Macromolecules structure and function

Fate of a glucose molecule and control of cellular respiration by enzymes

Biochemistry

Science Group 2

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The control of cellular respiration by using enzymes (431 words)

Introduction

Enzymes are biological catalysts that speed up reactions, this happens without them going under permanent change. These kinds of reactions, however need high temperatures, high pressures, extremes of pH and high concentrations of reactants, all of these would kill organisms. Without enzymes these chemical reactions would occur so slowly, if it would happen at all, that life would be impossible (Fosbery, Schmit and Wakefield-Warren, n.d.).

Induced-fit theory and lock and key

Enzymes have specifically shaped active sites, these active sites are complementary to the shape of the substrate molecule that's involved in the reaction. This usually means that the substrate molecule(s) are much smaller than the enzyme molecule so that they can fit into the active site (OCR biology, 2008).

Since the substrate molecule fits into the enzyme so well, the term "lock and key" is often used to describe how enzymes work. In this description the substrate (being the key) fits into the active site (being the lock), it is then held in place while the reaction is occurring (OCR biology, 2008). (See figure 1).

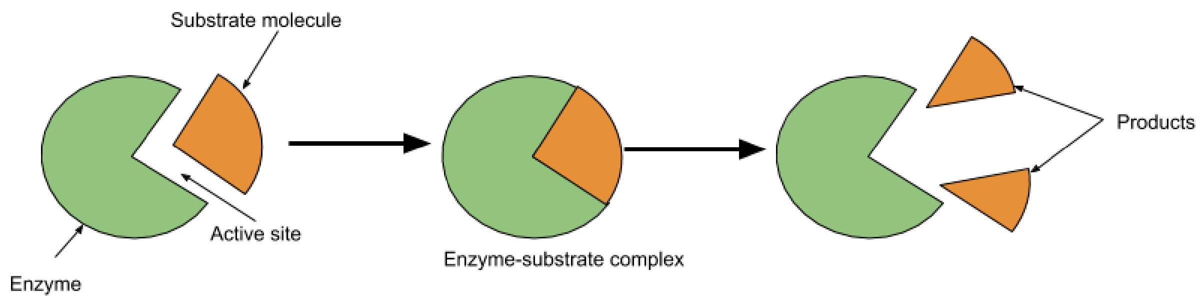


Figure 1. Self created and adapted (OCR biology, 2008).

However, with further investigation it has now been discovered that changes in the shape of the enzyme happen as the substrate binds to the active site. It has also been discovered that the charges on the amino acids in the active site do contribute to holding the substrate so that the reaction can occur. This is known as the induced fit theory (OCR biology, 2008). (See figure 2)

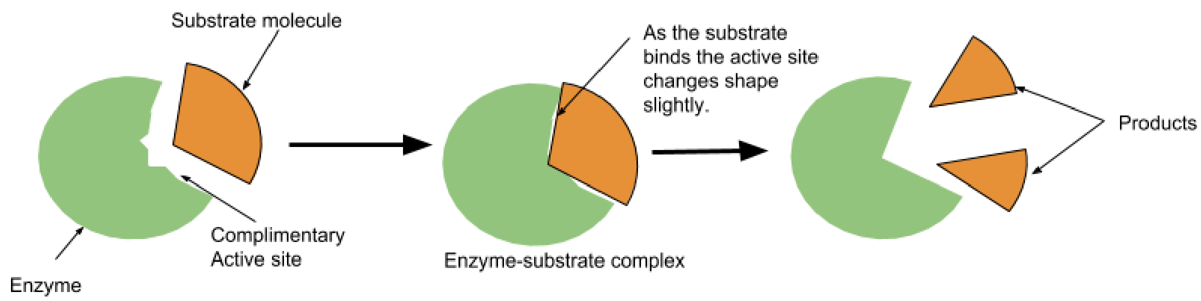


Figure 2. Self created and adapted (OCR biology, 2008).

