

AS Biology /9700

2020/2021

Full Notes

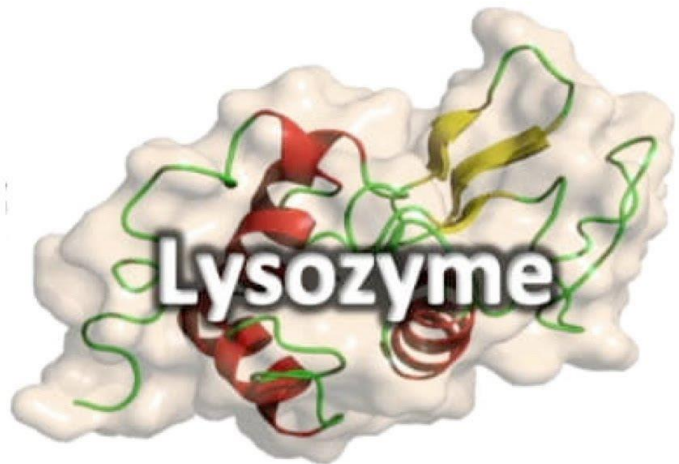
Produced By

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Enzymes!



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MR,

Metabolic reactions or Metabolism

Are **biochemical reactions** that take place within an organism and necessary for its life.

-Metabolic reactions inside living organisms is controlled by an enzyme.

Example Amylase and ATPase

Types of metabolic reactions

1-Anabolism

A metabolic reaction that leads to synthesis of **large molecules** from smaller units.

Example

Photosynthesis.

2-Catabolism

A metabolic reaction that leads to **breakdown of large molecules** into smaller units.

Example

Respiration

Enzymes

Globular protein

Enzymes are **tertiary structure** protein.

Enzymes are usually soluble

Because **hydrophilic R- groups** of their amino acids are directed outwards to form bonds with the surrounding water.

Substrate

A substance on which an enzyme acts.

Example

Starch is the substrate of amylase

Catalyst

A substance which speeds up a metabolic reaction without being changed or change the products of the reaction.

Intracellular and extracellular enzymes:

Intracellular

Enzymes function inside cells

Extracellular

Enzymes are secreted to function outside cells

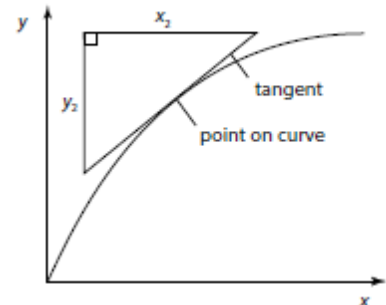
June/2004 and June 2007

Which bonds are the last to break when an enzyme is heated?

- A disulphide
- B hydrogen
- C hydrophobic interactions
- D ionic

Measuring the rate of metabolic reaction

- By measuring the amount of *substrate* changed per unit time.
- By measuring the amount of the *products* formed per unit time.
- By calculating the *slope of a tangent* to the curve as close to time 0 (zero) as possible.



Initial rate of reaction

Is the rate of an enzyme controlled reaction at the beginning which is the fastest.

Turnover rate

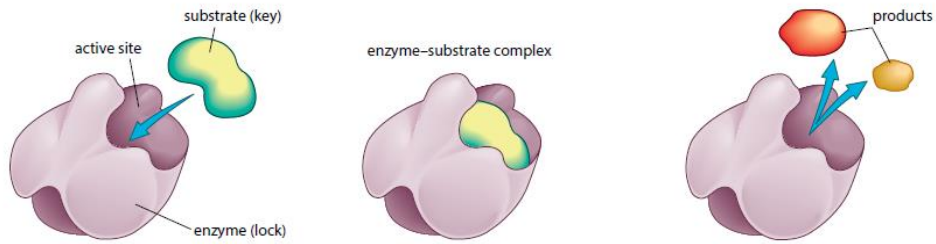
The number of *substrate molecules* that can be converted into products in one second.

