



Second Stage

Practical Physical Pharmacy II

Lab: 3



Introduction

Reaction kinetics: Is studying the rate of reaction and factors affecting it.

The rate of any reaction is expressed as the change in concentration per unit time

$$\text{Rate} = \pm dc/dt$$

Where, *dc* is change in concentration.

dt is change in time.

Introduction

+ means an increase in conc. with time (when the reaction is formation reaction).

- means a decrease in conc. with time (when the reaction is hydrolysis reaction).

Rate of Reaction

Is the velocity or speed at which the reaction proceeds, it is proportional to the product of molar concentration of reactants, each raised to a power which is equal to the number of moles undergoing the reaction.



► **Rate** $\propto [A]^a [B]^b$

Rate = **k** $[A]^a [B]^b$ Where **k**: reaction rate constant

Rate of Reaction

Rate of reaction is influenced by:

1. Concentration of reactant and products
2. Ionic strength
3. Solvent
4. Temperature

Properties of reaction rate constant

- ❖ Depends on temperature
- ❖ It has a positive value
- ❖ Its unit depends on the order of reaction
- ❖ A higher k means a faster reaction

Orders of reaction

Definition

It is the no of atoms or molecules whose concentration determine the rate of reaction.

Main types

- ▶ Zero order
- ▶ First order
- ▶ Second order

Zero- order Kinetics

Rate of reaction is independent on concentration of reactants.

$$- dc/ dt= k$$

After get the integration:

$$c_t = c_0 - kt$$

- Where, c_t : is the conc. at time t.
- ❖ c_0 : is the initial conc. or conc. at time 0.
- ❖ k : is zero order reaction rate constant
- ❖ t : time

Zero- order Kinetics

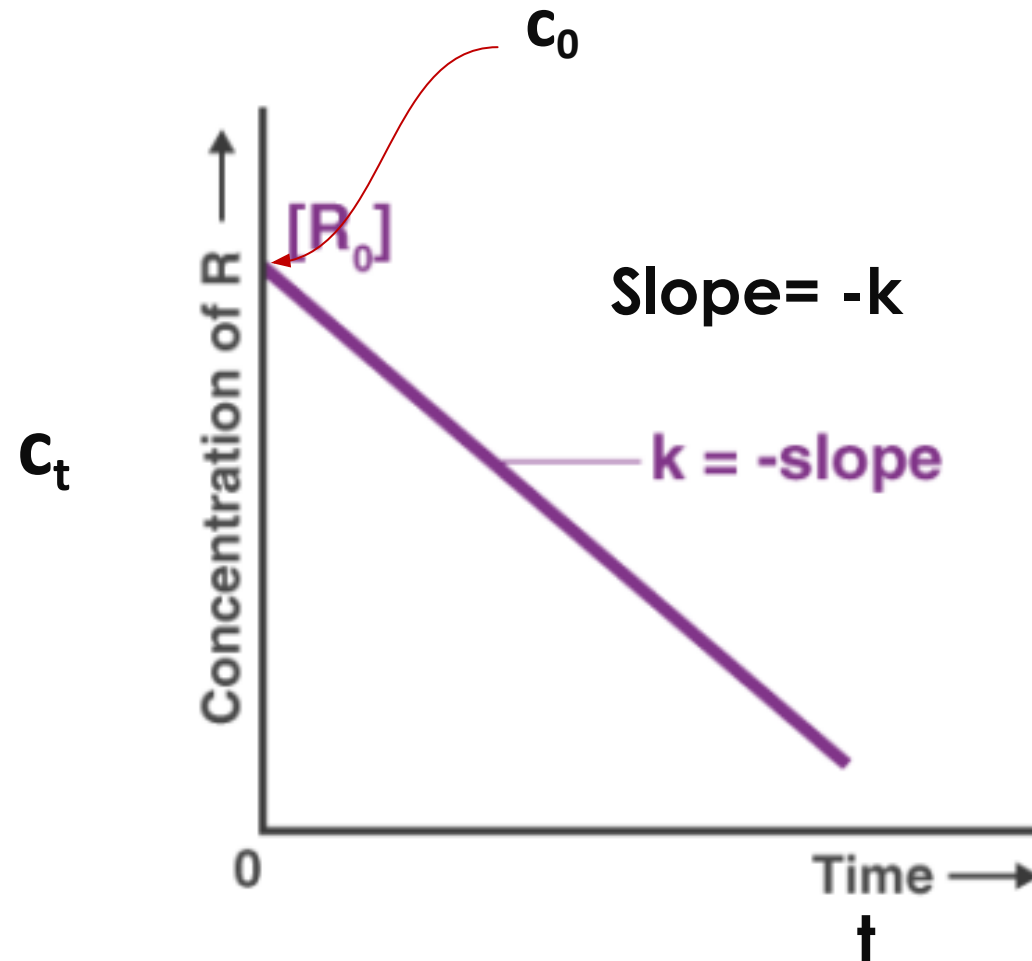
When we compare this equation with linear equation:

$$Y = a - bx \text{ (linear equation)}$$

- ❖ c_t : represent Y-axis.
- ❖ c_0 : represent Y- intercept.
- ❖ k : represent slope.
- ❖ t : represent X-axis.

Note: the unit of k of zero order reaction is (mole/L/ unit time).

Zero- order Kinetics



First- order Kinetics

Rate of reaction depends on the concentration of one term only, although there may be more than one reactants involved in the reaction.

- ❖ $- dc/dt \propto c$

- ❖ $- dc/dt = kc$

- ❖ After get the integration:

- ❖ $\log c_t = \log c_0 - kt/2.303$

First-order Kinetics

When we compare this equation with linear equation:

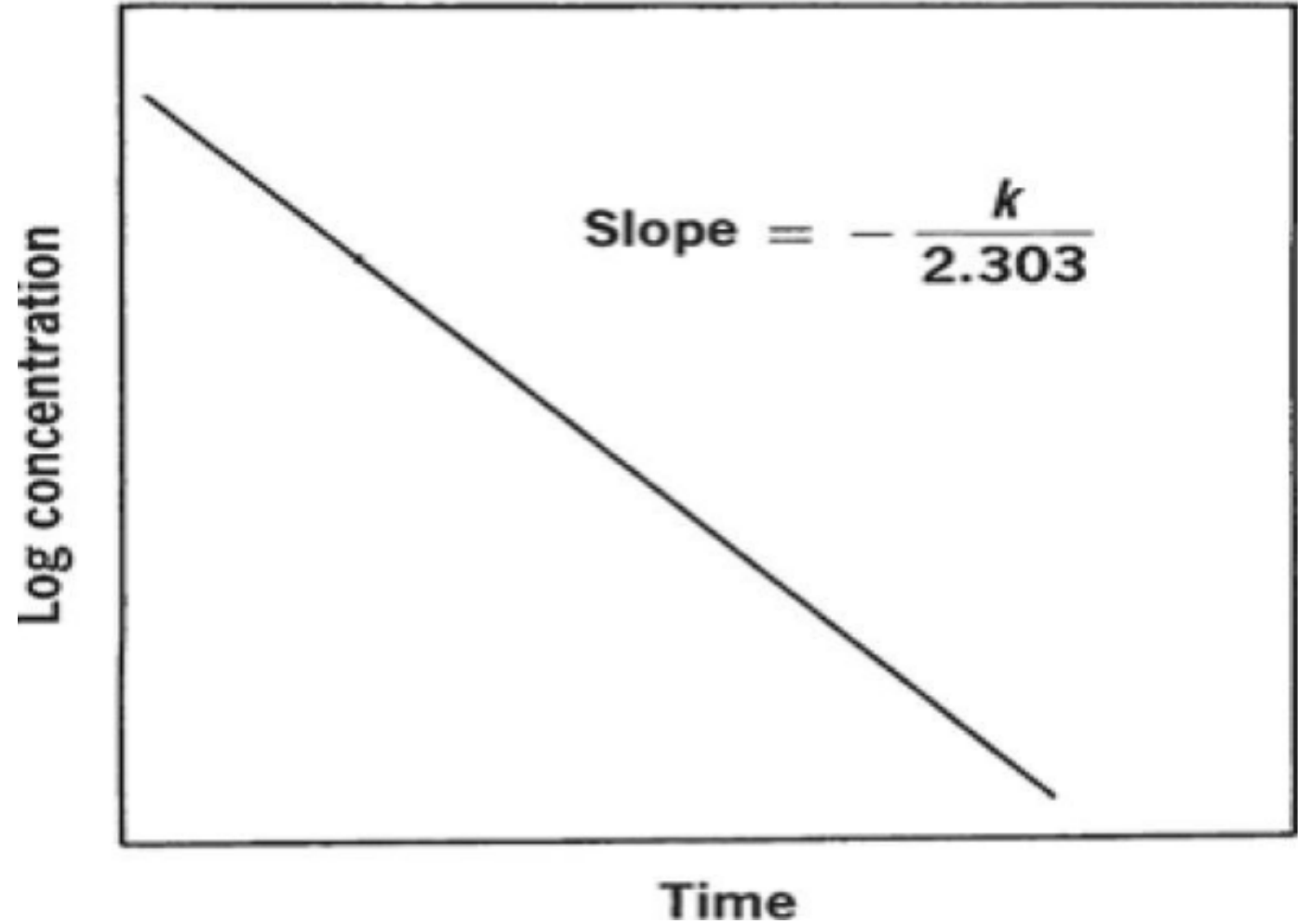
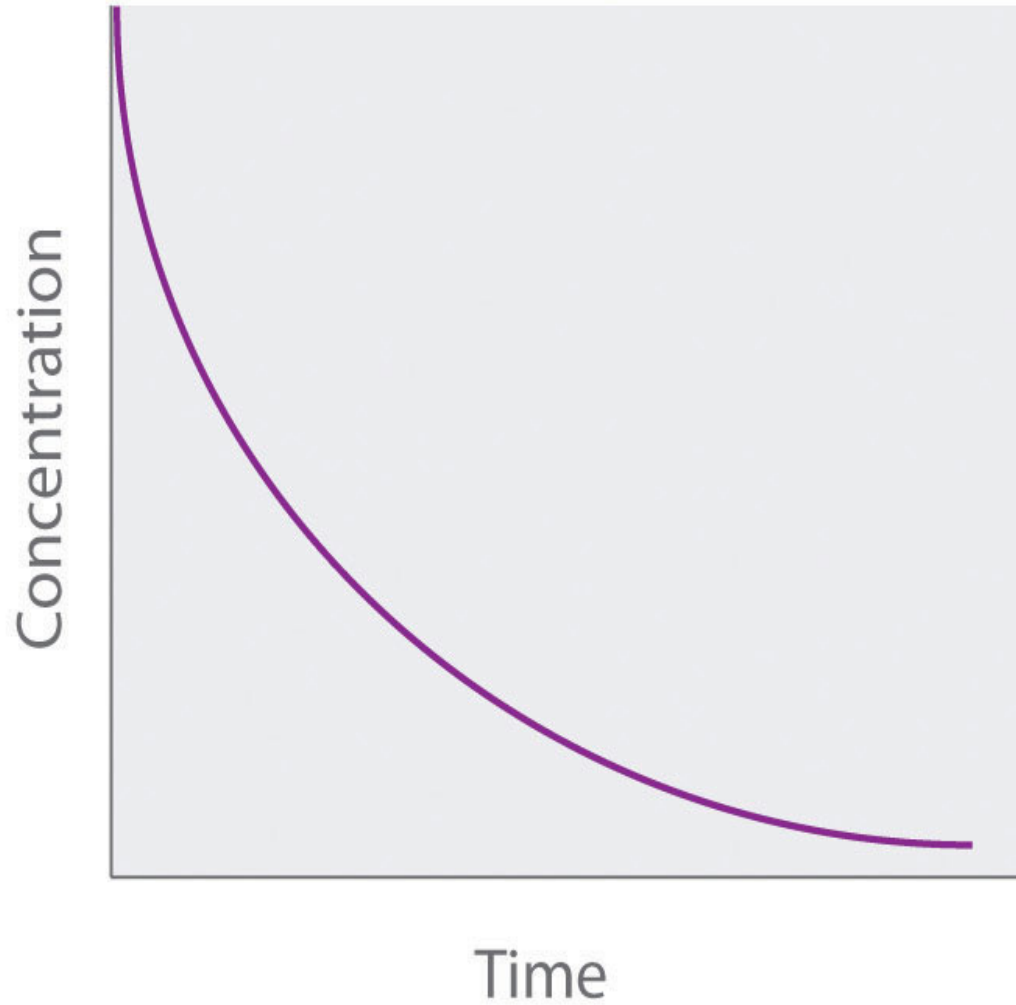
$$Y = a - bx \text{ (linear equation)}$$

c_t : represent Y-axis.