Effects of PH and temperature on enzymes

In a chemical reaction, a certain amount of energy is required to be supplied to the chemicals for the reaction to start. This is called activation energy, this energy is usually provided by heat, this is where collision theory comes into the chemical reaction. An increase in heat causes particles to move faster and thereby causing more collisions. Enzymes lower the amount of activation energy required, often resulting in a lower temperature when reactions start, compared to if the enzyme wasn't present. This essentially speeds up the rate of reaction (Faudemer et al., n.d.). (See figure 1).

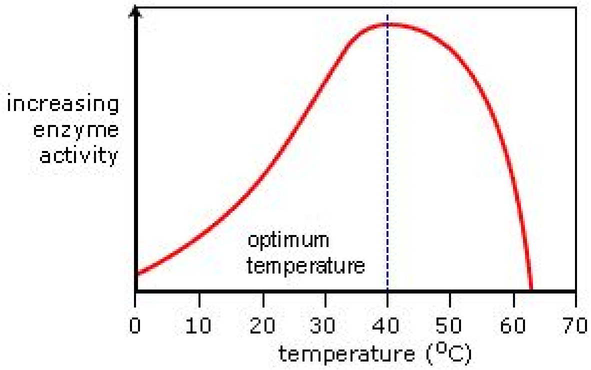


Figure 1. (Adam-Day, 2016).

Enzymes also react differently with different pH levels which measures the Acidity and Basicity of a solution. Different enzymes however, have different Optimum pH values at which the bonds within them are influenced by the ions H^+ and OH^- in such a way that the shape of the enzyme changes and is the most complimentary to their substrate. At the Optimum pH, the rate of reaction is at an optimum (Adam-Day, 2016). (See figure 2).

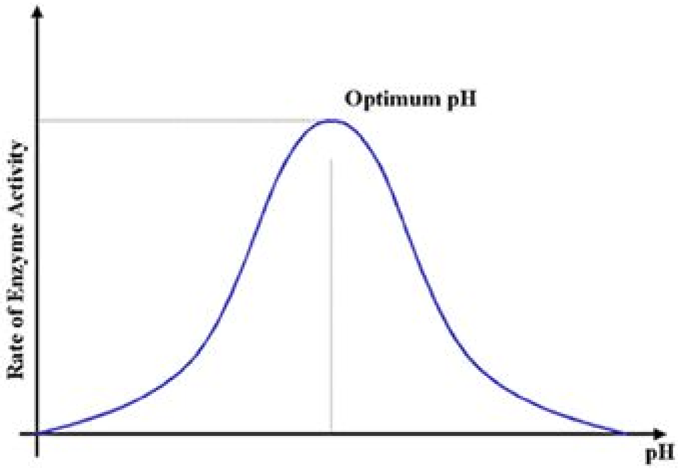


Figure 2. (Adam-Day, 2016).

Fate of the Glucose molecule (783 words)

The Glucose molecule assists in both aerobic and anaerobic respiration depending on if there is Oxygen present when it meets pyruvate, which I will go into more detail about later in the first section of this assignment. Both Aerobic and anaerobic respiration produce ATP, but aerobic is more efficient than anaerobic. This is shown by the 38 ATP that is produced during aerobic respiration compared to the 2 that is produced during anaerobic respiration (Cheney, 2018).

Glycolysis

Glycolysis happens in the Cytoplasm of the cell, since this stage of respiration doesn't require oxygen, it occurs in both aerobic and anaerobic respiration. The glucose molecule is phosphorylated causing, 2 ATP to lose a phosphate each, this activates the glucose which produces a six carbon sugar containing 2 phosphate molecules - a phosphoglucose molecule (S-cool.co.uk, 2018). (See figure 3).

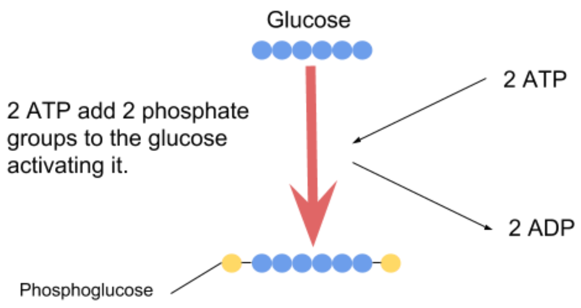


Figure 3. Self created and adapted (Norman, 2017).