Active site

A depression or cleft in the enzyme molecule (3-12 amino acids) which comes in direct contact with the substrate.

Enzyme- substrate complex

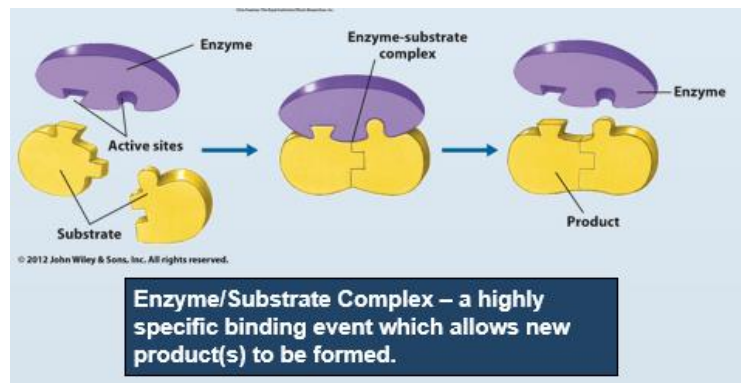
When the active site forms hydrogen bonds with the substrate forming a temporary complex which is then breaks into products and enzyme.



a An enzyme has a cleft in its surface, called the active site. The substrate molecule has a complementary shape.

b Random movement of enzyme and substrate brings the substrate into the active site. An enzyme-substrate complex is temporarily formed. The R groups of the amino acids in the active site interact with the substrate.

c The interaction of the substrate with the active site breaks the substrate apart. An enzyme-product complex is briefly formed, before the two product molecules leave the active site, leaving the enzyme molecule unchanged and ready to bind with another substrate molecule.

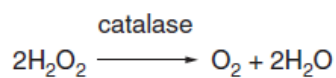


Activation energy

- The **amount** of energy needed to make substrates react.
- Enzymes speed up the metabolic reactions by lowering the activation energy.

Nov/2011

- 2 A student investigated the initial rate of reaction of catalase in breaking down hydrogen peroxide into oxygen and water:



The volume of oxygen collected was recorded over a period of 140 seconds. The results are shown in Fig. 2.1.

