Beer’s Law

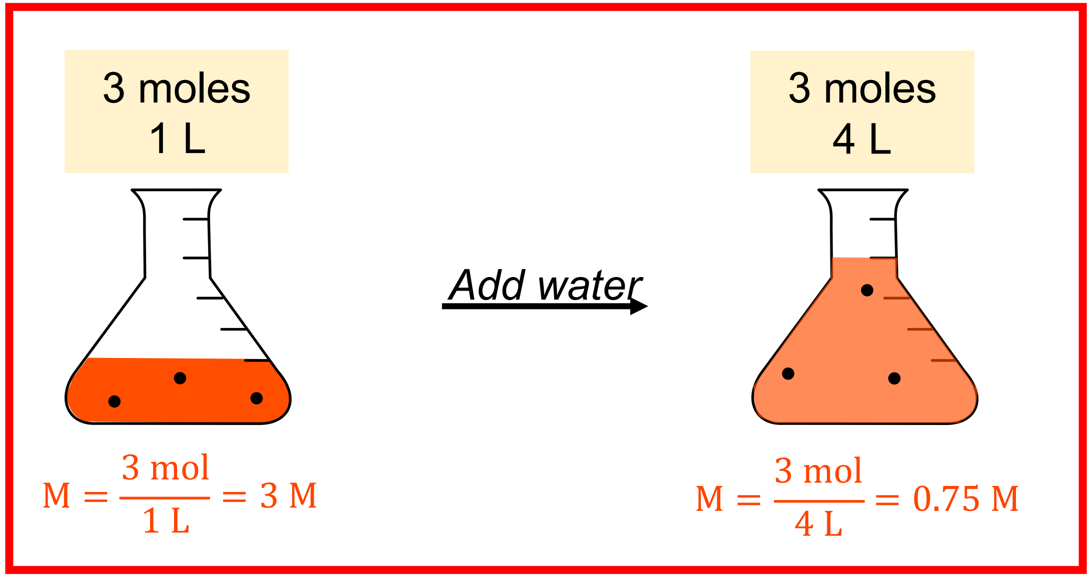
DR. MIOY T. HUYNH
YALE UNIVERSITY
CHEMISTRY 161
FALL 2019

www.mioy.org/chem161

How can we measure concentration?

$$\text{Concentration} = \frac{\text{moles of solute}}{\text{Volume (L) of solution}} \quad ; \quad \text{M} = \frac{\text{mol}}{\text{L}}$$

When we dilute a solution, its color usually gets lighter (or less intense)!



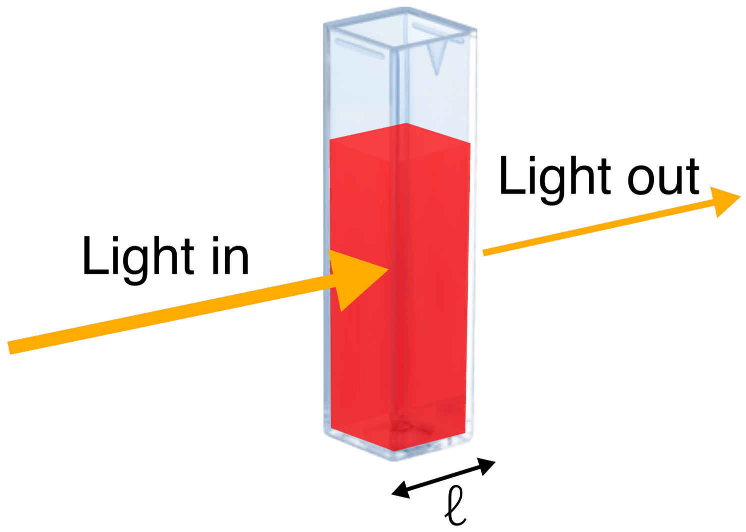
One way to measure the concentration of a solution is to measure the intensity of the solution's color.