The phosphoglucose is then converted into 2 molecules of a 3 carbon sugar containing a phosphate called triose phosphate. Next the triose phosphate molecules becomes oxidised when hydrogen is removed and another phosphate added. The spare hydrogen is added to NAD+, which is reduced to NADH (Cheney, 2018). (See figure 4)

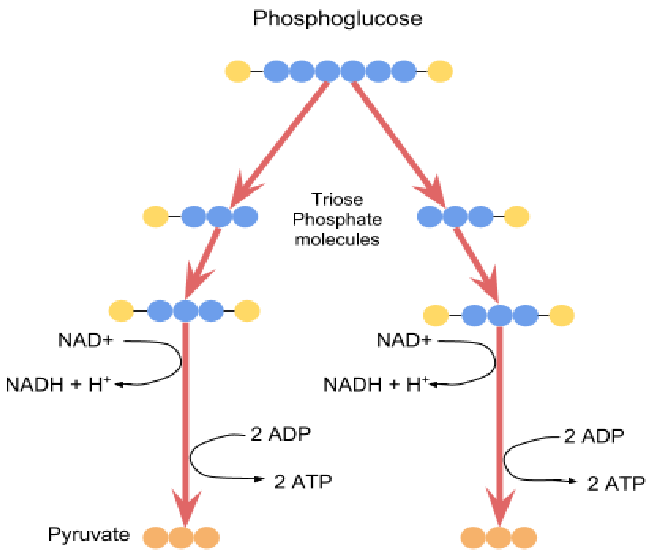


Figure 4. Self created and adapted (Norman, 2017).

2 ATPs are made directly from the conversion of each Triose phosphate to pyruvic acid (Pyruvate) as the phosphate groups are removed. 2 of these created ATPs are then used in glycolysis again (S-cool.co.uk, 2018). (See figure 5 for results of glycolysis).

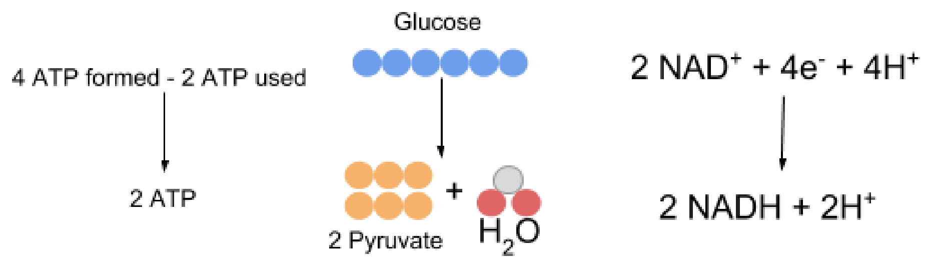


Figure 5. Self created and adapted (Norman, 2017).

Link Reaction

The pyruvate enters the mitochondrion, a CO_2 and hydrogen molecule are removed from each of them. This forms 2 2C molecules. The hydrogen is transferred to the NAD+. The 2C molecule is then combined with the vitamin Coenzyme A (CoA) to create the 2C compound acetylCoA (S-cool.co.uk, 2018). (See figure 6).

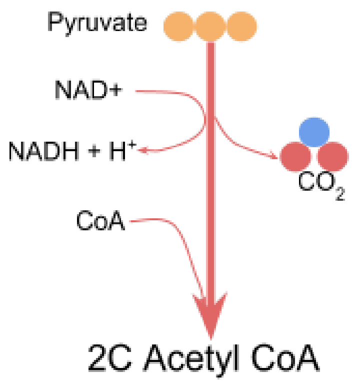


Figure 6. Self created and adapted (S-cool.co.uk, 2018).

