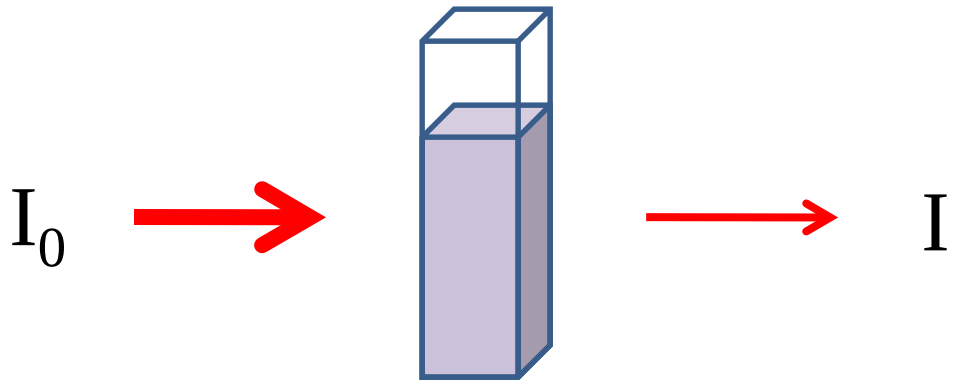
Chemistry 201

Beer's Law

NC State University

Beer's law

We can use the absorption of light by chemical compounds to determine their concentration in solution.



Beer's law

Light is attenuated exponentially in the solution:

$$I = I_0 10^{-A}$$

The attenuation factor is A the absorbance. We can also write

$$A = -log_{10}\left(\frac{I}{I_0}\right)$$

Since absorbance is measured on a log scale we can see that A = 1 means that 10% of the light is transmitted and A = 2 means that only 1% of the light is transmitted.

Thinking on a log scale

We are used to thinking on a linear scale. However, there are few easy rules of thumb to help you understand the values on a log scale. When A = 0.3 approximately 50% of the light is transmitted. We can write:

$$0.5 = 10^{-0.3}$$

This can be extended since half as much light is transmitted for 0.6, i.e.

$$0.25 = 10^{-0.6}$$

And again

$$0.125 = 10^{-0.9}$$

Absorbance

Absorbance depends linearly on concentration, c, and on path length, d: $A = \epsilon c d$

The quantity ϵ is the extinction coefficient. It is a measure of the ability of a particular molecule to absorb light. The extinction coefficient is usually reported at a particular wavelength. Often it is reported at the peak wavelength, λ_{max}. However, the extinction coefficient is a function of wavelength (or frequency actually). We should understand that it tells how strongly a molecule absorbs at any given wavelength or frequency.

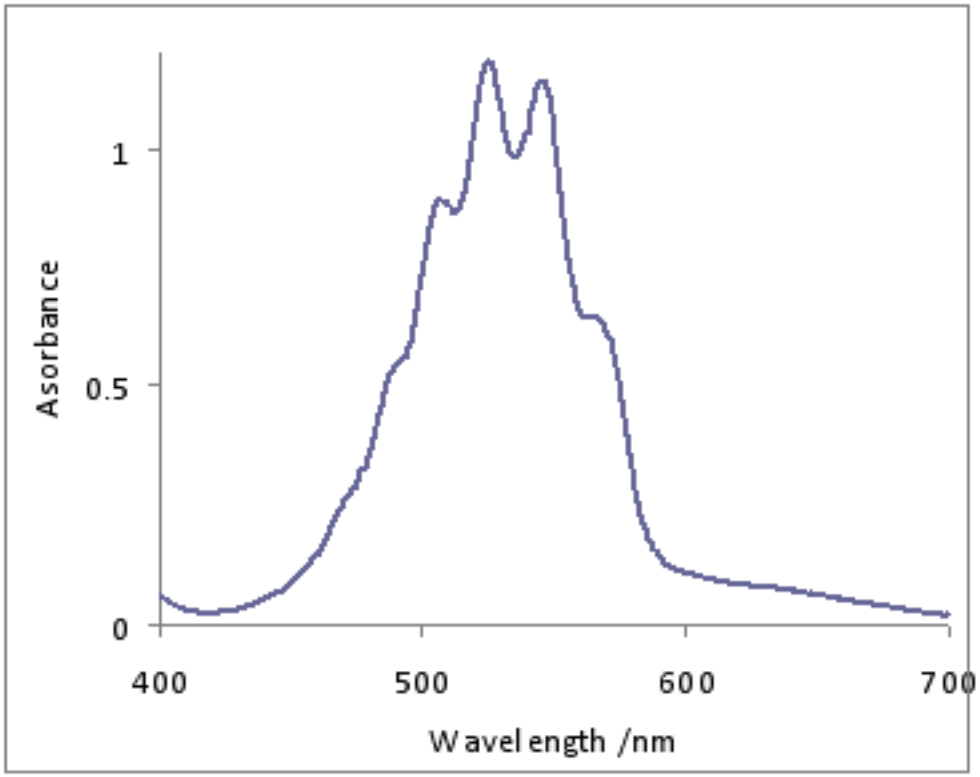
Measuring the extinction coefficient

The extinction coefficient can be measured by making solutions of various masses of a compound dissolved in a solvent. Then the absorption spectra of each are determined. A plot of absorbance vs. concentration should be a straight line with a slope equal to ϵ.

Note that the units of ϵ are $M^{-1}\ cm^{-1}$.

Potassium permanganate

The permanganate ion, MnO_4^- in aqueous solution has an intense purple color due to an O → Mn ligand-to-metal charge transfer band (LMCT) in much of the visible region. This band shows a progression in the symmetric Mn-O stretching vibration.



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