- ❖ c_0 : represent Y- intercept.
- ❖ $-k/2.303$: represent slope.
- ❖ Slope = $-k/2.303$ or $k = -2.303 \times \text{slope}$
- ❖ t : represent X-axis.

Note: the unit of k of first order reaction is $(\text{time units})^{-1}$.

First- order Kinetic reaction



Half-life ($t_{50\%}$) & Shelf-life ($t_{10\%}$)

Half-life ($t_{50\%}$) Is the time required for the drug to decompose to half its original concentration at room temperature.

$$t_{50\%} = 0.693/k_{25\text{ }^\circ\text{C}} \text{ (for first order reaction)}$$

❖ Shelf-life ($t_{10\%}$)

❖ Is the time required for the drug to lose 10% of its original conc. at room temp. It is used to calculate expiration date of drug.

$$\square t_{10\%} = 0.105/k_{25\text{ }^\circ\text{C}} \text{ (for first order reaction)}$$

Experimental Work

Name of Experiment: Hydrolysis of aspirin

Aims of Experiment:

- 1- To study the hydrolysis of Aspirin in aspirin solution.
- 2- To study the effect of temperature on aspirin.
- 3- To calculate the hydrolysis rate constant of aspirin solution at room temp (K 25°C).
- 4- To determine the half-life and shelf life of aspirin solution.

Procedure

- 1-For each group: Prepare 50 ml of aspirin solution in a conical flask by mix 0.9 g of aspirin with 1.8 g of trisodium citrate (TSC) and complete the volume to 50 ml by addition of D.W.
- 2- Dissolve as much as possible by shaking for 5 minutes
- 3- Set aside for 5 minutes.
- 4- filter the solution in another conical flask.
- 5- Take 5 ml from the filtrate to calculate c_0

Procedure

- 6- Add 2 drops of ph.ph. indicator.
- 7- Titrate against 0.2 N of NaOH solution
- 8- Record the E.P. when the color changes from colorless to pink
(record this E.P as X)
- 9- Put each conical flask in one of three water bathes adjusted at 45°C, 60°C and 75 °C except the first group (continue with 25 °C).

Procedure

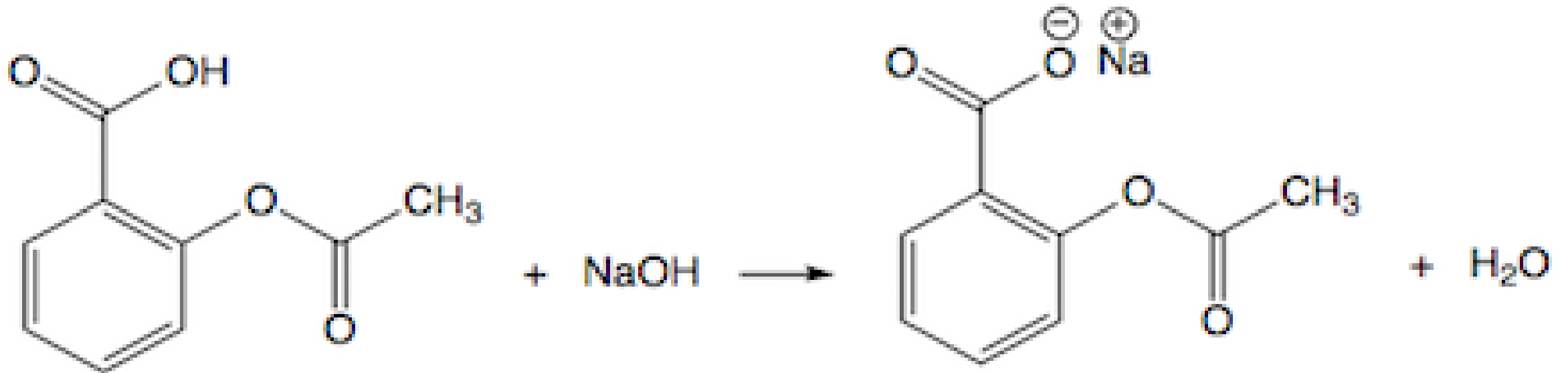
- 10- After 10 minutes take 5 ml from each conical flask into another conical flask
- 11- Add 2 drops of Ph.Ph. indicator.
- 12- Titrate against 0.2 N of NaOH
- 13- Record the E.P as Y10
- 14- Repeat the process every 10 minutes with recording the end points as (Y20, Y30, and Y40).

