Biology Coursework

Planning

Title

In this experiment, I am going to investigate the effect of heat on the respiration of yeast.

Safety

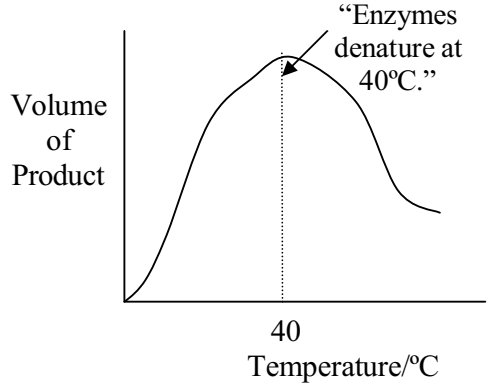
When doing the experiment there will only be one main hazard and that will be the hot water. One way of controlling this hazard is for the teacher to bring us the hot water instead of all walking to the front of the classroom to get the hot water. To always have green paper towel so that if the beaker needs picking up the green paper towel can be wrapped around the beaker and used as a handle and instead of pouring the hot water from the beaker into the other beaker, use a dropper to transfer the water. Another way of controlling the hazard of hot water is to keep all electrical sockets and electrical equipment off when someone is not keeping an eye on them; this is because water near electricity can cause someone to have an electric shock. It is also important to make sure that if any water is spilt on the floor it is wiped up immediately so as not to cause someone to slip and hurt themselves. These points would all help in preventing a hazard.

Prediction

I think that as the temperature rises by 10ºC each time the rate of Carbon Dioxide bubbles produced will double. I think that his will happen until the temper ature of the water reaches 40ºC, when I think that the rate of carbon dioxide bubbles produced will fall quite dramatically.

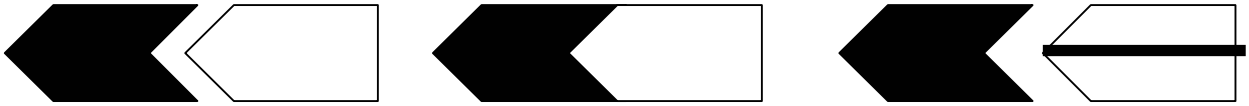
Scientific Explanation

I think that every time the temperature goes up by 10ºC the rate of Carbon Dioxide bubbles produced will double because the higher the temperature of the water, the more energy the molecules involved in the reaction has. This makes them move around faster, increasing the chance of them colliding with one another, with enough energy to cause a reaction. When an enzyme is heated at high temperatures, around 40ºC - 50ºC, the enzyme stops working and therefore its reaction stops or slows down. This is because the heat energy causes the enzyme molecules to change shape so they longer cause the reaction to happen. When this happens, it is said that the enzyme has been denatured (*Complete GCSE Biology*). It is said that all "enzymes denature at 40ºC" and this is a rule, and this is why I think that rate of Carbon Dioxide bubbles produced will fall quite dramatically when the temperature of the limewater is 40ºC.



