Factors affecting Enzyme Activity

- The **activity** of an **Enzyme** is affected by its **environmental conditions**. Changing these **alter** the **rate of reaction** caused by the enzyme. In nature, organisms **adjust** the **conditions** of their enzymes to produce an **Optimum rate of reaction**, where **necessary**, or they may have enzymes which are **adapted** to **function well** in **extreme conditions** where they live.

**Temperature**

- **Increasing temperature increases** the **Kinetic Energy** that **molecules** possess. In a **fluid**, this means that there are **more random collisions** between molecules per unit time.

- Since enzymes catalyse reactions by **randomly colliding** with **Substrate molecules**, **increasing temperature increases the rate of reaction**, forming more product.

- However, **increasing temperature also increases** the **Vibrational Energy** that molecules have, specifically in this case **enzyme molecules**, which puts **strain** on the **bonds** that **hold** them together.

- As temperature increases, **more bonds**, especially the **weaker Hydrogen** and **Ionic** bonds, will **break** as a result of this strain. Breaking bonds within the **enzyme** will cause the **Active Site** to **change shape**.

- This change in **shape** means that the **Active Site** is **less Complementary** to the **shape** of the **Substrate**, so that it is **less likely** to **catalyse** the reaction. Eventually, the enzyme will become **Denatured** and will **no longer function**.

- As **temperature increases**, more enzymes' **molecules' Active Sites' shapes** will be **less Complementary** to the **shape** of their **Substrate**, and more enzymes will be **Denatured**. This will **decrease** the **rate of reaction**.

- In summary, as **temperature increases**, **initially** the **rate** of reaction will **increase**, because of **increased Kinetic Energy**. However, the effect of **bond breaking** will become **greater and greater**, and the **rate** of reaction will begin to **decrease**.
• The temperature at which the **maximum rate** of reaction occurs is called the enzyme's **Optimum Temperature**. This is different for **different enzymes**. Most enzymes in the human body have an Optimum Temperature of around 37.0 °C.

**pH - Acidity and Basicity**

• **pH** measures the **Acidity** and **Basicity** of a solution. It is a measure of the **Hydrogen Ion** (H⁺) **concentration**, and therefore a good indicator of the **Hydroxide Ion** (OH⁻) concentration. It ranges from **pH1** to **pH14**. **Lower pH** values mean **higher** H⁺ concentrations and **lower** OH⁻ concentrations.

• **Acid** solutions have pH values **below 7**, and **Basic** solutions (alkalis are bases) have pH values **above 7**. **Deionised water** is **pH7**, which is termed 'neutral'.

• H⁺ and OH⁻ Ions are **charged** and therefore **interfere** with **Hydrogen** and **Ionic** bonds that **hold together** an enzyme, since they will be **attracted** or **repelled** by the **charges** created by the bonds. This interference causes a **change in shape** of the **enzyme**, and importantly, its **Active Site**.

• **Different enzymes** have **different Optimum pH values**. This is the pH value at which the bonds within them are influenced by H⁺ and OH⁻ Ions in such a way that the **shape** of their **Active Site** is the most **Complementary** to the **shape** of their **Substrate**. At the Optimum pH, the **rate** of reaction is at an optimum.

• Any **change** in pH **above** or **below** the **Optimum** will **quickly** cause a **decrease** in the **rate** of reaction, since **more** of the enzyme molecules will have **Active Sites** whose **shapes** are not (or at least are less) **Complementary** to the **shape** of their **Substrate**.
Small changes in pH above or below the Optimum do not cause a permanent change to the enzyme, since the bonds can be reformed. However, extreme changes in pH can cause enzymes to Denature and permanently lose their function.

Enzymes in different locations have different Optimum pH values since their environmental conditions may be different. For example, the enzyme Pepsin functions best at around pH2 and is found in the stomach, which contains Hydrochloric Acid (pH2).

**Concentration**

- Changing the Enzyme and Substrate concentrations affect the rate of reaction of an enzyme-catalysed reaction. Controlling these factors in a cell is one way that an organism regulates its enzyme activity and so its Metabolism.

- Changing the concentration of a substance only affects the rate of reaction if it is the limiting factor: that is, it the factor that is stopping a reaction from proceeding at a higher rate.

- If it is the limiting factor, increasing concentration will increase the rate of reaction up to a point, after which any increase will not affect the rate of reaction. This is because it will no longer be the limiting factor and another factor will be limiting the maximum rate of reaction.

- As a reaction proceeds, the rate of reaction will decrease, since the Substrate will get used up. The highest rate of reaction, known as the Initial Reaction Rate is the maximum reaction rate for an enzyme in an experimental situation.
Substrate Concentration

- **Increasing Substrate Concentration increases** the rate of reaction. This is because more substrate molecules will be colliding with enzyme molecules, so more product will be formed.

- However, after a certain concentration, any increase will have no effect on the rate of reaction, since Substrate Concentration will no longer be the limiting factor. The enzymes will effectively become saturated, and will be working at their maximum possible rate.

![Graph showing the relationship between Substrate Concentration and Rate of Reaction](image)

Enzyme Concentration

- **Increasing Enzyme Concentration** will increase the rate of reaction, as more enzymes will be colliding with substrate molecules.

- However, this too will only have an effect up to a certain concentration, where the Enzyme Concentration is no longer the limiting factor.

![Graph showing the relationship between Enzyme Concentration and Rate of Reaction](image)