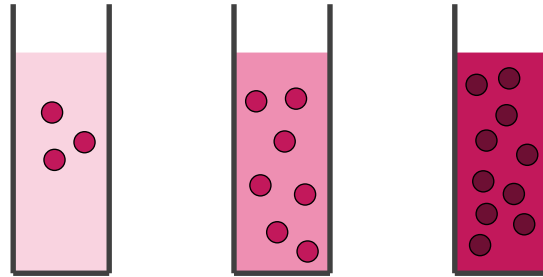


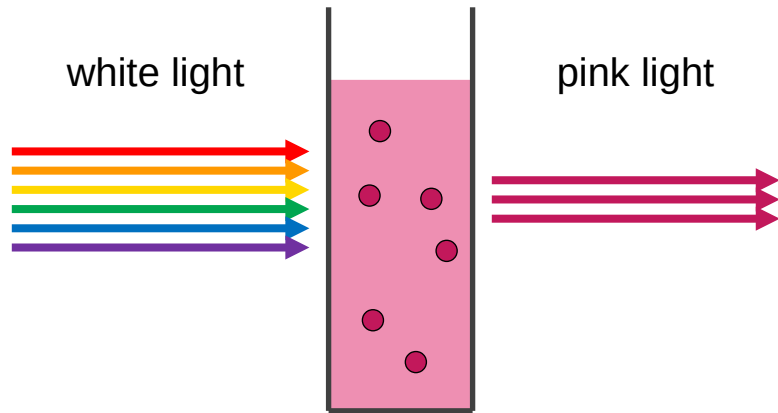
Essential Question

How can color tell us concentration?



Why Solutions Have Color

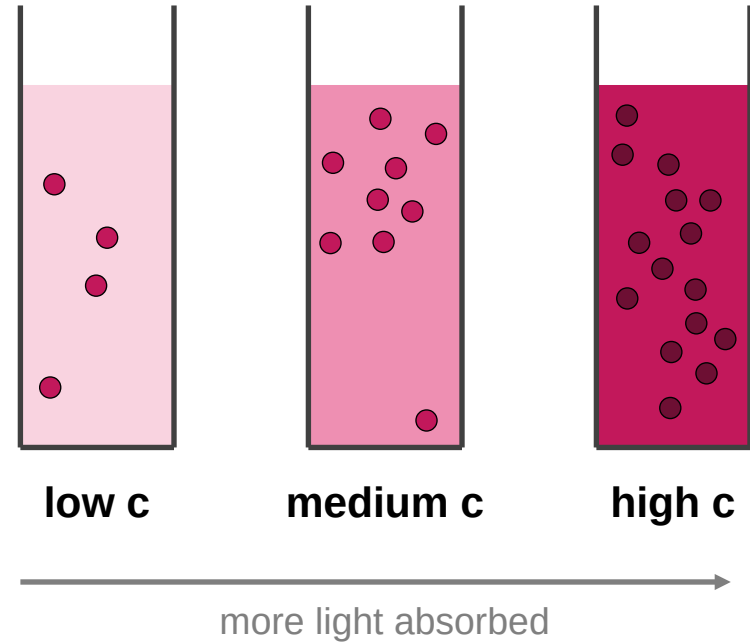
- White light has all colors
- A solution **absorbs** some colors
- We see the colors that pass through



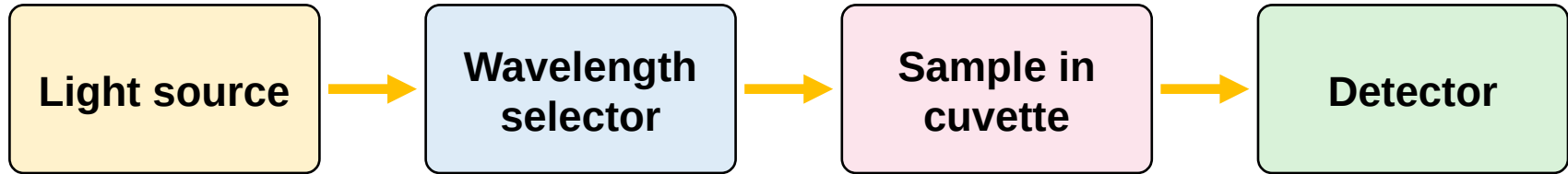
$\text{CoCl}_2(\text{aq})$ absorbs blue-green light

