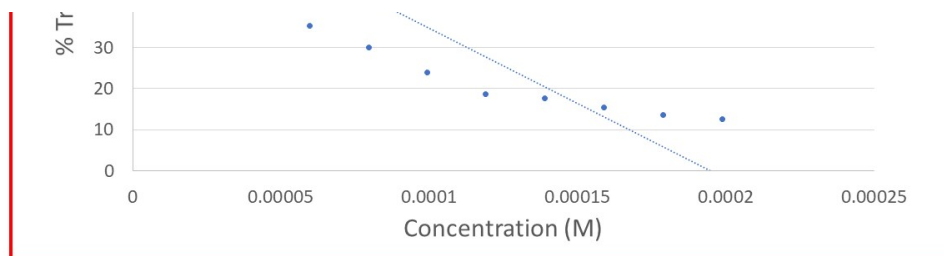
Graph 1: Resistance vs. Concentration
(SAMPLE ANSWER BELOW)



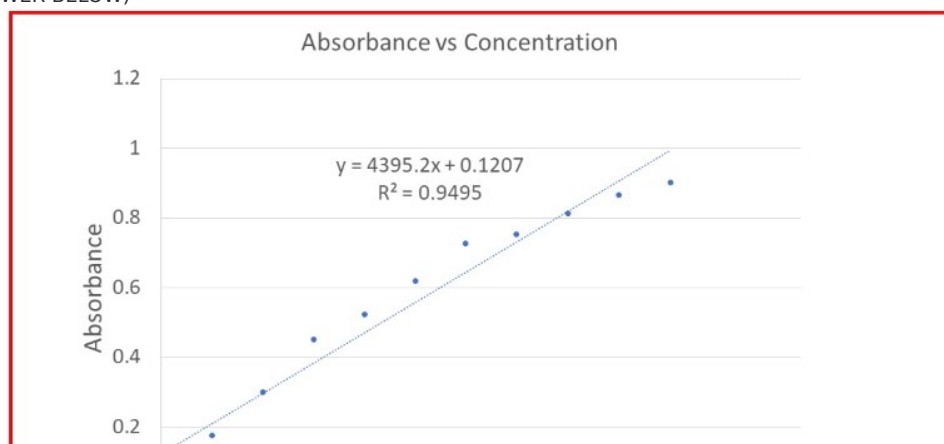


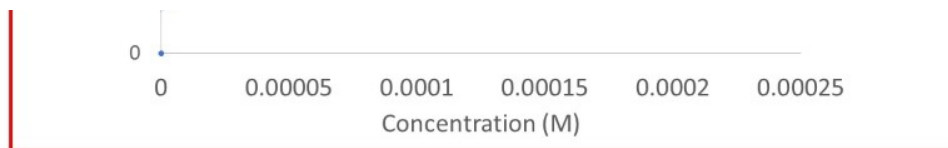
Graph 2: % Transmittance vs. Concentration
(SAMPLE ANSWER BELOW)



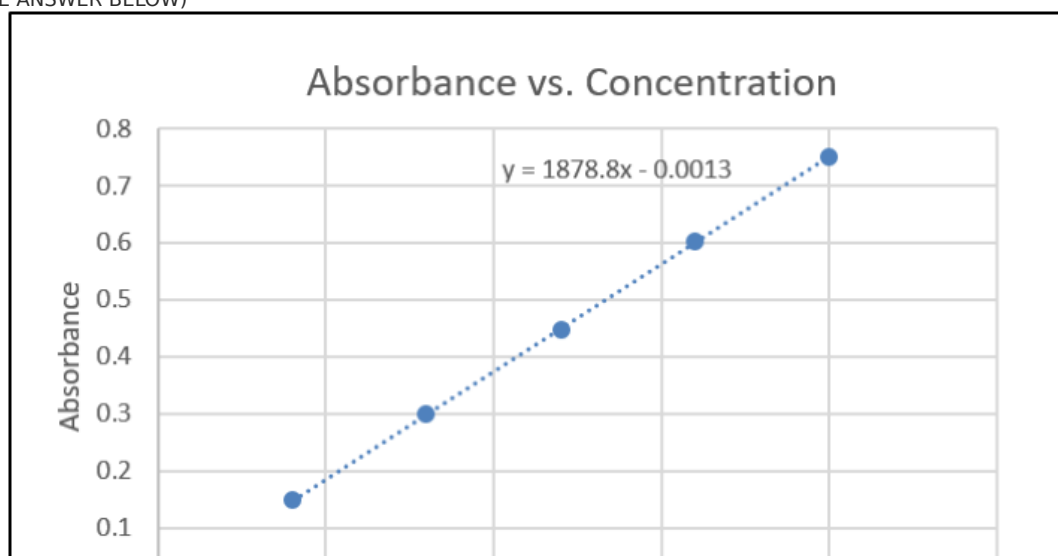


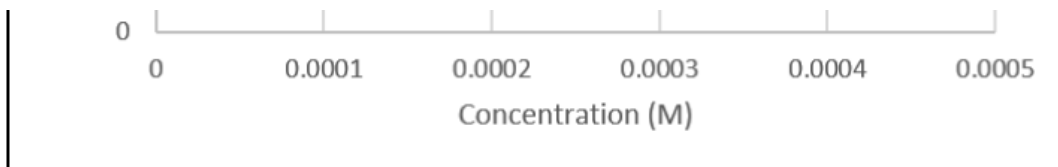
Graph 3: Absorbance vs. Concentration
(SAMPLE ANSWER BELOW)





