# Beer's Law and Spectrophotometry

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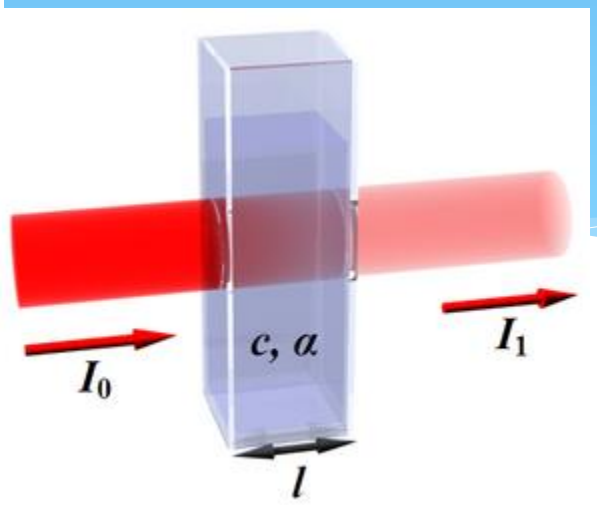
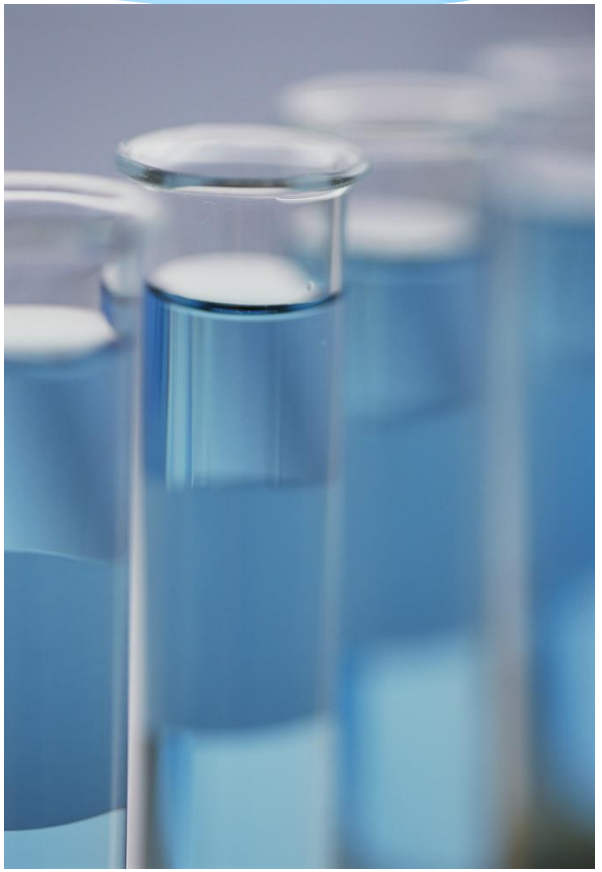