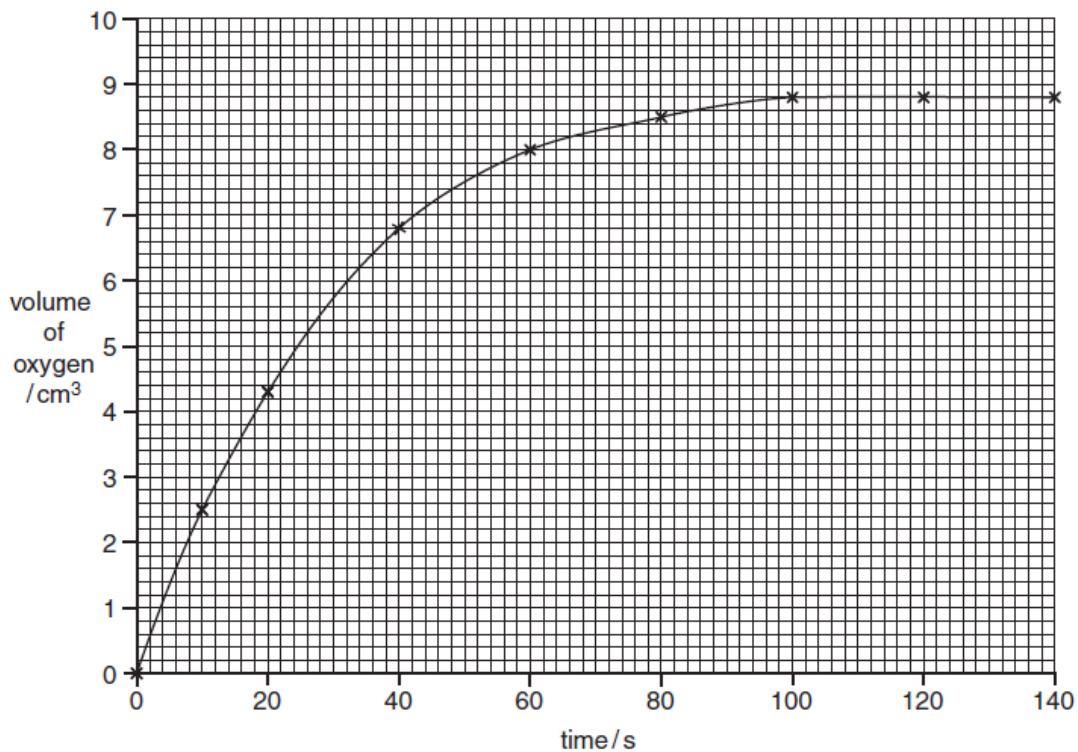


Fig. 2.1

- (a) (i) Use the information in Fig. 2.1 to calculate the initial rate of reaction in $\text{cm}^3 \text{s}^{-1}$.

Show your working.

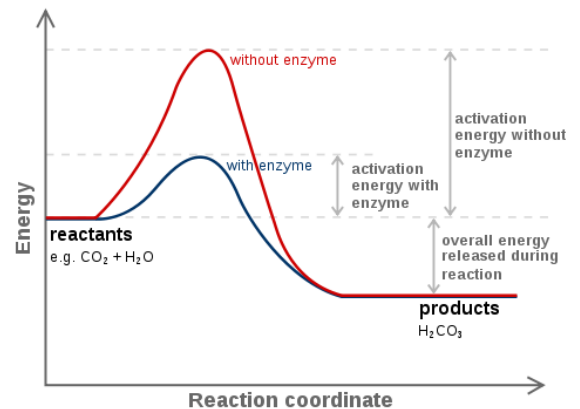
answer $\text{cm}^3 \text{s}^{-1}$ [2]

How enzymes lower the activation energy

1-By holding the substrate in a particular way pulling them slightly out of shape so they can react easily as formation or breakdown of bonds becomes easier.

(interaction between R-groups of the enzyme and the atoms of the substrate can break or encourage the formation of bonds in the substrate).

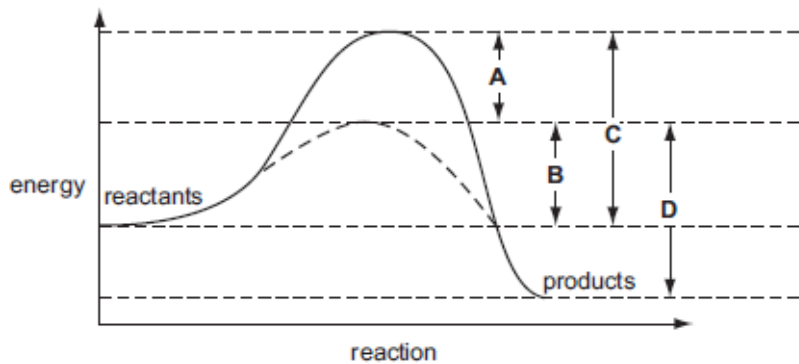
2-By providing **alternative reaction pathway** in which less energy is needed.



Nov 2006

The graph shows the activation energy of an enzyme-catalysed reaction and the same reaction without a catalyst.

Which arrow shows the activation energy of the uncatalysed reaction?

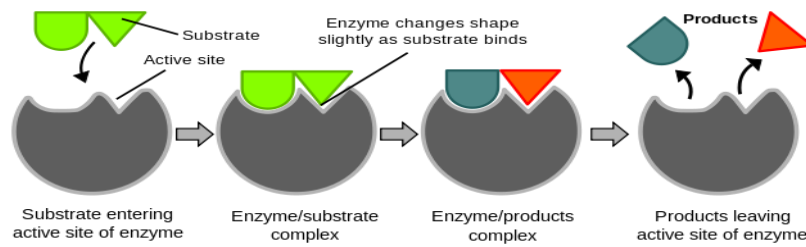


Enzymes are specific. Why? Because the active site will only allow one shape of molecule to fit.