Krebs cycle

The Acetyl Coenzyme A, which is the 2 carbon compound from the Link reaction, is combined with a 4 Carbon compound to form a 6 carbon compound. Next, decarboxylation reaction occurs which removes Carbon atoms and joins them to 2 Oxygen atoms to form Carbon dioxide. At the same time, a dehydrogenation reaction occurs as well, removing the hydrogen atoms and joining them to NAD+ or FADH to form NADH and $FADH_2$. After this, 2 ATP molecules are generated directly in the Krebs cycle. The 4 carbon compound is regenerated and the cycle begins again (Cheney, 2018). (See figure 7).

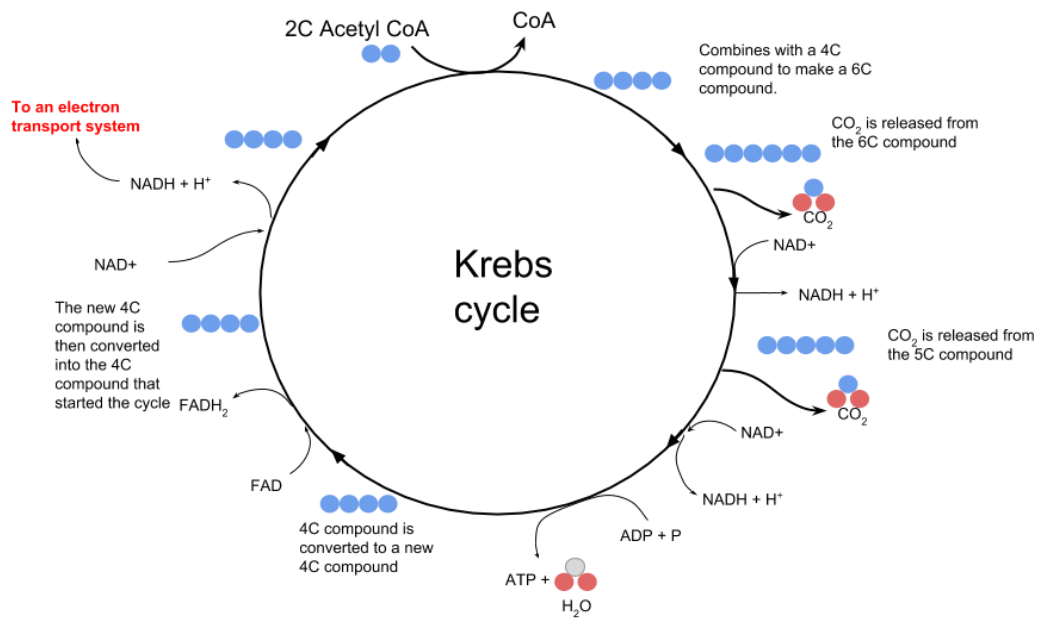


Figure 7. Self created and adapted (Help, 2014).

Electron transport chain

Ending from the Krebs Cycle, the FAD and NAD bring the hydrogen to the mitochondrial membrane, where a collection of proteins are found. (Scienceaid.net, 2018). NADH and $FADH_2$ release the electrons into the transport chain (BBC Bitesize, 2018), the electrons pass from carrier to carrier and lose energy (Scienceaid.net, 2018). This allows hydrogen ions to be pumped across the membrane which is used to synthesise ATP by a protein called ATP Synthase, converting ADP into ATP (BBC Bitesize, 2018).

The final step of the electron transport chain, is where each electron is reunited with a H+ proton to form a Hydrogen atom. These immediately combine with oxygen to form water (Cheney, 2018).

This process produces a total amount of 34 ATP (Cheney, 2018). (See figure 8).

