Why kinetics is very important in Pharmacy?

Kinetics is a rate process. It has many applications in the field of pharmaceutics including:
1. Stability and incompatibility where the rate process is generally one that leads to the inactivation of a drug through either decomposition or loss of the drug by its conversion to a less favorable physical or chemical form.
2. Dissolution, in which the primary concern is the rapidity with which a solid dosage form is converted to a molecular solution of the drug.
3. Absorption, distribution and elimination processes that are associated with the role of absorption of a drug into the body, the rate at which the drug is subsequently distributed through the body and the rate at which it is removed from distribution by factors such as metabolism, storage within a body organ or fat, and by excretory routes.
4. Drug action at the molecular level for which convenient model may be constructed assuming that the generation of a response by a drug is a rate process.
The Rate Expression

The rate, velocity, or speed of a reaction

*Reaction rate* is the change in the concentration of a reactant or a product with time.
Reaction Kinetics and Drug Stability

\[ \text{rate} = - \frac{dA}{dt} \]

\[ \text{rate} = \frac{dB}{dt} \]
rate = \( \frac{-dA}{dt} \)

\( dA = \) decrease in concentration of A over time period dt

rate = \( \frac{dB}{dt} \)

\( dB = \) increase in concentration of B over time period dt

Because \([A]\) decreases with time, \(dA\) is negative.
The Rate Expression

\[ \pm \frac{dC}{dt} \]

This expression gives the increase (+) or decrease (-) of concentration, C, within a given time interval, dt.

\[ R_f = \frac{dA}{dt} = - \frac{dB}{dt} \quad R_f = \frac{dC}{dt} = \frac{dD}{dt} \]

A + B → C + D
The Rate Expression

\[ \pm \frac{dC}{dt} \]

This expression gives the increase (+) or decrease (-) of concentration, C, within a given time interval, dt.

\[ - \frac{d (A)}{dt} = - \frac{1}{2} \frac{d (B)}{dt} \]
The Rate Expression

\[ \text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH} \leftrightarrow \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O} \]

\[
\text{rate} = - \frac{d[\text{CH}_3\text{COOH}]}{dt} = - \frac{[\text{CH}_3\text{COOH}]_{\text{final}} - [\text{CH}_3\text{COOH}]_{\text{initial}}}{t_{\text{final}} - t_{\text{initial}}} = - \frac{[80.46] - [94.14]}{10 - 5}
\]

<table>
<thead>
<tr>
<th>time</th>
<th>% acetic acid remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>94.14</td>
</tr>
<tr>
<td>10</td>
<td>80.46</td>
</tr>
<tr>
<td>15</td>
<td>72.64</td>
</tr>
<tr>
<td>30</td>
<td>51.14</td>
</tr>
<tr>
<td>45</td>
<td>35.50</td>
</tr>
</tbody>
</table>
The rate law

The rate of a chemical reaction is proportional to the product of the molar concentration of the reactants each raised to a power equal to the number of molecules of the substance undergoing reaction:

A + B → C + D

The rate equation can be written as:

\[ R_f = - \frac{dA}{dt} = - \frac{dB}{dt} = k(A)(B) \]

In which \( k \) is known as the reaction rate constant.
The order of reaction

The overall order of a chemical reaction is the sum of the exponents of the concentration terms in a reaction kinetics equation that after integration gives a linear plot.

\[ a \text{A} + b \text{B} \rightarrow g \text{G} + h \text{H} \]

The rate equation can be written as:

\[
\begin{align*}
-\frac{1}{a} \frac{d(A)}{dt} &= -\frac{1}{b} \frac{d(B)}{dt} \\
&= \frac{1}{g} \frac{d(G)}{dt} = \frac{1}{h} \frac{d(H)}{dt} = K(A)^m (B)^n
\end{align*}
\]

reaction is \( m \)th order in A

reaction is \( n \)th order in B

reaction is \( (m + n) \)th order overall
The order of reaction

The overall order of a chemical reaction is the sum of the exponents of the concentration terms in a reaction kinetics equation that after integration gives a linear plot.

\[ a \ A + b \ B \rightarrow g \ G + h \ H \]

The rate equation can be written as:

\[
- \frac{1}{a} \frac{d(A)}{dt} = - \frac{1}{b} \frac{d(B)}{dt} = \frac{1}{g} \frac{d(G)}{dt} = \frac{1}{h} \frac{d(H)}{dt} = K(A)^m(B)^n
\]

Concentration term exponents \((m \text{ and } n)\) are usually small whole numbers but may be fractional, negative or zero.

They are unlikely to be the stoichiometric factors for the overall rate law.
Reaction Mechanisms

Simple elementary step

Sequence of elementary steps
Reaction Mechanisms

Simple elementary step

Sequence of elementary steps

Elementary processes are reversible $A \rightleftharpoons B$

- Exponents for concentration terms are the same as the stoichiometric factors for the elementary process
Reaction Mechanisms

Simple elementary step

Sequence of elementary steps

- One elementary step is usually slower than all the others and is known as the **rate determining step**.

- **Intermediates** are produced in one elementary process and consumed in another. They do not appear in the overall chemical equation or the rate law.