Procedure

1- at zero time (t=0)

There is no hydrolysis of aspirin, so only aspirin will react with NaOH

End point= X (vol. of NaOH react with aspirin)

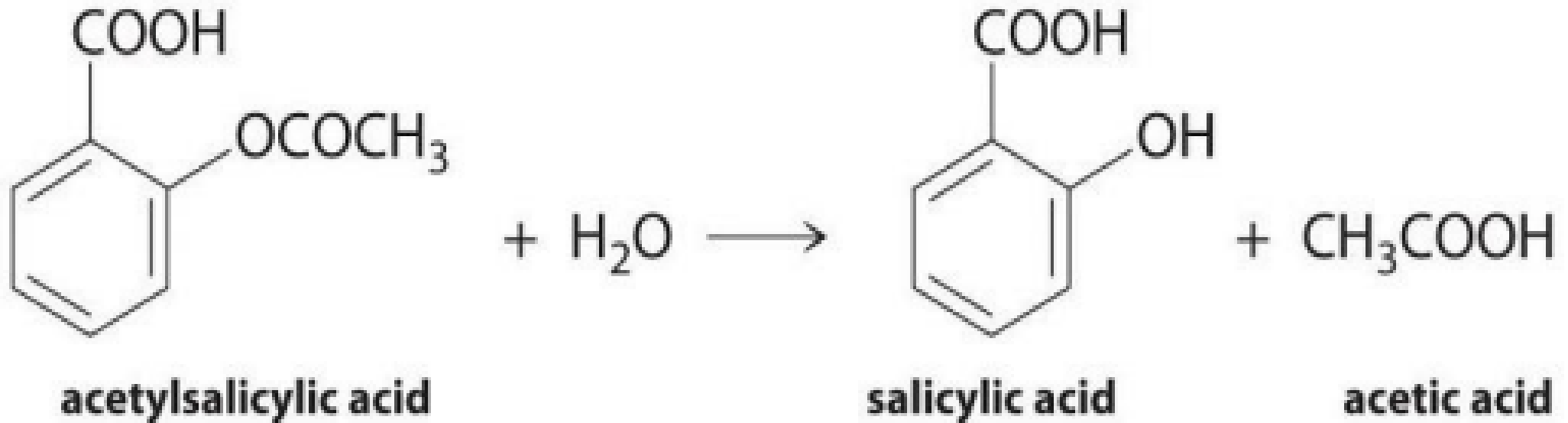


Acetylsalicylic acid

Sodium acetylsalicylate

Procedure

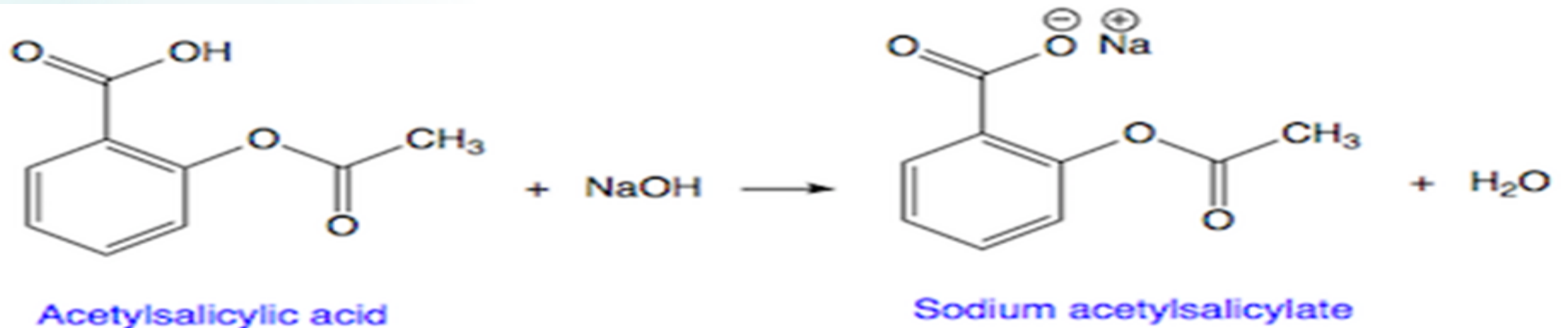
2. At time > 0 (during partial hydrolysis):