=Means that each enzyme can catalyse a certain metabolic reaction by acting on a certain substrate or substrates, this can be explained by lock and key hypothesis and induced fit hypothesis.

Lock and key hypothesis

- In this hypothesis the lock represents the enzyme while key represents the substrate.
- It states that each enzyme has a particular shape of its active site in which the substrate or substrates) can be exactly fitted.

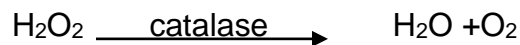


Induced fit hypothesis (the modern hypothesis for enzyme action)

It states that when a substrate becomes in contact with specific enzyme, this induces changes in their shape to form enzyme-substrate complex.

-Enzyme molecules are more flexible than is suggested by rigid lock and key.

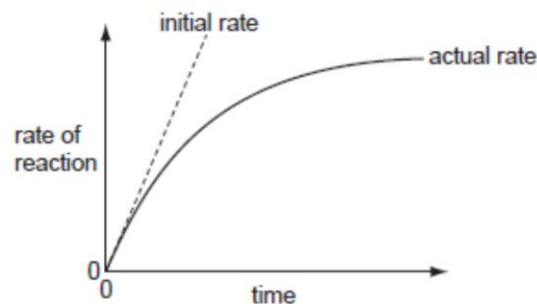
Example



-Lysozyme found in tears and saliva breaks polysaccharide chains in cell wall of bacteria.

Nov/2010/12

A fixed volume of the enzyme catalase was added to a fixed volume of hydrogen peroxide solution. The diagram shows how the rate of the reaction changed over the course of the reaction.

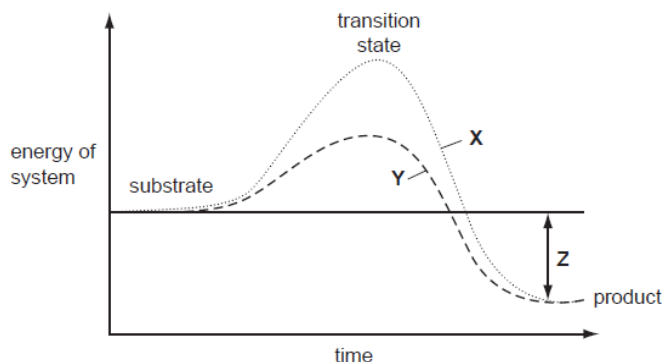


Why did the actual rate of reaction decrease over time?

- A The enzyme active sites become saturated.
- B The enzymes were denatured.
- C The product inhibited the reaction.
- D The substrate molecules were used up.

Nov/2007

The graph shows the effect of an enzyme on a reaction.



Which combination identifies X, Y and Z?

	X	Y	Z
A	catalysed reaction	uncatalysed reaction	activation energy
B	catalysed reaction	uncatalysed reaction	energy lost during reaction
C	uncatalysed reaction	catalysed reaction	energy gained by product
D	uncatalysed reaction	catalysed reaction	overall energy change

Factors that affect enzyme action

1-Effect of PH on activity of enzymes

-Each enzyme has a certain pH in which it works best; it is known as **optimum pH**.

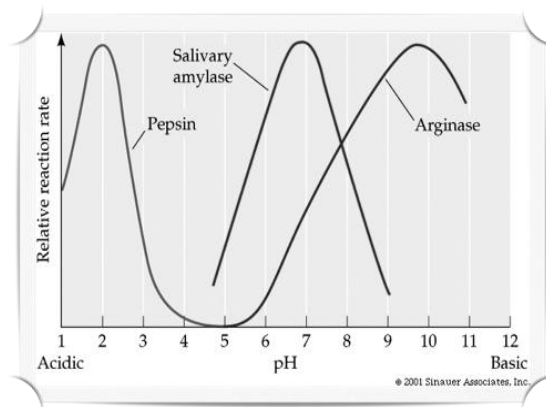
-Any increase or decrease around this pH leads to a decrease in activity of this enzyme.