Darker Means More Concentrated

- More solute particles in the light path
- More particles absorb more light
- Darker color = higher concentration



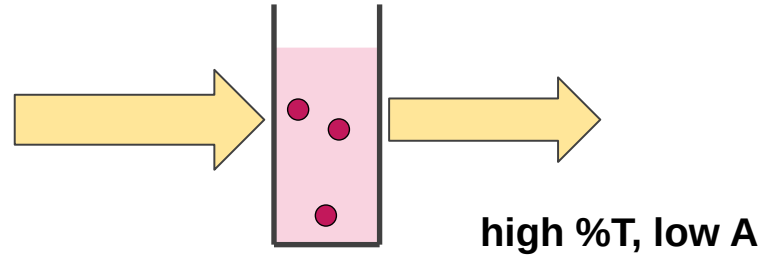
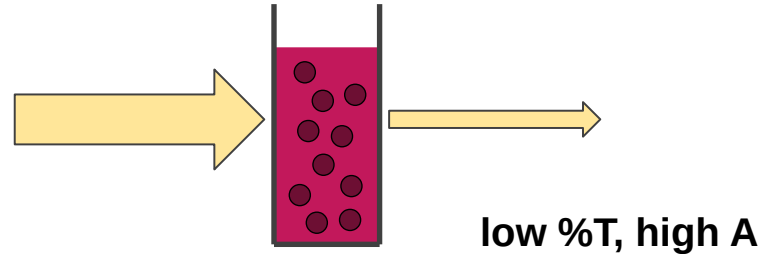
The Spectrophotometer



- Picks **one** wavelength (color) of light
- Detector measures the light that gets through
- Reports %T or absorbance (A)

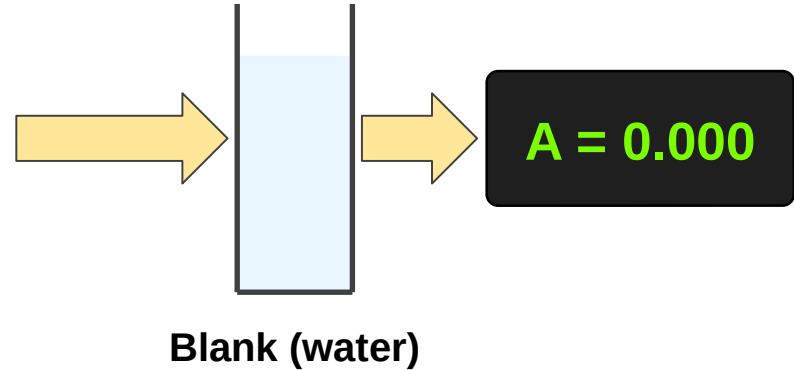
Transmittance and Absorbance

- **Transmittance** (%T): % of light that passes through
- **Absorbance** (A): light that is absorbed, no units
- A goes up $\rightarrow$ %T goes down
- 100% T means $A = 0$