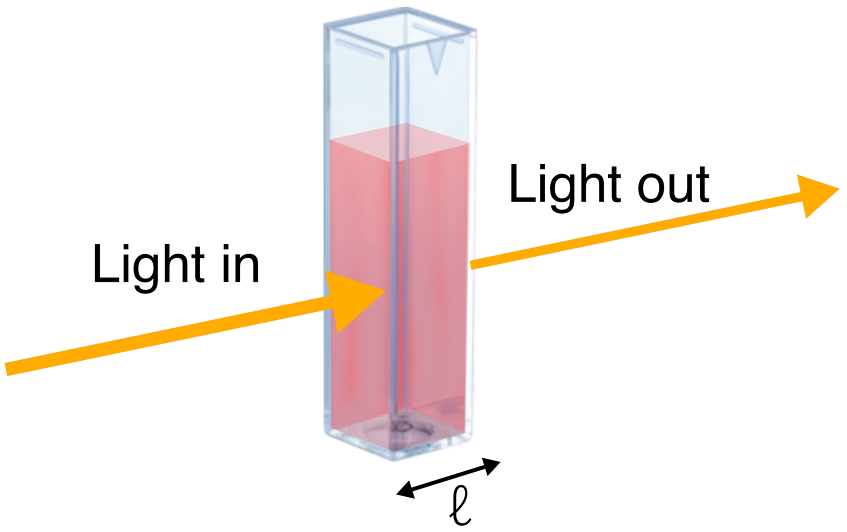
- Concentrated solutions are usually deeper in color and absorb more light.
- Diluted solutions are usually lighter in color and absorb less light.

What are we measuring?

We measure the absorbance!

If we shine a light through a sample, the ratio between the amount of light coming out (this the amount of light not absorbed by the solution) and the amount of light we shined into the solution is the absorbance (A).





- Concentrated solutions are usually deeper in color and absorb more light.
- Diluted solutions are usually lighter in color and absorb less light.

Beer's Law

$$A = \varepsilon c \ell$$

A = absorbance (dimensionless; no units)

ε = molar absorptivity $\left(\frac{\text{L}}{\text{mol}\cdot\text{cm}}\right)$

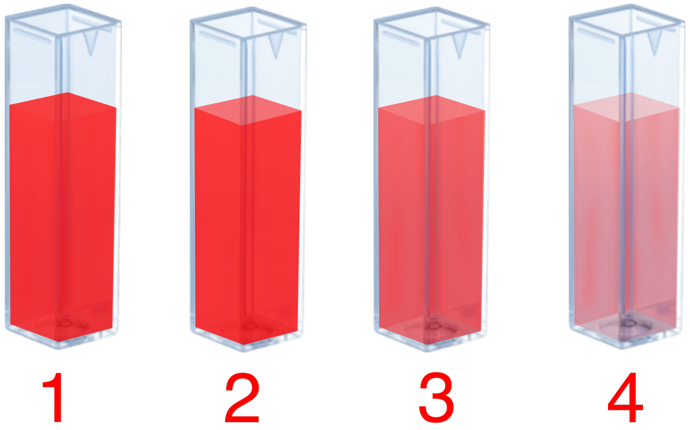
c = concentration $\left(\frac{\text{mol}}{\text{L}}\right)$

ℓ = pathlength (cm)

How do we use Beer's Law?

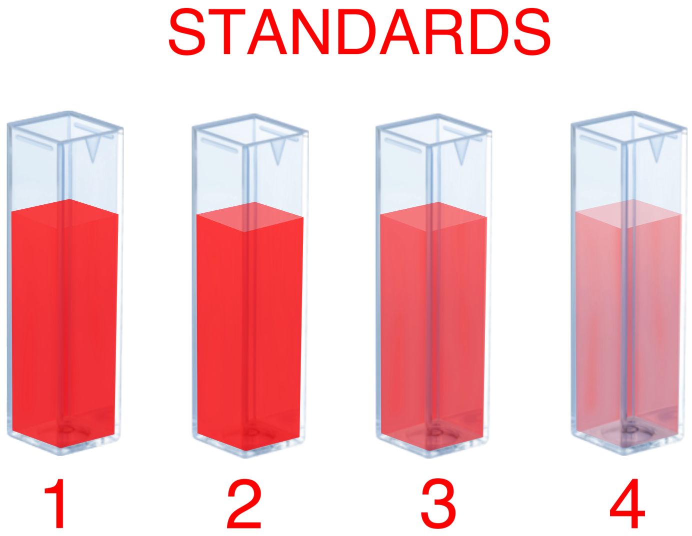
1. Prepare a series of solutions with known concentrations (these are called standards).