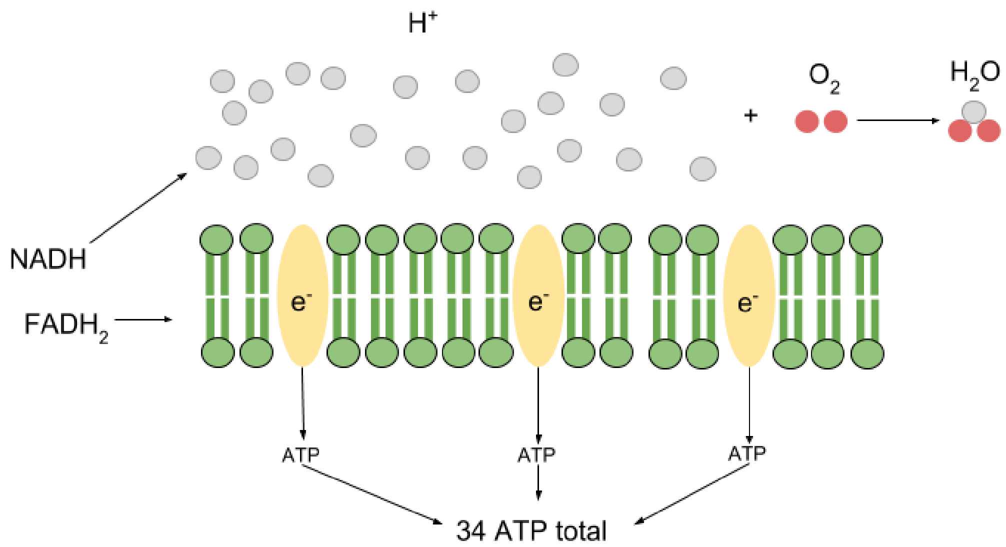


Figure 8. Self created and adapted (Scienceaid.net, 2018).

Anaerobic respiration

If oxygen is unavailable, the link reaction, Krebs cycle and the electron transfer chain processes cannot occur, but Glycolysis can so NADH is still produced. For glycolysis to continue, the NADH must be reoxidised where the hydrogen is removed (Cheney, 2018).

In mammals for example, pyruvate that is produced from glycolysis be reduced to Lactic acid (lactate) using the Hydrogen atom from NADH. When this happens, the NADH is oxidised to NAD^+ and is then available for glycolysis later on (Shmoop.com, 2018). (See figure 9)

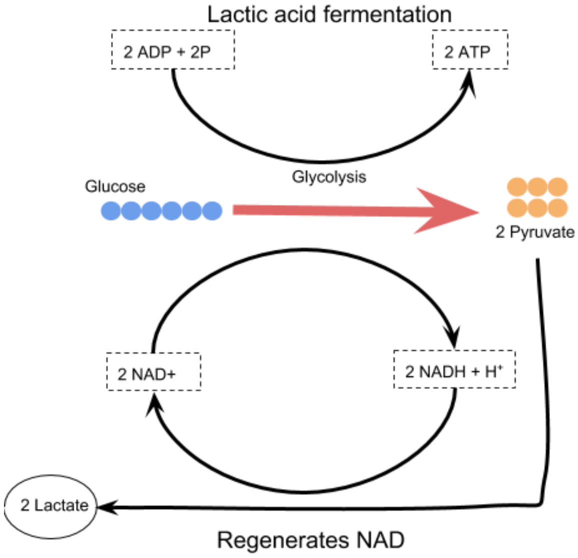


Figure 9. Self created and adapted (Shmoop.com, 2018).

Bacteria have a different but similar way of respiration without oxygen. In yeast for example, the pyruvate is reduced to ethanol instead of lactate (Shmoop.com, 2018). This method releases 2 molecules of CO_2 rather than none in the production of lactate, it then takes the H+ ion from NADH to form Ethanol. The NAD+ product left from this is then later reused in Glycolysis. This process is called alcoholic fermentation (Cheney, 2018). (See figure 10).

From these processes however, only 2 ATP are produced, since the only ATP produced is during glycolysis, making it much less efficient than aerobic respiration (Cheney, 2018).