The Denaturing of an Enzyme

Reaction at Less than 40ºC

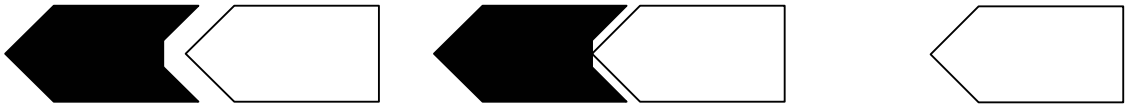


Enzyme Substrate

Substrate fits into enzyme molecule forming enzyme-substrate complex

Enzyme Products

Reaction at More than 40ºC



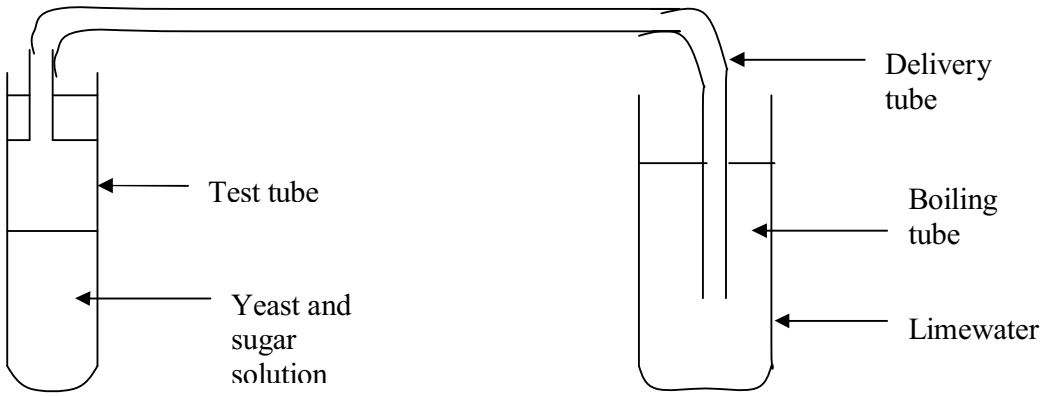
Denatured Enzyme Substrate

Enzyme-substrate complex cannot form

Substrate is not broken down so the usual products are not formed

Preliminary Experiment and Calculations

In my preliminary experiment, I am going to use the temperatures of 22ºC, 30ºC and 40ºC. I have decided to use these temperatures, as 22ºC is the temperature of the room in which I am going to do the experiment and 30ºC and 40ºC are very round numbers. They increase by 10ºC, which is what I want so that I can see whether it is accurate that if the temperature is increased by 10ºC the rate of carbon dioxide produced will double as well. I am going to start the experiment with 30ºC then go onto 22ºC and then finally do 40ºC. This is because 30ºC is a good temperature to get the yeast "started up". I then will decrease the temperature instead of increasing it because if I were to do the 40ºC temperature I would denature the yeast and have to use new yeast to do 22ºC, which would not be a fair test.



I am going to set up the apparatus as shown above and firstly set the limewater to 30ºC. When I get the water to 30 º C, I will leave the yeast in it for five minutes in order for the yeast to equilibrate, which means become an equal temperature to the water. I will then count the number of bubbles that come out of the delivery tube per minute and I will do this for three minutes in total therefore collecting three results for each temperature. Once I collect all the results for 30ºC, I will repeat exactly the same experiment with 22ºC and then 40ºC. In the preliminary experiment, I am going to use limewater instead of water and therefore prove that Carbon Dioxide is the gas that is being given off in the bubbles as when Carbon Dioxide is given off into limewater the limewater turns milky.

The results I got for my preliminary experiment were as follows:

	Number of bubbles per minute		
Temperatures/ºC	1st minute	2nd minute	3rd minute
22ºC	9	29	30
30ºC	33	35	35
40ºC	37	39	38

I am going to change the temperatures that I use in my main experiment as I don't think I have enough and 22º C is a very random temperature so instead of using the temperatures above I am going to use 10ºC, 20ºC, 30ºC, 40ºC and 50ºC. I am going to use these temperatures, as they are round numbers; they increase by 10ºC, which is what I want in order to prove if my prediction was correct. They are probably going to be easy temperatures to get the water to, as I found 22ºC a bit of a challenge, because it was a slightly weird value to find.

Variables

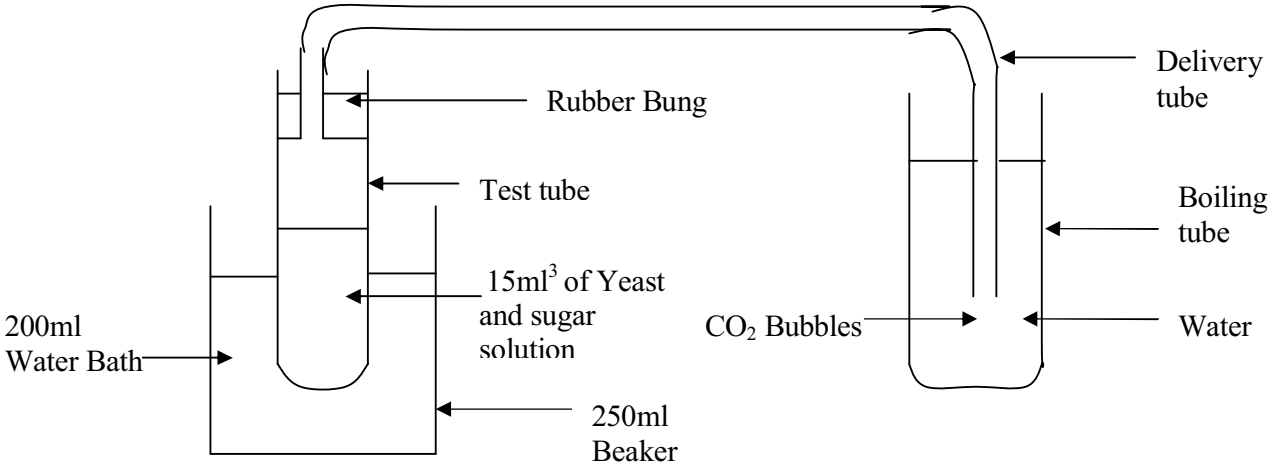
Maintain or Constant (Control Variables)	Change or Vary (Independent Variable)	Monitor or Observe (Dependent Variable)
Amount of limewater (preliminary experiment) / water (main experiment) added to the same tube.	Temperature of water bath.	Number of Carbon Dioxide bubbles made per minute.
Equilibration time.		
Amount of yeast and sugar solution used.		
Level of water in water bath.		
Amount of time counting bubbles for, 3 separate minutes.		