# Solution Concentration Reminders

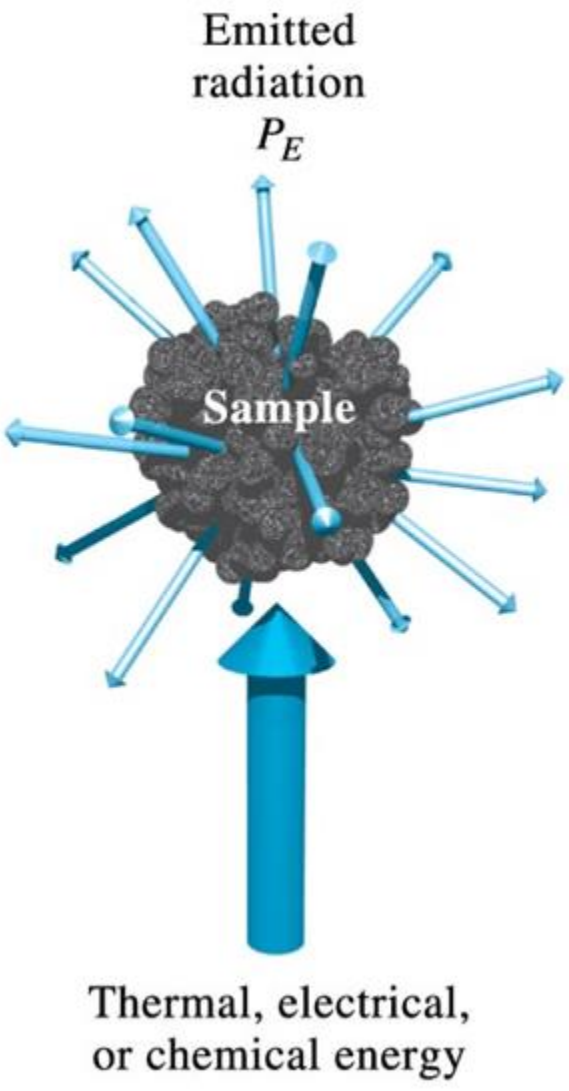
* Concentration expresses how the amount of solute and the amount of solution compare
* Our unit of choice: Molarity = mol/L
* Conc is moles (number of ions/atoms/molecule) per volume
* More molecules means more light is "caught"
* The color fade as concentration is lessened

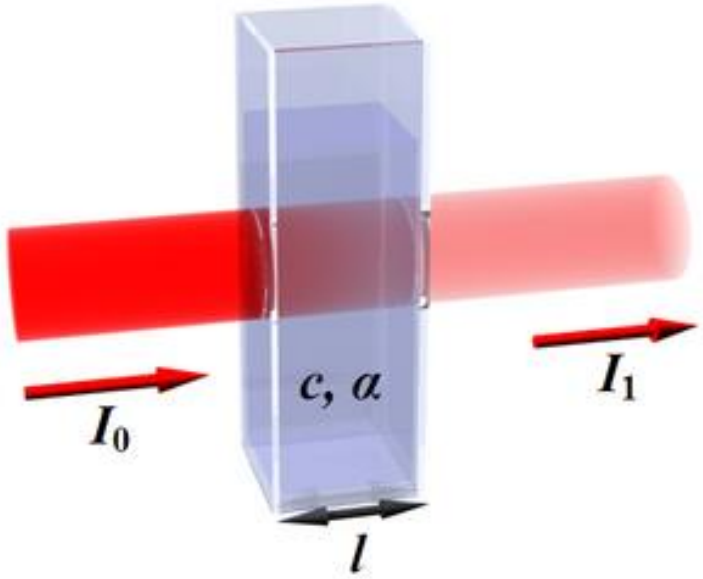


# Beer's Law

* Beer's Law quantifies the relationship between color (or any light absorbing species) and concentration
* Beer's Law states that the *absorbance* of light by a solution is directly proportional to
  * Emissivity
  * Cell width
  * concentration

# Conceptual Basis of Beer's Law




- Light of a particular wavelength enters the 'sample'.

- Light *scatters* from particles in solution reducing light transmission

- Light is *absorbed* by molecules/particles and remitted at different wavelengths, reducing light transmission

# A little more In-depth:

Beer's Law is stated in a way to make certain quantities easy to compare and interpret.

Parameters:

*b* – sample pathlength (usually 1cm)

c – concentration (mol/vol)

$\alpha$ – molar absorption coefficient ($\propto 1/\lambda$)