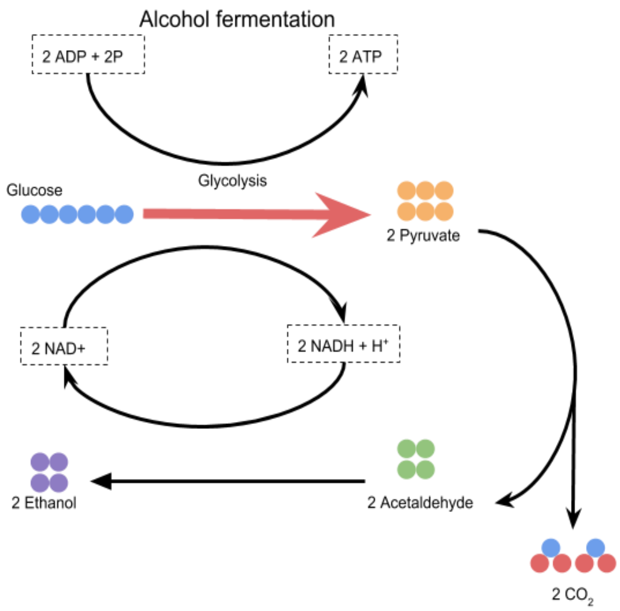


Figure 10. Self created and adapted (Shmoop.com, 2018).

Experiment to investigate the effects of pH and Temperature on Enzymes (appendix)

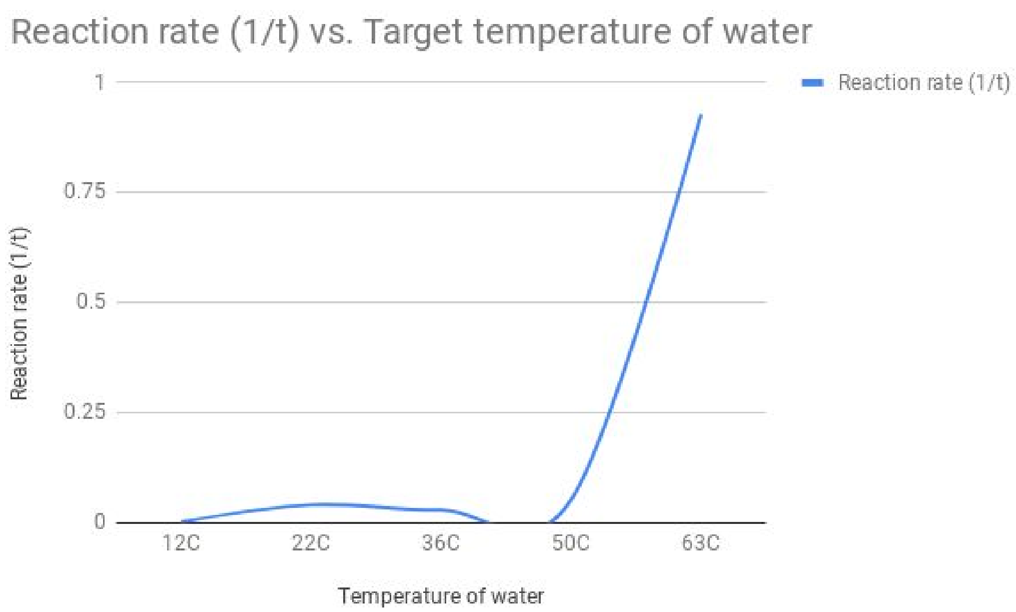
Two experiments were carried out to look at the effects on the enzymes Amylase and Lipase. The Amylase experiment was designed to test starch under specific pH and the Lipase experiment was to test it on Lipids under different temperatures. The rate of reaction was calculated using the formula 1/Time.

How temperature affects rate rate of reaction on Lipase

Lipase results:

Target temperature of water	Timer taken for solution to turn colourless (s)				Average time (s)	Reaction rate (1/t)
	1	Actual temp	2	Actual temp		
Ice	N/A	N/A	660	12C	660	0.0015
R/T	34.16	N/A	15	22C	24.58	0.0407
40C	23.34	N/A	45	36C	34.17	0.0293
55C	20.70	N/A	18	50C	19.35	0.0517
70C	11.56	N/A	10	63C	10.78	0.9276

During this experiment we hadn't heated the enzyme itself as well as the mixture of the enzyme along with the lipids. With this it shows that the experiment was done incorrectly. Most enzymes best temperature to react should be around 40C as this correlates with the human bodies temperature. Lipase has an optimum temperature of 50C but the results above show that the lipids were broken down much faster with the higher temperatures. While the reaction rate shows high, this may not be true as the particles may be moving so fast that the collisions are not all that successful. We also had not taken the actual temperature of the water, whereas the group where I got the second set of results had done providing a more accurate results.