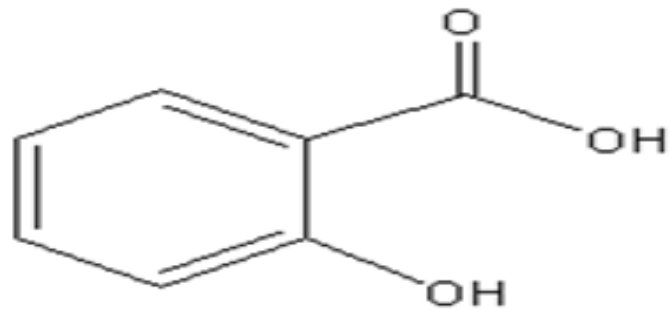
Procedure

So during titration NaOH will react with unhydrolyzed aspirin. In addition to Salicylic acid and Acetic acid as shown below.

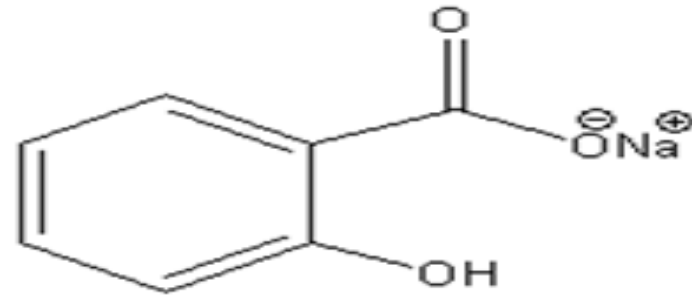
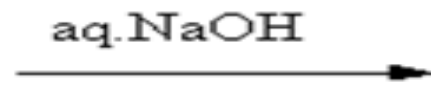
End point = Y (vol. of NaOH that reacts with aspirin, salicylic acid and acetic acid at time t).



Procedure



Salicylic acid



Sodium salicylate



Procedure

3. After complete hydrolysis of aspirin (at the end of hydrolysis):

All aspirin will be converted to salicylic acid and acetic acid, and both products will react with NaOH.

End point= $2X$ (volume of NaOH that reacts with salicylic acid and acetic acid after complete hydrolysis of aspirin).

Calculation

To obtain the weight (g.) of aspirin remaining after certain time (t) we need to use:

$$(2X - Y) \times \text{Chemical Factor}$$

$$\% \text{ weight of aspirin remaining} = \frac{\text{weight of aspirin remaining}}{\text{weight of total aspirin}} \times 100\%$$

$$\% \text{ weight of aspirin remaining} = \frac{2X - Y * \text{chemical factor}}{X * \text{chemical factor}} \times 100\%$$

