INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

COURSE	ROLL NO.	NAME	
CH 117L	23B0912	Aditya Somapala	10/10
ASSIGNMENT NO. 6		DUE DATE	SUB. DATE

Experiment-6: Investigating chemical kinetics using a self-made polarimeter

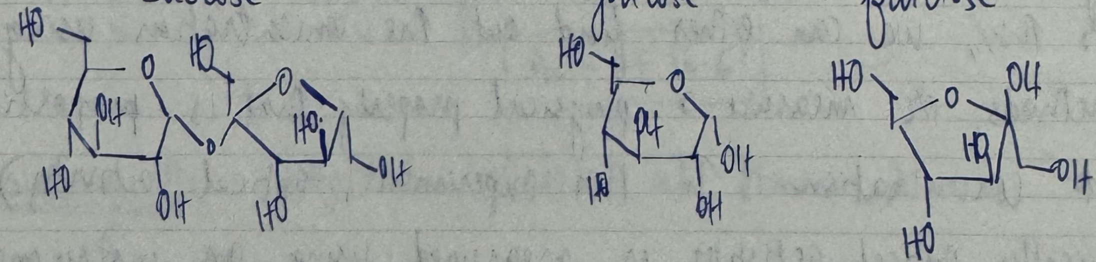
Aim:

To construct a working polarimeter using LEGO, and determine the rate constant for the inversion of sucrose using this polarimeter.

Principle:

→ Sucrose hydrolyzes in acidic medium (H^+) to give glucose and fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightleftharpoons{H^+} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{fructose}}{C_6H_{12}O_6}$$



→ The rate of this reaction depends on the concentrations of sucrose, water and acid.

→ But since a large excess of ~~ce~~ water is needed and the acid acts as a catalyst, the rate of the reaction depends only on the concentration of sucrose.

→ Therefore, it is a first order reaction.

→ So, the differential rate law is

$$v = -\frac{d[\text{Sucrose}]}{dt} = K[\text{Sucrose}]$$

K = Specific rate constant.

⇒ integral form: $\ln[\text{Sucrose}] = Kt + C$ C = Constant

with limits [Sucrose] at t = 0 and [Sucrose] at t, we get

$$\boxed{K = \frac{2.303}{t}\log_{10}\left(\frac{[\text{Sucrose}]_0}{[\text{Sucrose}]_t}\right)}$$

→ The rate of a chemical reaction can be ~~written~~ followed by measuring the concentrations of either reactants or products as a function of time.

→ For this, we can either find out the concentration using chemical methods, or measure a physical property that is proportional to concentration. (In this experiment, optical activity)

→ Typically, optical activity is measured using an instrument known as a polarimeter.

→ The extent of rotation of the plane of polarized light is a measure of the optical activity of the solution.

INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

COURSE CH117L 23B0912	ROLL NO.	NAME Aditya Samapala	
ASSIGNMENT NO. 6		DUE DATE	SUB. DATE

Observations:

1) Blank reading / Calibration reading :

We get the angle for minimum transmission

$$\boxed{\theta_0 = -5^\circ}$$

2) Measuring A_∞ (optical rotation at $t \to \infty$)

We get the angle for A_∞ to be

$$\boxed{A_\infty = -3.5^\circ}$$

3) Measuring A_0 (optical rotation at $t = 0$)

We get the angle for A_0 to be

$$\boxed{A_0 = +16.6^\circ}$$

4) Measuring A_t (optical rotation at time t)

Solution used = 20 mL 40% Sucrose + 20 mL 2M HCl.

reaction $\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{fructose}}{C_6H_{12}O_6}$

$A_0 - A_\infty = +16.5 - (-3.5) = 20$

Time t (mins)	Optical rotation A_t	$A_t - A_\infty$	$\log_{10}\left(\frac{A_0 - A_\infty}{A_t - A_\infty}\right)$	K (min^{-1})
5	+15.5	$15.5 - (-3.5) = 19$	$= \log_{10}\left(\frac{20}{19}\right) = 0.0223$	0.0103
10	+13.5	$13.5 - (-3.5) = 17$	$\log\left(\frac{20}{17}\right) = 0.0706$	0.01626
15	+13	$13 - (-3.5) = 16.5$	$\log\left(\frac{20}{16.5}\right) = 0.0835$	0.0128
20	+9.5	$9.5 - (-3.5) = 13$	$\log\left(\frac{20}{13}\right) = 0.1870$	0.0215
25	+9	$9 - (-3.5) = 12.5$	$\log\left(\frac{20}{12.5}\right) = 0.2041$	0.0188
30	+8.5	$8.5 - (-3.5) = 12$	$\log\left(\frac{20}{12}\right) = 0.2218$	0.0170

Calculation (for $t = 5$ min)

We have $A_t = +15.5$, $A_\infty = -3.5$ and $A_0 = +16.5$

$\Rightarrow A_0 - A_\infty = +16.5 - (-3.5) = 16.5 + 3.5 = 20.$

$\Rightarrow A_5 - A_\infty = +15.5 - (-3.5) = 15.5 + 3.5 = 19.$

from the integrated rate law, we have

$$K = \frac{2.303}{t} \log_{10}\left(\frac{A_0 - A_\infty}{A_t - A_\infty}\right)$$

$$\Rightarrow K = \frac{2.303}{5} \cdot \log_{10}\left(\frac{20}{19}\right) = \frac{2.303}{5} \times 0.0223 = 0.0103.$$

INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

COURSE	ROLL NO.	NAME	
CH117L	23B0916	Aditya Samapala	
ASSIGNMENT NO. 6		DUE DATE	SUB. DATE

Calculation of avg. rate constant

$$K = \frac{K_1 + K_2 + K_3 + K_4 + K_5 + K_6}{6}$$

$$= \frac{0.0103 + 0.0162 + 0.0128 + 0.0215 + 0.0188 + 0.0170}{6}$$

$$= \frac{0.0966}{6}$$

$$\boxed{K = 0.0161}\ min^{-1}$$

Result:

→ The value of rate constant for the hydrolysis of sucrose is

$$\boxed{K = 0.0161\ min^{-1}}$$

2

3/3