Name _____ Date _____ Period _____

ZornScience
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Beer's Law Virtual Lab

Chemistry and AP Chemistry

Open **activities.zornscience.org/beers-law-lab/** and follow each step. Show your work with units.

Objective

Use a spectrophotometer to find how **absorbance** depends on **wavelength** and on **concentration**, then use a calibration curve to find the concentration of an **unknown**.

NGSS alignment: HS-PS4-4 (supporting). Evaluate claims about the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Practices and concepts: Planning and carrying out investigations; Analyzing and interpreting data; Using mathematics; Patterns; Scale, proportion, and quantity.

AP alignment: 3.13 Beer-Lambert Law. Skills 2.E (identify sources of experimental error) and 5.F (calculate an unknown quantity from known quantities).

Meet the simulation

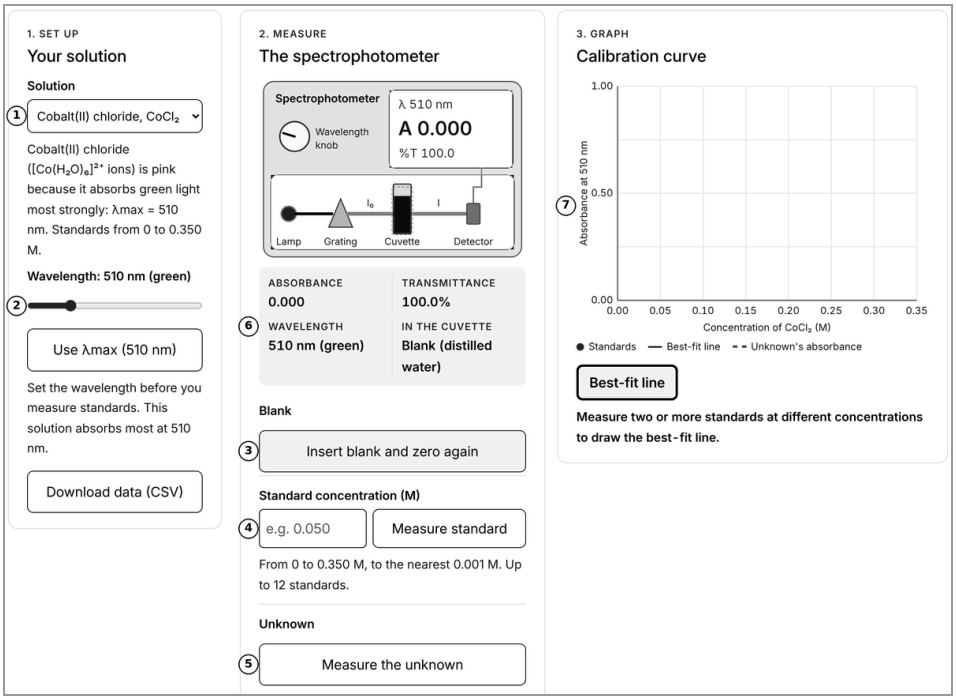


Figure 1. The Beer's Law Spectrophotometer Lab after zeroing. The dark display is shown inverted for printing.

(1) Solution menu.

(2) Wavelength slider (380 to 950 nm). It locks once you have standards.

(3) Inserts the blank (water) and sets A = 0.

(4) Type a standard's concentration, then select **Measure standard**.

(5) Measures the unknown sample.

(6) Readouts: absorbance, transmittance, wavelength, what is in the cuvette.

(7) Calibration curve with best-fit line.

Pre-lab

1. Beer's law is A = εbc. Name each variable and its unit.

2. A solution has ε = 4.8 L/(mol·cm) in a 1.00 cm cuvette. Predict its absorbance at 0.150 M.

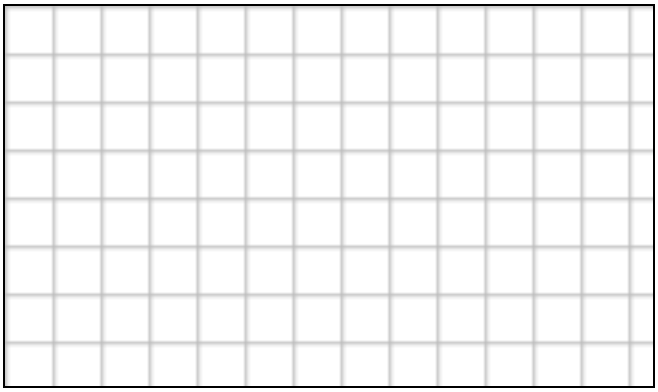
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3. Cobalt(II) chloride solution looks pink. Predict which color of light it absorbs most. Explain.