$$C\% = 2X - Y / X\%$$

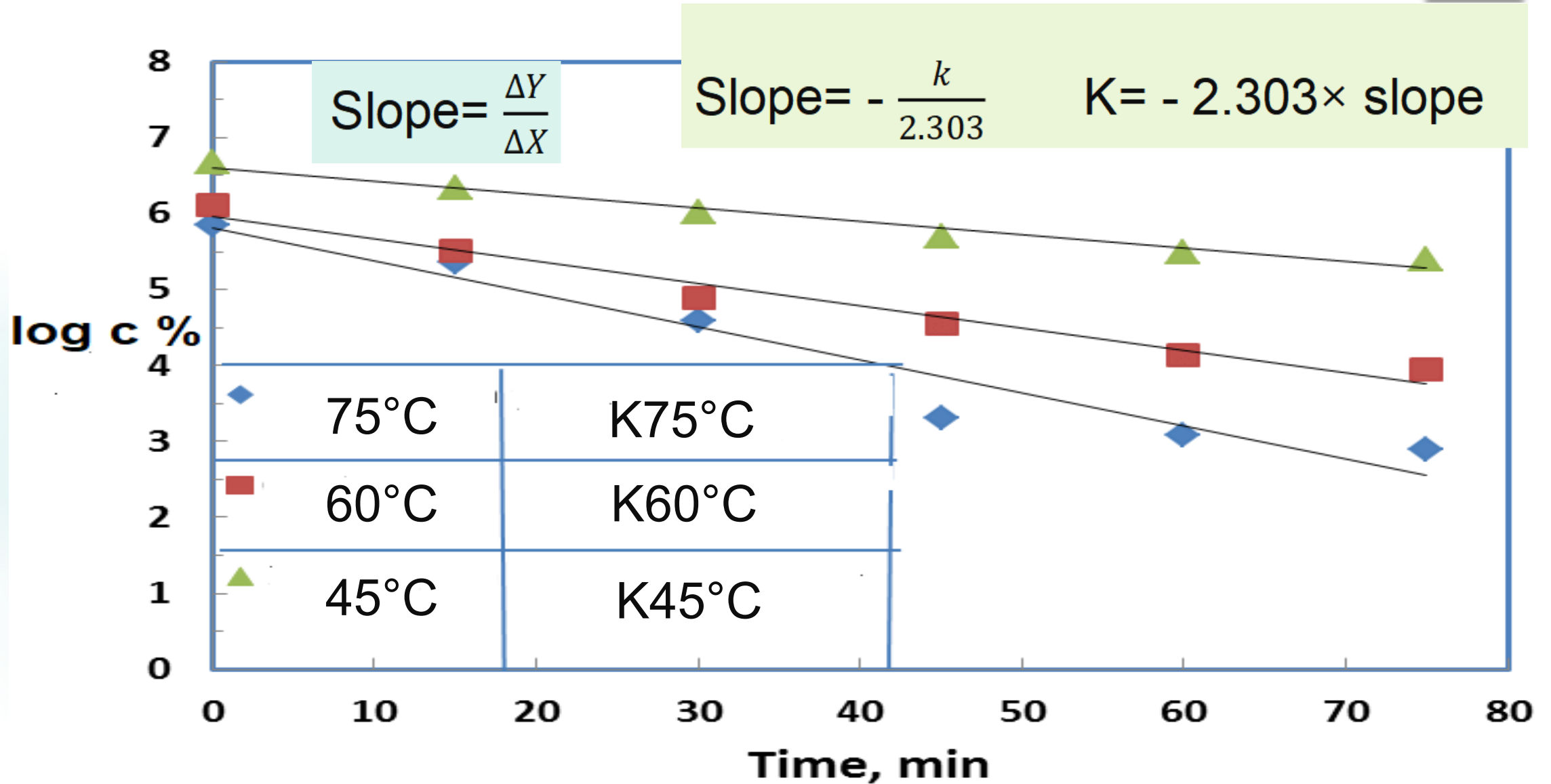
Calculation

X represent the end point at zero time (before any hydrolysis)

Y represents the end point at time t (during partial hydrolysis)

2X represent the end point after complete hydrolysis (at the end of reaction).

Calculation



Calculation

- End points are increased with both the time and the temp.
- This is because each one molecule of aspirin is decomposed into 2 molecules of acids which are acetic acid and salicylic acid which consumed double the volume of NaOH that was consumed by aspirin molecules before hydrolysis.

Calculation

Arrhenius plot

1. Calculate $K_{45^{\circ}\text{C}}$, $K_{60^{\circ}\text{C}}$ and $K_{75^{\circ}\text{C}}$ (from the slope at 45°C , at 60°C and at 75°C respectively)
2. Calculate $\log K_{45^{\circ}\text{C}}$, $\log K_{60^{\circ}\text{C}}$ and $\log K_{75^{\circ}\text{C}}$.
- 3-Convert the temp, from ($^{\circ}\text{C}$) to (K) where:

$$T(\text{K}) = ^{\circ}\text{C} + 273$$

Calculation

Arrhenius plot

4. Calculate $1/T$ for each temp.

5- Plot $(\log K)$ vs. $(1/T)$ which is called Arrhenius plot.

6-Get $\log K_{25^\circ\text{C}}$ from the Arrhenius plot then calculate $K_{25^\circ\text{C}}$.

7- Calculate $t_{50\%}$ and $t_{10\%}$.