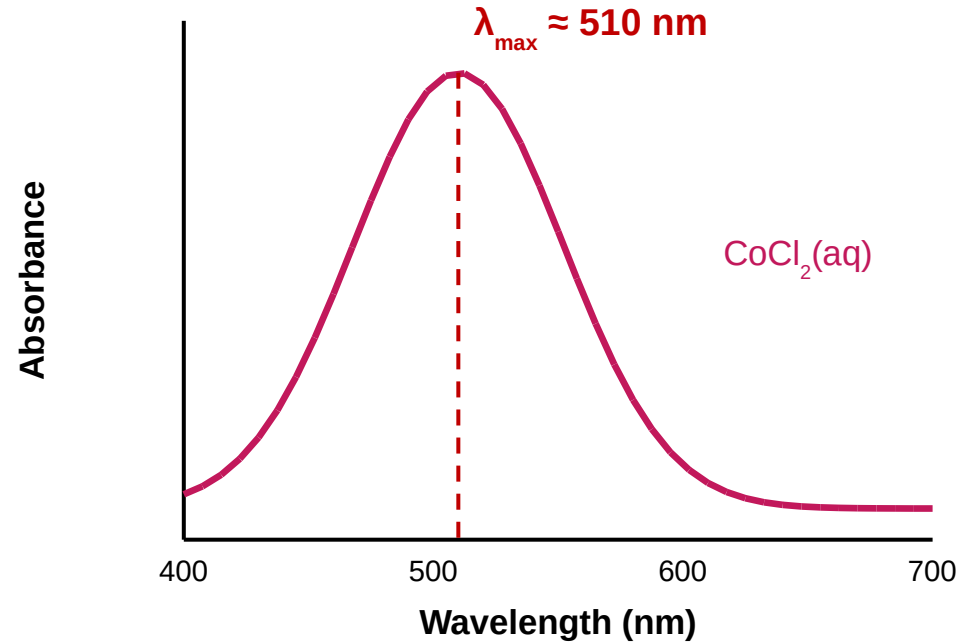
The Blank

- Cuvette with **solvent only** (water)
- Set the instrument to $A = 0$ (100% T)
- Removes light absorbed by the cuvette and solvent
- Re-blank if you change the wavelength



Choosing a Wavelength

- Use λ_{max} : the wavelength of **maximum absorbance**
- Biggest change in A when c changes
- Use the same wavelength for every reading



Beer's Law Equation

$$A = \epsilon L C$$

A

absorbance

no units

ϵ

**absorption
coefficient**

$\text{M}^{-1}\text{cm}^{-1}$, depends on
the substance and λ

L

path length

cm, the cuvette width
(usually 1.00 cm)

C

concentration

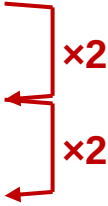
M (mol/L)

Some books write $A = \epsilon b c$ (b = path length)

A Direct Proportion

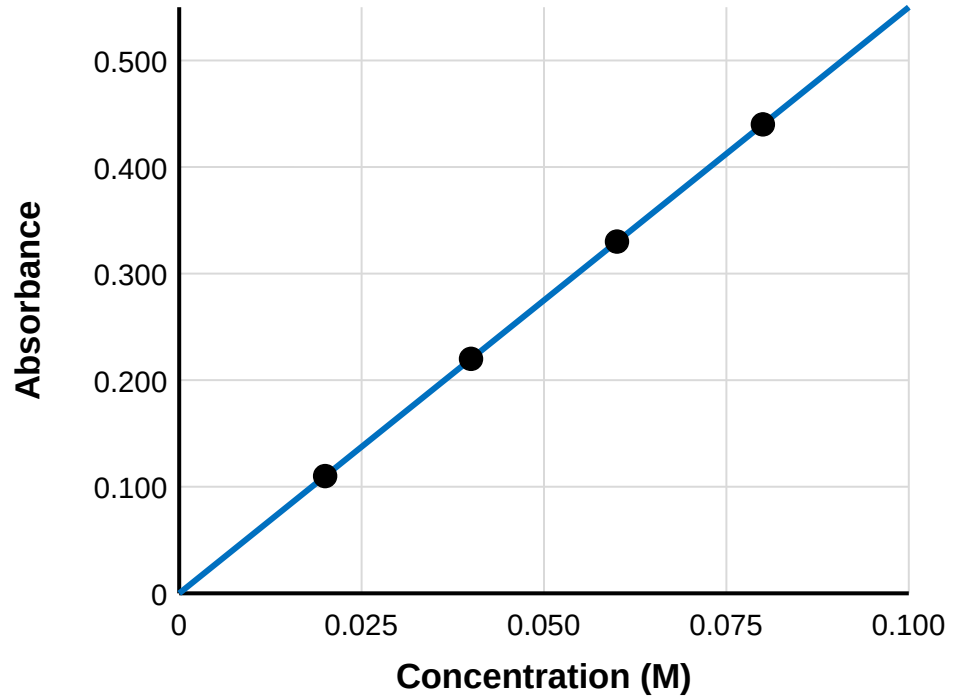
- Same substance, wavelength, and cuvette
- A is directly proportional to c
- Double c $\rightarrow$ double A
- Graph is a straight line through (0, 0)