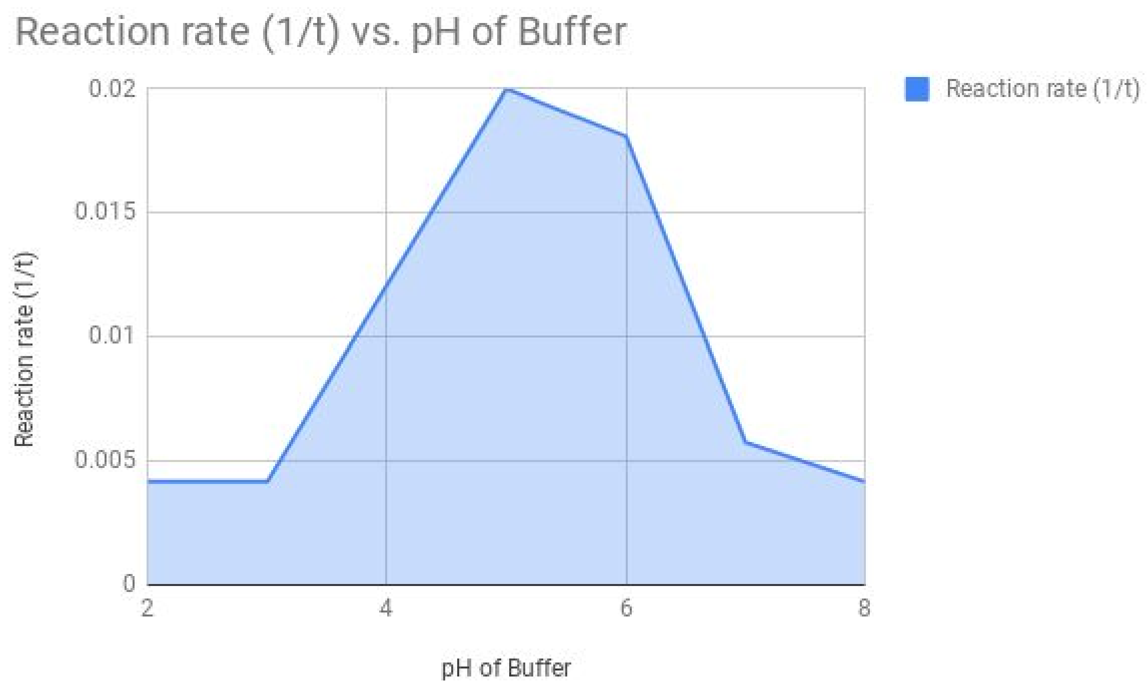


How pH affects the reaction rate of Amylase

Amylase results:

pH of Buffer Test	Time taken for reaction to go to completion (Iodine stay a pale brown colour) Time, t (s)				Average time (s)	Reaction rate (1/t)
	1 (2ml starch)	2 (1ml starch)	3 (1ml starch)	4 (1ml starch)		
2	240	240	240	240	+240	0.00417
3	240	240	240	240	+240	0.00417
5	100	100	50	60	50	0.02
6	120	120	60	55	55	0.0181
7	240	240	170	240	176.7	0.00576
8	240	240	240	240	+240	0.00417

While I didn't actually perform this experiment, I have been able to get results from other groups. There are 3 main points I would like to make from observations from the other groups, at pH 7 the amylase didn't break down all the starch. At pH 8 the solution was still blue/ black meaning there was no breakdown at all. And at pH 3 it was very slow to react. The Optimum pH level as shown by this experiment is pH 5, asit broke down the starch in a relatively fast time. Where the reaction took longer than 4 minutes, the time was cut off so it is possible to conclude that if left, the starch may have been broken down eventually.



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