STANDARDS



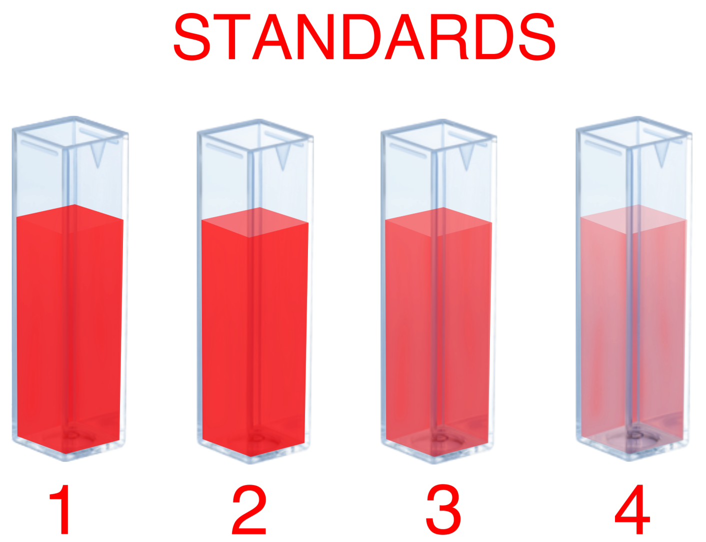
How do we use Beer's Law?

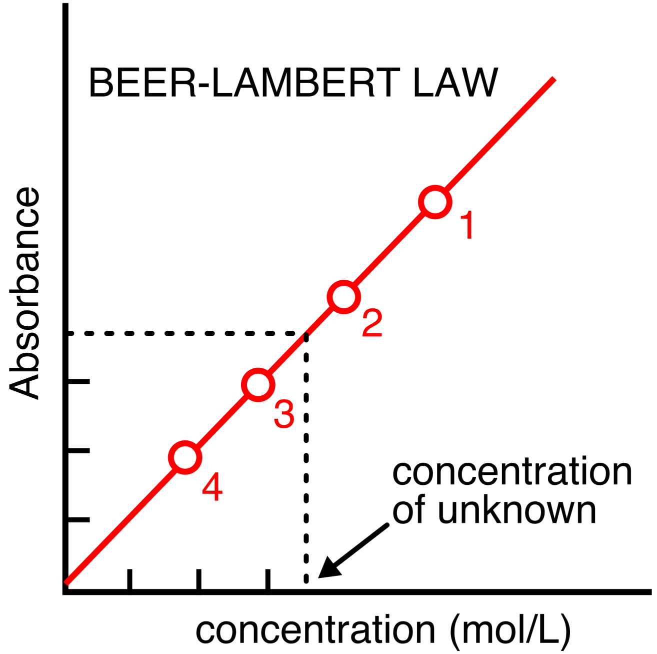
1. Prepare a series of solutions with known concentrations (these are called standards).
2. Measure absorbance of each standard solution.



How do we use Beer's Law?