I – light intensity (W/m^2)

$$T = I / I_o \qquad \log(\frac{I_o}{I}) = \alpha bc \qquad A = \alpha bc$$

$$I = I_o 10^{-\alpha bc}$$

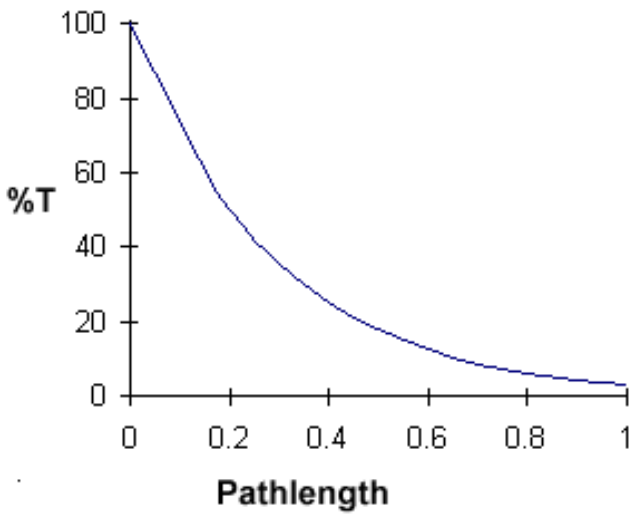
$$A = -\log T = \varepsilon b M$$

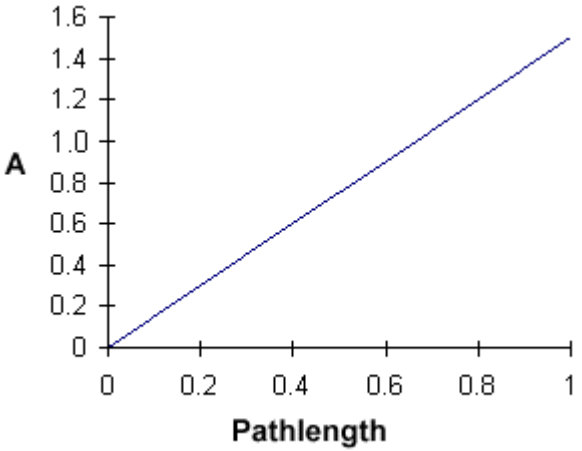
What is the absorbance when the light transmitted is 50% of the initial beam in a 2 cm path length cell for a concentration of $10^{-3}$ M?

# Graphical Relationship

* % transmission and % absorption are not linearly related to concentration
* For a graph to be useful, a straight line is needed
* **ABSORBANCE = log(1/T) = -log(T)**

# A little more In-depth:



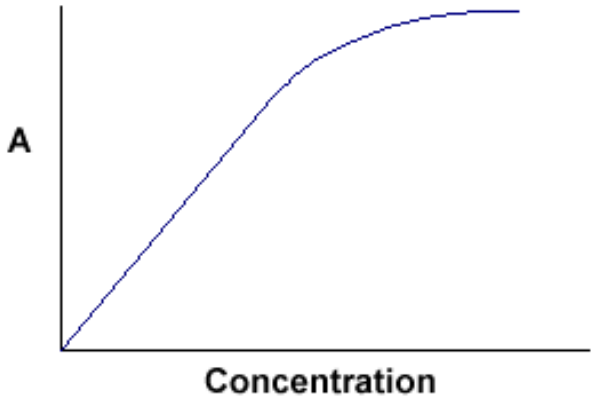
# Connection between absorption and transmittance

