UCB008

UCB008 - APPLIED CHEMISTRY

Beer's Law

by

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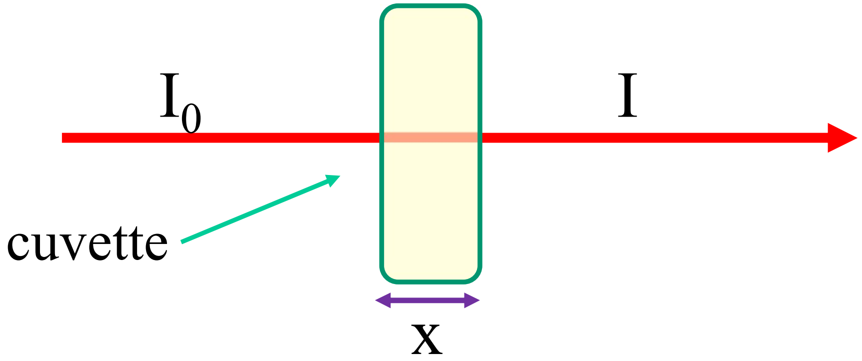
Learning Outcomes

At the end of this session participants should be able to:

- Understand and apply Beer's law in spectroscopy

Lambert Beer's Law / Beer's Law



- When a beam of monochromatic radiation passes through a solution of an absorbing substance, then, rate of decrease of intensity of radiation with the thickness of absorbing medium is directly proportional to intensity of incident radiations and concentration of solution.

(OR)

- The intensity of a beam of monochromatic radiations decreases exponentially with increase in the thickness and the concentration of the absorbing solution

Lambert's Beer Law

$$-dI/dx \propto I\,C$$

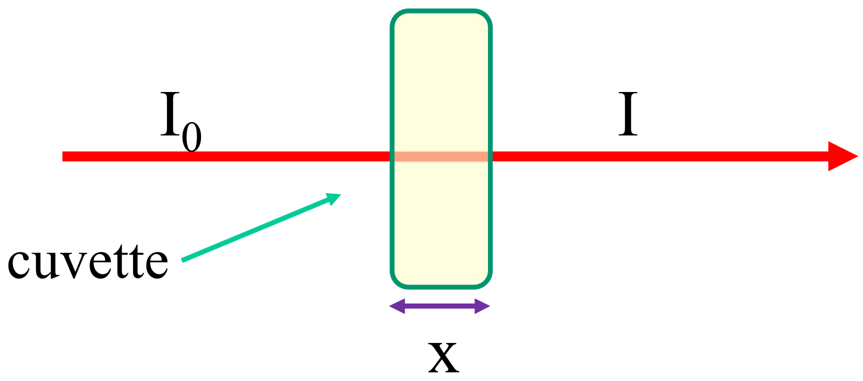
$$-dI/dx = \alpha\, I\, C$$

$\alpha \longrightarrow$ Depends on nature of absorbing medium

$$I_0 \text{ when } x = 0$$

$$I \text{ when } x = x$$

$$\int_{I_0}^{I} -dI/I = \int_{x=0}^{x=x} \alpha c\, dx$$



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$$\ln I/I_0 = -\alpha c x$$

$$I/I_0 = e^{-\alpha c x}$$

$$I/I_0 = 10^{-\frac{\alpha c x}{2.303}}$$

$\overline{\quad\quad}$ = a (Absorptivity) – Conc.- gm/L

ε (Molar Absorptivity) – Conc.- moles/L

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$$\text{Log } I/I_o = -\varepsilon c x$$