c (M)	A
0.020	0.096
0.040	0.192
0.080	0.384



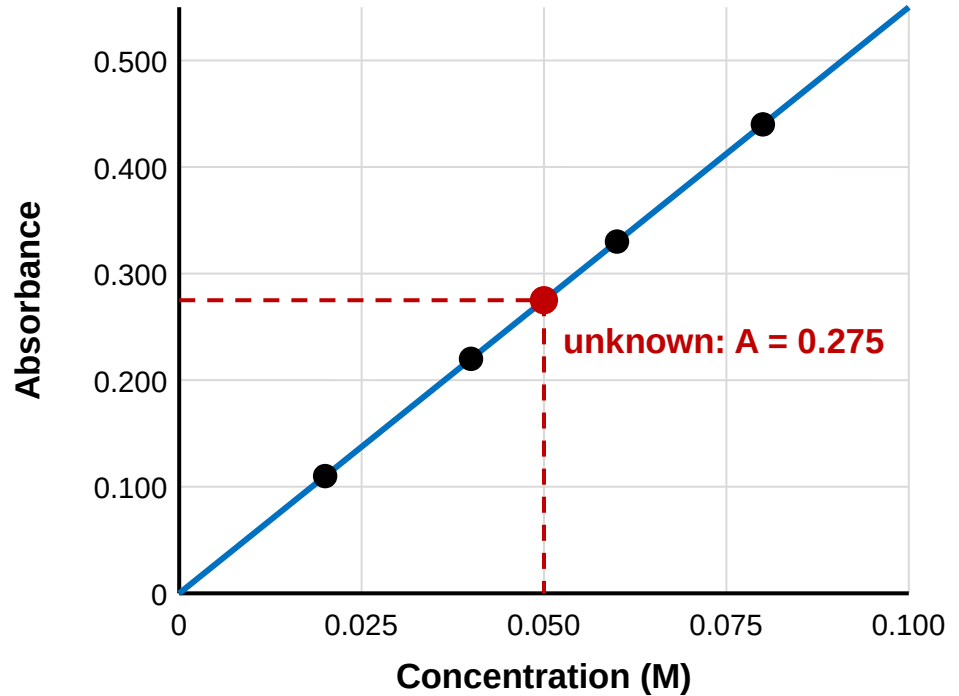
Making a Standard Curve

- Make **standards** of known c (by dilution)
- Measure A for each standard
- Graph A (y) vs. c (x)
- Draw a best-fit line through $(0, 0)$



Finding an Unknown

- slope = $A \div c$ (units: M^{-1})
- slope = ϵL
- $c_{\text{unknown}} = A_{\text{unknown}} \div \text{slope}$
- Or read it from the line



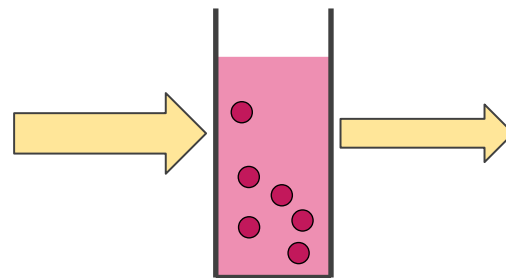
Sources of Error

Mistake	Measured A	Calculated c
Fingerprints or smudges on cuvette	too high	too high
Water drops left in cuvette (sample diluted)	too low	too low
Air bubbles in the light path	too high	too high

Tip: wipe each cuvette with a KimWipe and hold it by the top

Example: Solving for Concentration

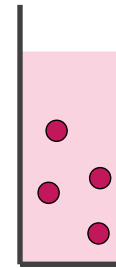
A CoCl_2 solution has an absorbance of 0.384 in a 1.00 cm cuvette. The absorption coefficient is $4.80 \text{ M}^{-1}\text{cm}^{-1}$. What is the concentration?