Calculation

$$\text{Log } k = \left(\frac{-E_a}{2.303 RT} \right) + \log A \quad (\text{Arrhenius Equation})$$

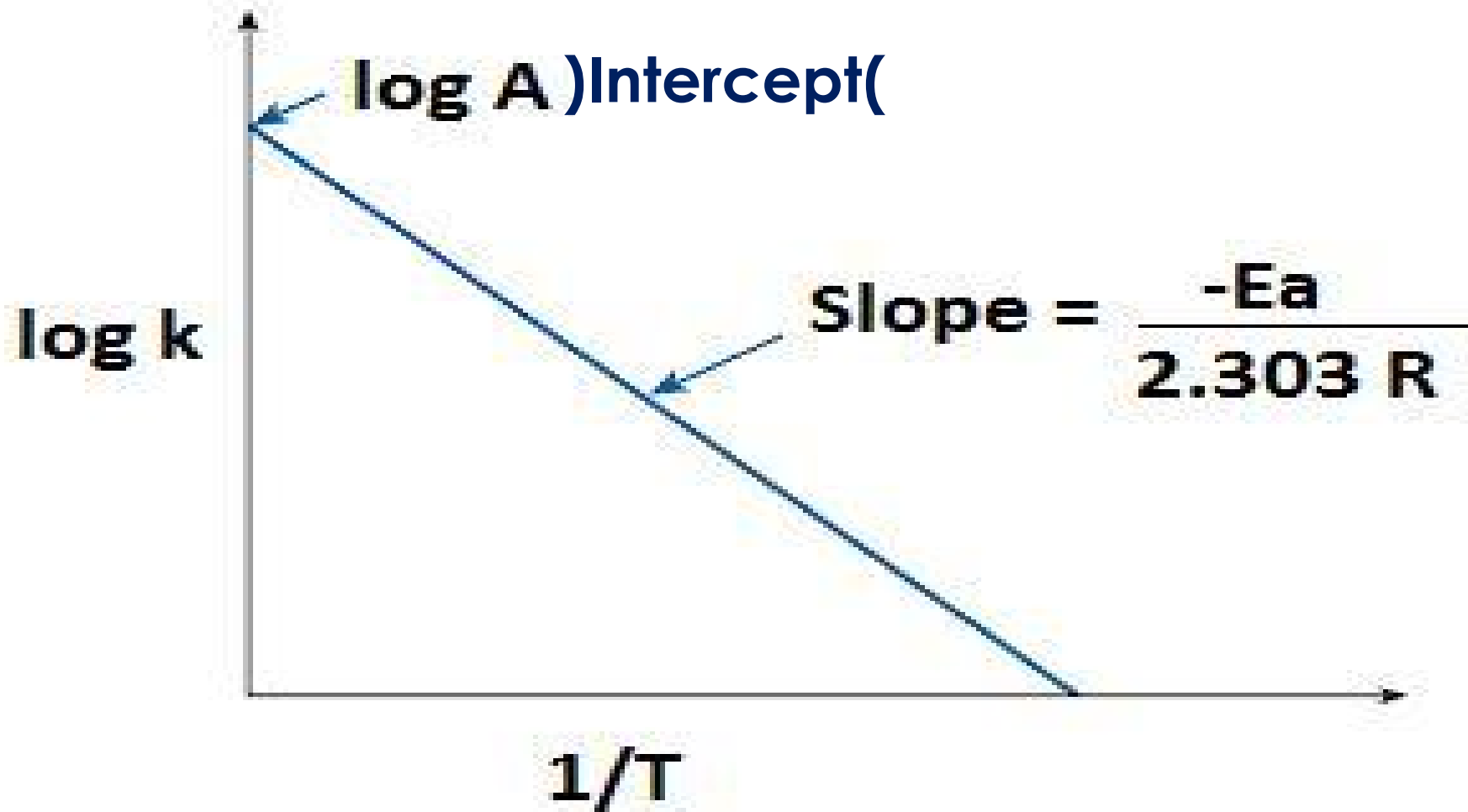
E_a = Energy of activation

R = Gas constant

T = Temperature in Kelvin

A is a constant known as frequency factor. It gives frequency of binary collisions of reactant molecules per second per liter

Calculation



Calculation

Temp. (°C)	slope	K	log k	T (K)	1/T
25 °C	??	??			
45 °C					
60 °C					
75 °C					

Calculation

$$\text{half life} = t_{50\%} = 0.693/k_{25\text{ }^\circ\text{C}}$$

□ $\text{shelf life} = t_{10\%} = 0.105/k_{25\text{ }^\circ\text{C}}$

End of Lab-3