$$\text{Log } I_o/I = \varepsilon c x$$

$$\boxed{A = \text{Log } I_0/I = \varepsilon c x}$$

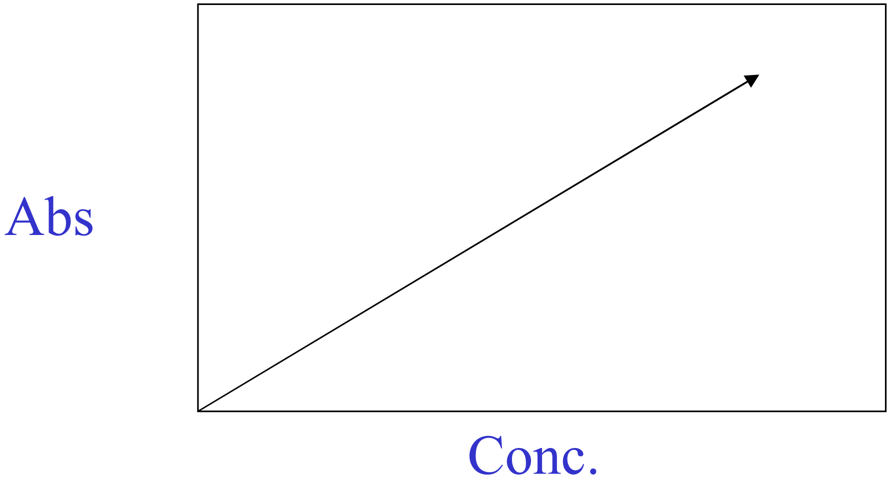
$$\boxed{A = a\, b\, c}$$

$\text{Log } I/I_o = -\varepsilon c x$

$\text{Log } I_o/I = \varepsilon c x$

$$\boxed{A = \text{Log } I_0/I = \varepsilon c x}$$

$$\boxed{A = a\,b\,c}$$



Absorbance:

- Logarithmic ratio of the intensity of incident radiation to the intensity of transmitted radiation

$$A = \text{Log } I_0/I$$

- I_0 – Intensity of incident radiation
- I - intensity of transmitted radiation

Transmittance:

- The ratio of the intensity of transmitted radiation to the intensity of incident radiation

$$T = I / I_0$$

Relation between Absorbance and Transmittance:

$$A = \text{Log } 1/T$$

Limitations

Beer's law is valid in the following conditions

1. Beer's law is applicable to dilute solutions only

•Beer's law is strictly applicable to solutions in which concentration dependent interaction among absorbing molecules and ions are at a minimum. Such interaction, which usually begin to appear at concentrations greater than 0.01M alter molar absorptivities and thus lead to non-linear relationship between absorbance and concentration.

•Deviations also arise because the molar absorptivity (ε) of a substance is dependent upon the refractive index of the solution which in turn becomes dependent upon the concentration of analyte at concentration greater than 0.01M.

•These refractive index changes lead to concentration dependent variations in the molar absorbtivity of the analyte and departs from Beer's law.

Limitations

Beer's law is valid in the following conditions

1. Beer's law is applicable to dilute solutions only

2. Monochromatic radiations

3. Solute must not undergo association, dissociation, polymerization, hydrolysis in the solvent

$$\begin{array}{ccccc} \text{MeBI} & \longleftrightarrow & (\text{MeBI})_2 & \longleftrightarrow & (\text{MeBI})_3 \\ 660\text{nm} & & 610\text{nm} & & 500\text{nm} \\ 1\text{x}10^{-5}\text{M} & & 1\text{x}10^{-5}\text{M-5x } 10^{-3}\text{M} & & 5\text{x}10^{-3}\text{M – above} \end{array}$$

Precautions

1. When absorbance depends on the pH of the medium, the acid base buffers used should not cause any interference in absorbance

2. Clear solution free from foreign substances should be used as blank or test solution

3. Absorption values should be stable and reproducible i.e., factors like pH and time affecting the nature of solute chemically must be fixed

In the next session…..

- Atomic spectroscopy

Lambert's Law

$$-dI/dx \propto I$$

$$-dI/dx = K I$$

I_0 when $x = 0$

I when $x = x$

$$\int_{I_0}^{I} -dI/I = -\int_{x=0}^{x=x} K dx$$

$\ln I/I_0 = -kx$ $\quad I/I_0 = e^{-kx}$ $\quad I/I_0 = 10^{-\frac{kx}{2.303}}$

$\overline{\quad\quad} = a$ (ABSORPTIVITY)

$$I/I_0 = 10^{-ax}$$

$$\text{Log } I/I_0 = -ax$$

$$\boxed{A = \text{Log } I_0/I = ax}$$