1. Prepare a series of solutions with <u>known</u> concentrations (these are called standards).
2. Measure absorbance of each standard solution.
3. Plot A vs. c → ε = slope



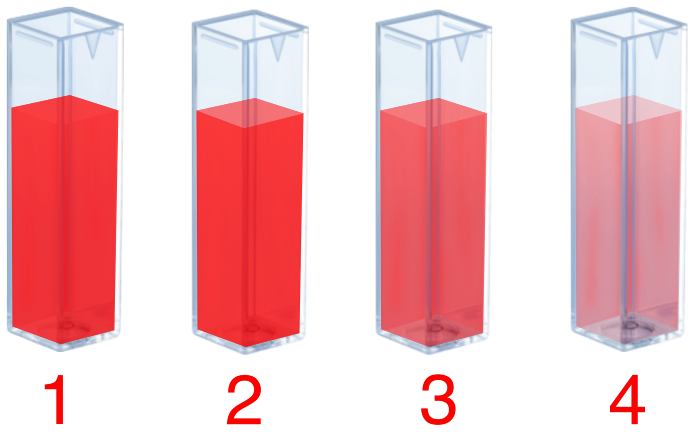


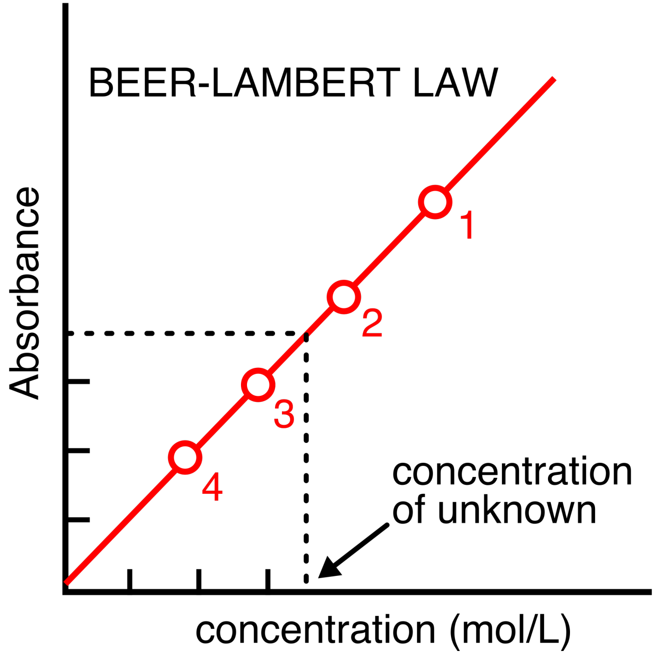
How do we use Beer's Law?

1. Prepare a series of solutions with <u>known</u> concentrations (these are called standards).
2. Measure absorbance of each standard solution.
3. Plot A vs. c → ε = slope

If you measure the absorbance (A) of an unknown concentration of the same solution, you can use Beer's Law to find the concentration!

STANDARDS





What is the concentration of a light-absorbing species if its molar absorptivity is 1.52×10^3 $mol^{-1} \cdot L \cdot cm^{-1}$, and the measured absorbance in a 1.00 cm cuvette is 0.742?

What is the concentration of a light-absorbing species if its molar absorptivity is 1.52×10^3 $mol^{-1} \cdot L \cdot cm^{-1}$, and the measured absorbance in a 1.00 cm cuvette is 0.742?

We want to find the concentration of the unknown solution.

What is the concentration of a light-absorbing species if its molar absorptivity is 1.52×10^3 mol^{-1}·L·cm^{-1}, and the measured absorbance in a 1.00 cm cuvette is 0.742?

We want to find the concentration of the unknown solution.

We can set up Beer's Law and solve for concentration c:

What is the concentration of a light-absorbing species if its molar absorptivity is 1.52×10^3 $mol^{-1} \cdot L \cdot cm^{-1}$, and the measured absorbance in a 1.00 cm cuvette is 0.742?

We want to find the concentration of the unknown solution.

We can set up Beer's Law and solve for concentration c:

$$A = \varepsilon c \ell$$

$$c = \frac{A}{\varepsilon \ell}$$

$$= \frac{0.742}{\left(1.52\times10^3 \frac{\mathrm{L}}{\mathrm{mol}\cdot\mathrm{cm}}\right)(1.00\ \mathrm{cm})}$$

$$c = 4.95\times10^{-4}\ \frac{\mathrm{mol}}{\mathrm{L}}$$