***Major application of Beers' law*** - determination of unknown concentration by measuring absorbance:

| A | T |
|---|---|
| **0** | **1** |
| 1 | 0.1 |
| 2 | 0.01 |
| 3 | 0 |
| ∞ | **0** |

# When can I use Beer's Law?

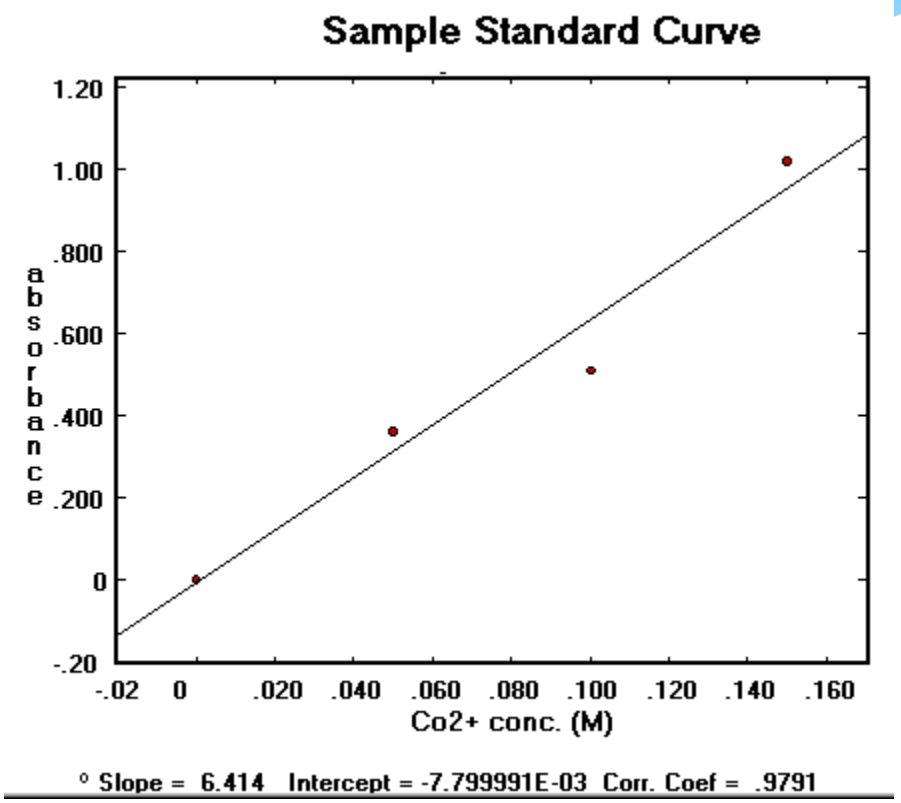
Only at low concentrations, where the absorbance is linear (single scattering event):




Rule of Thumb: A<1 for accurate results

# So, What Does This Means

* It means that a graph of absorbance of light by a "kind" of solution to the concentration is linear.
* We can find concentrations by comparison



# How Do We Do This?

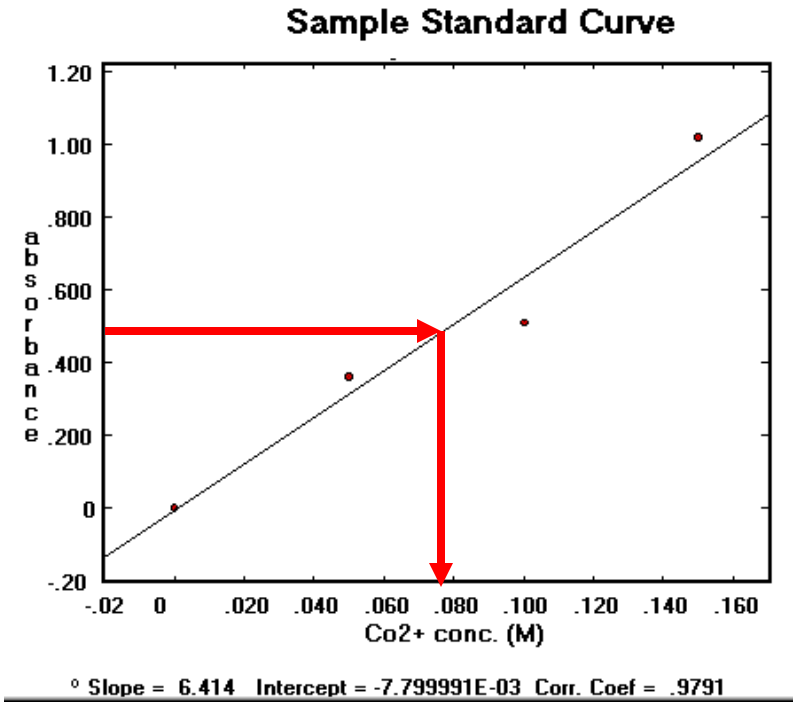
* We make several solutions with known concentrations
* We measure that transmittance and/or absorbance for the known solutions and the unknown solution
* We graph the knowns and interpolate for the unknown