Examples

- Optimum pH of amylase is 7: 7.5.
- Optimum pH of pepsin is 2: 2.5.
- Pa pain is a protease which is not affected by changes in pH.

Why changes in pH affect activity of enzymes?

= Because pH is the measure of concentration of hydrogen ions in a solution, therefore changes in pH leads to a change in concentration of hydrogen ions that can interact with **the R- groups** of amino acids **altering the charges** and so alter the bonds such as hydrogen and **ionic bonds** which are needed to maintain the globular shape of the enzyme especially its active site.

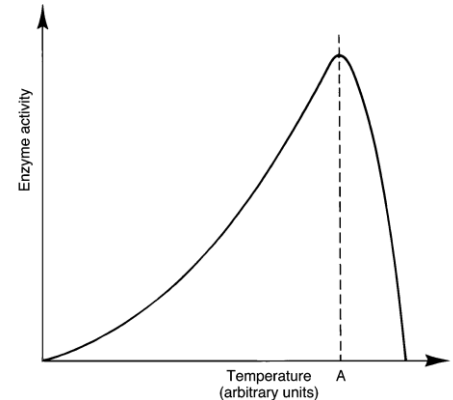


» Extremes of pH may denature certain { not all } enzymes.

2-Effect of Temperature on the activity of enzymes

Increasing temperature leads to an increase in the rate of the reaction up to an optimum temperature.

=Because increasing temperature leads to an increase in the **kinetic energy** of both enzyme and substrate molecules making them **collide** faster and this increases the rate of formation of enzyme/substrate.



Increasing temperature above the optimum leads to a decrease in rate of reaction

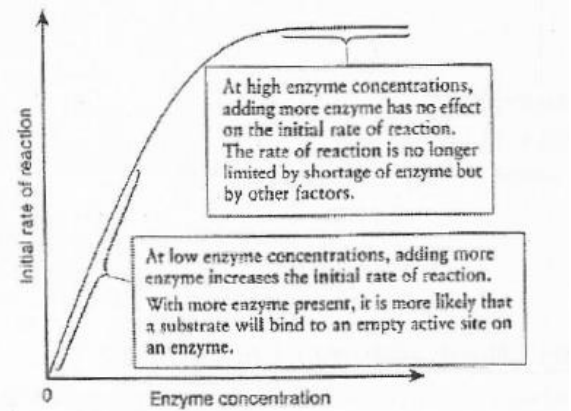
=Because energy can **breakdown** many bonds especially hydrogen bonds that hold the precise globular shape of the enzyme and its active site, this decreases rate of the reaction as substrates **fit less** well into the active site, then they **cannot be longer fit and the enzyme is said to be denatured.**

Enzyme denature

Means loss of its globular tertiary structure forming a primary structure.

3-Effect of enzyme concentration on the rate of a reaction

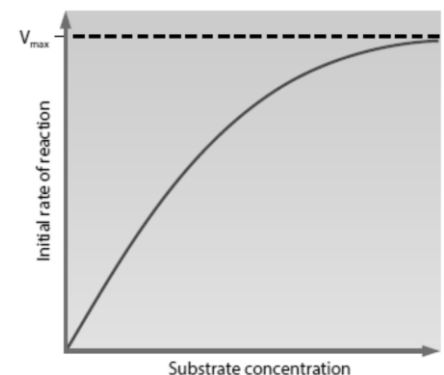
Its increase increases rate of reaction until **substrate** acts as **limiting factor.**



4-Effect of substrate concentration on the rate of a reaction

Its increase leads to an increase in the rate of reaction until **enzyme** acts as a **limiting factor.**

=As substrate concentration increases, the initial rate of reaction also increases.