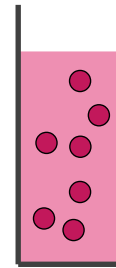
$L = 1.00 \text{ cm}$

Example: Using a Proportion

A 0.0400 M solution has an absorbance of 0.192. Using the same cuvette and wavelength, a second solution of the same substance has an absorbance of 0.336. What is its concentration?



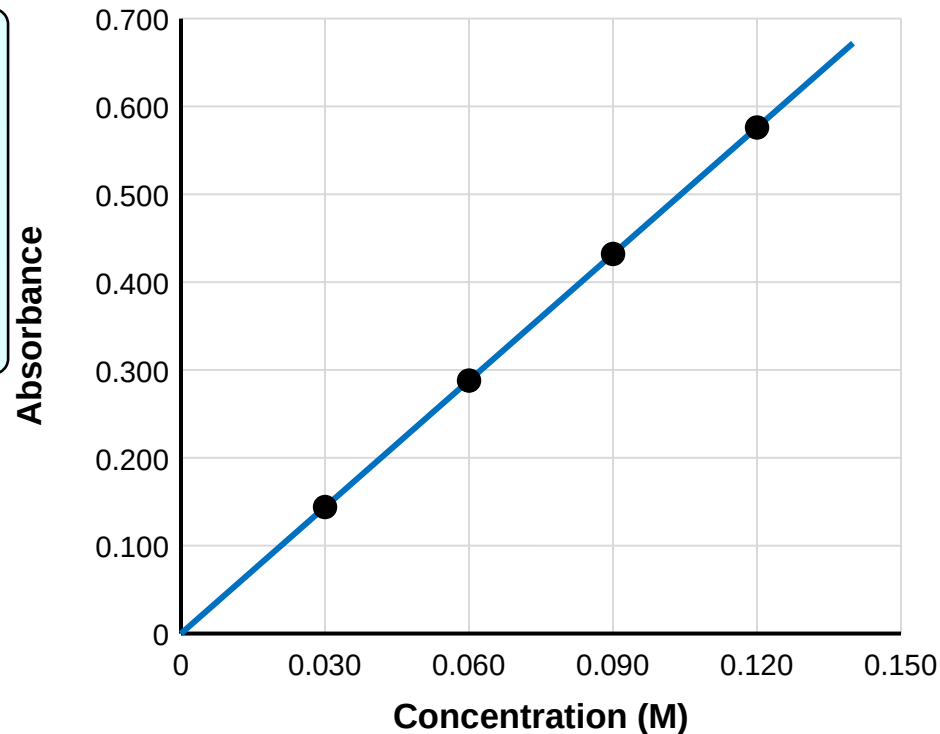
0.0400 M
 $A = 0.192$



? M
 $A = 0.336$

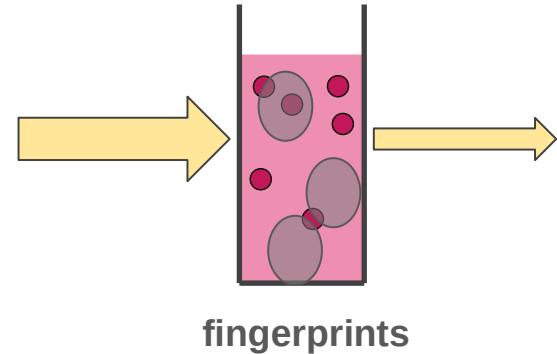
Example: Reading a Standard Curve

A student made this standard curve for CoCl_2 . (a) Calculate the slope. (b) An unknown has $A = 0.360$. What is its concentration?



Example: Error Analysis

A student leaves fingerprints on the outside of the cuvette holding the unknown. How does this affect the measured absorbance and the calculated concentration? Justify your answer.



Big Ideas

- Darker solutions absorb more light
- Beer's Law: $A = \epsilon Lc$
- Blank first, then measure at λ_{max}
- Standard curve: slope = $A \div c$, so $c = A \div \text{slope}$
- Smudges raise A ; leftover water lowers A