# A Successive Dilution Example

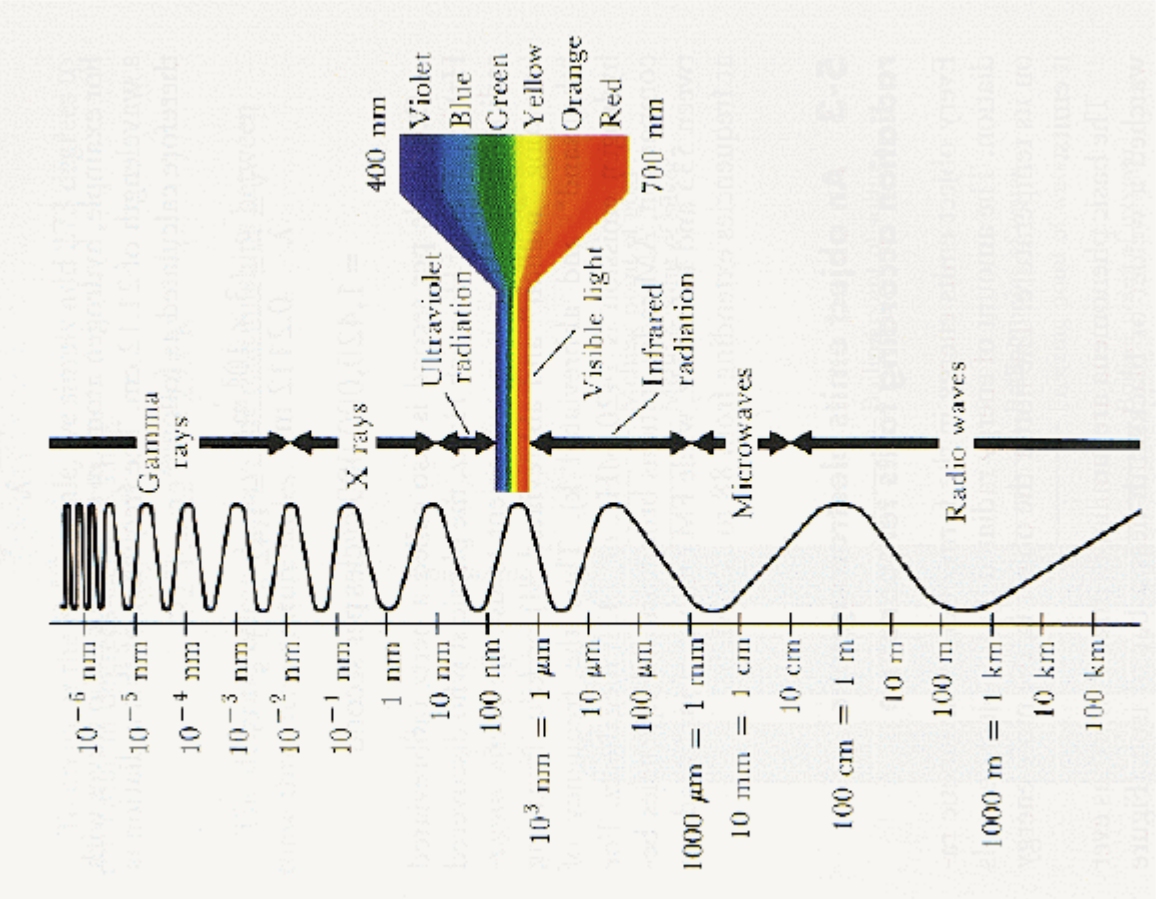
* Design a process of successive dilution to make 250.0 mls of the following solutions from a 1.00 M stock solution:  0.05 M, 0.10 M, 0.15 M.

# Finding the unknown

* Suppose this graph is generated
* The unknown absorbance is 0.500
* Find 0.500 absorbance
* Across and down
* The concentration is 0.775 (or so)



# Spectrum of electromagnetic waves




Spectrophotometry deals with light within ~200–1000 nm

# The Spectrophotometer