=Increasing the number of substrate molecules increases the probability that substrate will collide with enzyme to form an **enzyme-substrate complex**, At this point, the enzyme is in excess

=When active sites are occupied, no further increase in rate possible.

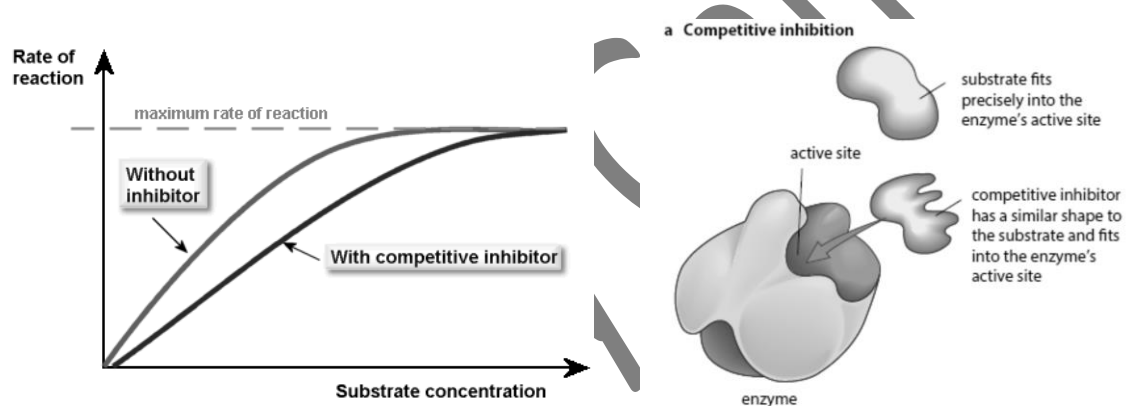
Inhibitors

Molecules that can **reduce** the rate of a metabolic reaction

Types of inhibitors

1-Competitive (or active site directed inhibitor)

=A molecule has a similar shape to the substrate, so can fit in the active site instead of the substrate.



=**Increasing concentration of the substrate** can reduce the effect of this type of inhibitors because it increases the chance for formation of enzyme-substrate complex.

=Its effect is **reversible (not permanent)** because it can be reduced by increasing concentration of the substrate.

2-Non -competitive (or non- active site directed inhibitor.)

> A molecule that can bind with a site other than the active site **{in allosteric site}**.

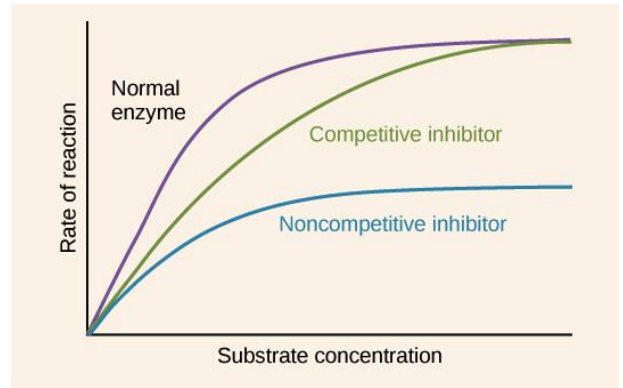
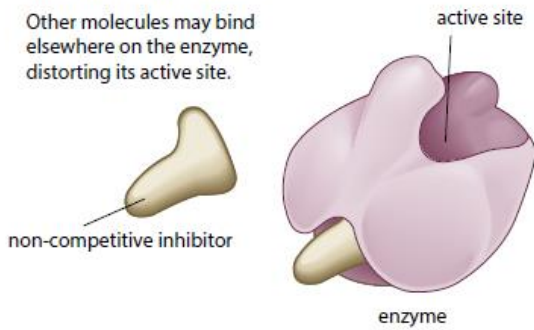
> If the inhibitor binds with **allosteric site** it can **disrupt hydrogen bonds and hydrophobic interactions** that hold the 3D- shape of the enzyme and therefore can affect its active site.