Graph 4: Exercise Question 2
(SAMPLE ANSWER BELOW)





Competency Review

Water is the most universal ____.

- ☐ solution
- ☐ solute
- ☒ solvent

✓

Determining the components and concentrations of the solute in a solution is an uncommon task of chemists.

- ☐ True
- ☒ False

✓

Spectroscopy is the study of how electromagnetic radiation interacts with atoms and molecules.

☒ True



☐ False

The visible region of the spectrum is located in the wavelength range between 400 nm and 700 nm.

☒ True



☐ False

In UV-Vis spectroscopy, the intensity of the light after it passes through the sample is referred to as ____.

☐ absorbance

☒ transmittance



☐ ultraviolet

☐ electromagnetic

Beer's law mathematically expresses the relationship between ____ and sample ____.

☐ transmittance; concentration

☒ absorbance; concentration



☐ absorbance; transmittance

☐ concentration; mass

A Beer's law plot is a graph showing the linear relationship between absorbance and concentration.

☒ True



☐ False

What information was used in this experiment to calculate the concentrations of colorimeter samples?

- ☐ Initial concentration of solution
- ☐ Initial volume of solution
- ☐ Final volume of solution
- ☒ All of the above

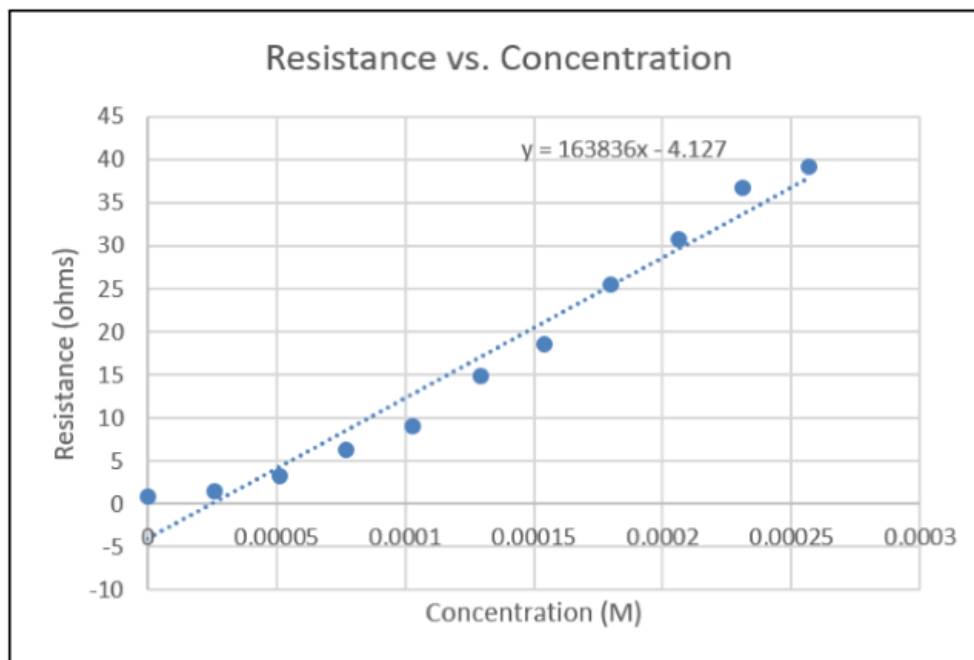


A multimeter measures light intensity as electrical resistance, which functions as ____ in a Beer's law plot.

- ☐ transmittance
- ☒ absorbance
- ☐ concentration
- ☐ solubility



Use the scatter plot and associated line of best fit to determine the concentration of an unknown sample with a resistance of 25 ohms.



- ☐ 0.0001 M
- ☐ 0.00015 M
- ☒ 0.000175 M
- ☐ 0.00025 M

✓

Extension Questions

At an environmental testing lab, a lab technician calculated the known concentration of the calibrating solution three times too high. How will this affect the results of the samples run using this calibration solution? What would be the possible consequences of reporting these results? (SAMPLE ANSWER BELOW)

The sample concentrations will be recorded too low. This will result in test results that give falsely low numbers. The client who receives these results may think his samples are at a safe concentration when they are not