Part A. Find the best wavelength (λ_{max})

1. Keep Solution = **Cobalt(II) chloride, $CoCl_2$**. Select **Insert blank and zero**.
2. Type **0.200** in the standard box and select **Measure standard**. Then select **Remove** next to Standard 1 in the data table. The 0.200 M sample stays in the cuvette, and the wavelength slider unlocks.
3. Move the slider to each wavelength in the table (use the arrow keys for exact values). Record the absorbance and the light color shown next to the wavelength.

Wavelength (nm)	Light color	Absorbance, 0.200 M
450		
480		
510		
540		
570		
600		



Sketch absorbance against wavelength on the grid.

4. What is λ_{max} for $CoCl_2$? Does this support your prediction in question 3?

5. Why should you measure your standards at λ_{max} instead of at 600 nm?

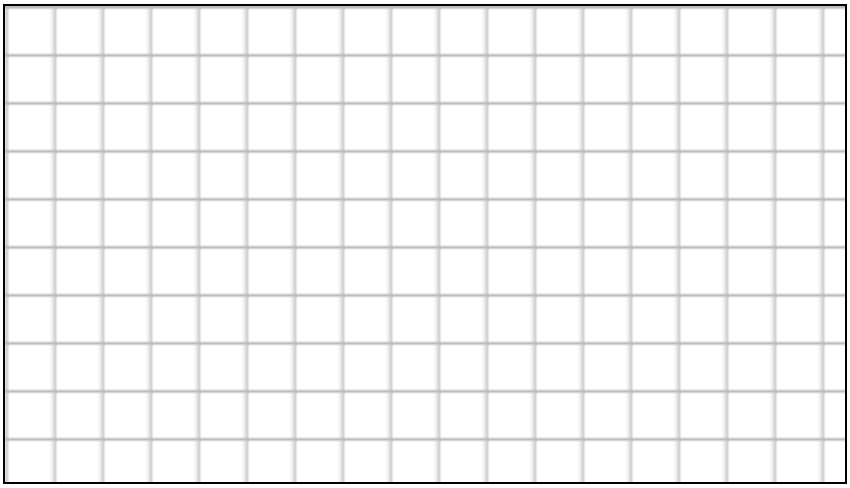
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Part B. Build a calibration curve and find the unknown

1. Select **Use λmax (510 nm)**. Measure standards of **0.050, 0.100, 0.150, 0.200, 0.250** and **0.300 M**, one at a time. Record each absorbance.
2. Select **Measure the unknown** and record its absorbance. (Each student's unknown is different.)

Concentration (M)	0.000 (blank)	0.050	0.100	0.150	0.200	0.250	0.300	Unknown
Absorbance at 510 nm	0.000							

6. Graph absorbance (y) against concentration (x). Draw a best-fit line and find its slope with two points on your line. Then compare your slope with the equation under the simulation's graph.



7. Use your best-fit line to calculate the concentration of your unknown: c = (A − b) / m. Then type it in the box and select **Check my answer**.

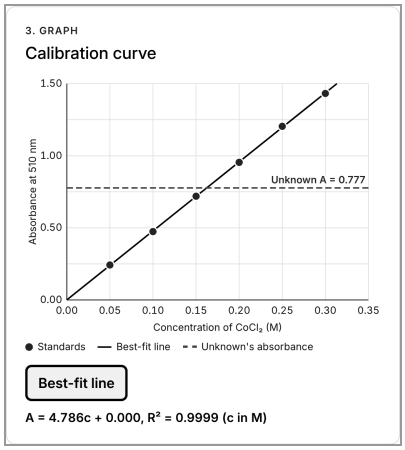


Figure 2. A calibration curve with the unknown's absorbance as a dashed line.

Your unknown's absorbance appears as a dashed line. Where it crosses the best-fit line, read straight down to the concentration axis. That is a graphical check of question 7.

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Analysis

8. The slope of the calibration line equals εb. Use your slope to calculate ε for $CoCl_2$ at 510 nm.

9. Clear standards, set the wavelength to **570 nm**, and measure the **0.100** and **0.200 M** standards. Record both absorbances and the new slope. Explain why the slope changed.

10. (AP extension) Transmittance is $\%T = 100 \times 10^{-A}$. Calculate %T for the 0.200 M standard at 510 nm and at 600 nm. Which wavelength lets more light reach the detector?

11. (AP extension) Give two errors in a real Beer's law lab and how each changes the calculated concentration of the unknown.

Conclusion

12. Write a claim that answers the objective. Support it with evidence from Parts A and B (specific numbers), then explain your reasoning with Beer's law.

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