=Not affected by increasing substrate concentration.

=Usually **irreversible if binds permanently**.

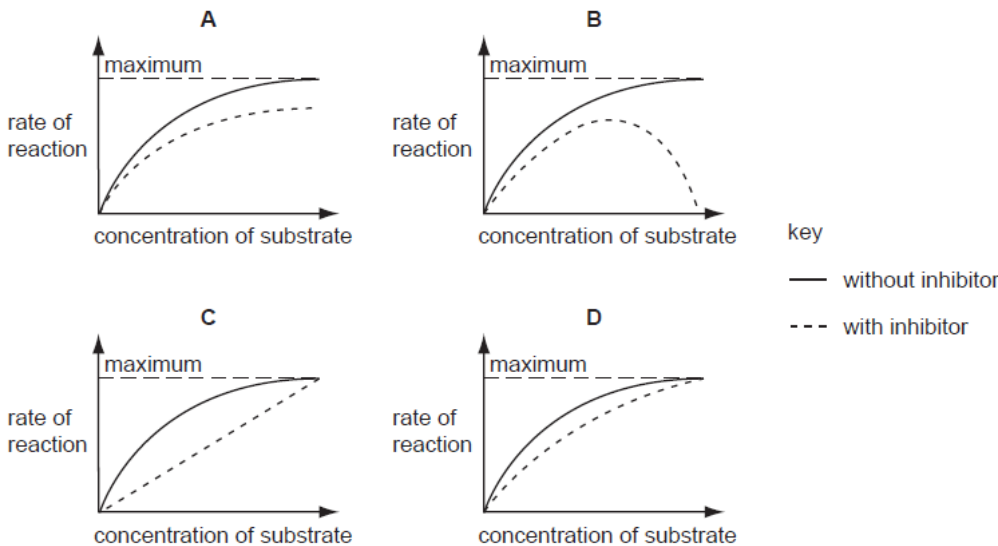
b Non-competitive inhibition

Other molecules may bind elsewhere on the enzyme, distorting its active site.



Nov/2007

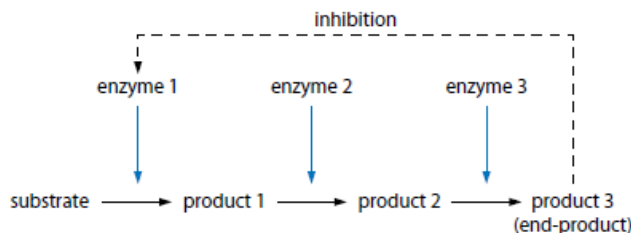
Which graph represents the action of a non-competitive inhibitor?



3-End product inhibition

Accumulation of end products can act as **barrier** between enzyme and its substrate decreasing the chance for collision.

⇒ End products **may bind** with the enzyme inhibiting the reaction but because it does not bind permanently, its effect is reversible.



One way of controlling metabolic reactions is to use the end-product of a chain of reactions as a non-competitive, reversible inhibitor.

Uses of inhibitors

- Control a reaction
- Many antibiotics act as inhibitors for bacterial or viral enzymes.

Example

Penicillin binds permanently to the active site of the bacterial enzyme which is essential for synthesis of bacterial cell wall.

Enzyme activator or cofactor

A molecule that **complete** the structural relationship between enzyme and its substrate.

Example

Chloride ion is necessary for activity of salivary amylase.

June 2007

The rate of enzyme catalysed reactions in human cells is regulated.

Which of the following may be involved in such regulation?

- 1 a change in enzyme concentration
- 2 a change in substrate concentration
- 3 inhibition by the final product of the reaction

- A** 1 only
B 3 only
C 1 and 2 only
D 1, 2 and 3