I am going to maintain the control variables to show that the reason the dependent variable is changing is not due to the change of the control variables stated above, but the independent variable, which is the temperature of the bath

water. If the control variables were not kept constant the number of carbon dioxide bubbles made per minute could change for any number of reasons shown above in the first and second column. However, the experiment is to investigate the effect of **heat** on the respiration of yeast, so the heat of the water must be the only variable that is changed by me throughout the whole experiment. In addition, if I did not keep the control variables constant the results I obtained would not be accurate or reliable and I would not be able to prove any scientific theories or any of my predictions.

Method

In my experiment, I am going to use a normal sized test tube and boiling tube, a delivery tube with a bung on one end of it, 15ml³ of yeast and sugar solution, ¾ of a test tube of normal tap water and a 250ml beaker with 200ml of water of the correct temperature in it. I shall also use ice cubes or hot water as an aid to get the water to the right temperature for the experiment.



I am going to set up the apparatus as shown above. I will put 15ml³ of yeast and sugar solution in a boiling tube with a syringe and I will then close the top of the boiling tube up with the rubber bung on the end of the delivery tube. I will give it a good shake to make sure the yeast is really mixed up with the sugar and to start the molecules vibrating a bit. I will then put 200ml of tap water into the beaker adding hot water but keeping at the 200ml level in order to get it to 30º C. When I get the water to 30ºC and it make sure its still at the 200ml level I will place the boiling tube in the beaker and turn on the timer to five minutes. This is the yeasts equilibration time. While this is happening, I will fill the test tube with ¾ of tap water and place in a test tube rack to stand. I will then wait for the yeast to equilibrate making sure to keep the water temperature at 30ºC and the water level at the 200ml point. I will keep the temperature at 30ºC using ice and hot water and I will keep the water level at 200ml using a dropper to extract the water that is over the 200ml line. When the five minutes is up I will dip the end of the delivery tube into the water in the test tube and start counting the bubbles that go into the water. I will do this for 3 minutes and record the results of how many bubbles escaped every minute. However, while I am doing this I must still make sure that

the temperature of the water is 30ºC and the water level is at 200ml³. When I collect all the results for 30ºC I will do the same experiment with the same process for 20ºC, 10ºC, 40ºC and finally 50ºC remembering not to change the water or the yeast solution but only the temperature of the water. I will also remember to keep the level of the water at 200ml so that it is a fair test. I will have to take great care when counting the bubbles and not take my eye of the test tube while counting in order not to miscount, however if I do or I find anomalous results I will carry on counting for a few more minutes and collect results for four and five minutes. I will then take the three values that are closest out of the five and I will take an average of the three to get how many bubbles on average were made for each temperature. I will then plot these results on a graph.

Obtaining evidence

These are a set of my first results:

	Number of Bubbles per minute/mins		
Temperature/ºC	1st Minute	2nd Minute	3rd Minute
10ºC	3	2	2
20ºC	9	10	11
30ºC	20	21	**24**
40ºC	**43**	49	49
50ºC	26	23	25

After repeating the experiment and drawing a graph, I made no changes because I found nothing wrong with the experiment I chose to do before, and nothing showed up on my graph that would make me need to change anything. The only thing was that I sometimes missed a bubble or two so I have to concentrate harder on what I am doing when I do the experiment.

The numbers that are in bold are slightly anomalous as they are not around the same range as the other numbers at that particular temperature. As I have said above the only way that I will be able to make sure that I do not get any anomalous results is to be more careful when counting the bubbles and try to be as accurate as possible with the control variables and the independent variable.

Analysing and Drawing Conclusions

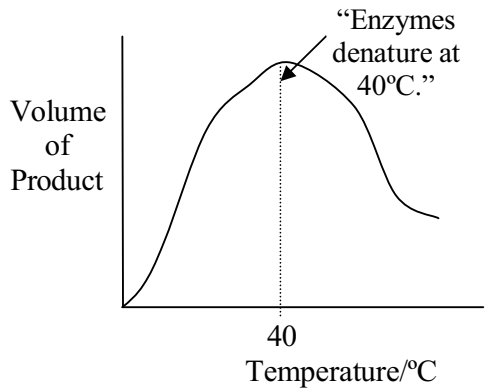
1. Analysis

After collecting my results and putting them in a table, I had to take an average of the three results for each temperature. I did this by adding up all the numbers, doing each temperature separately and dividing that total by three, which was how many results I had. This is the basic way for finding out the average for a few results and it works a lot better than using the median, mode and range if there are no anomalous results as it takes it account all of the results and cannot be swayed, as there are no anomalous results. It was compulsory that I took an average for

each temperature otherwise, it would have been almost impossible to draw a good graph.

Temperature/ºC	Average number of bubbles per minute/mins
10ºC	2.3…
20ºC	10
30ºC	21.67
40ºC	47
50ºC	24.67

I drew a basic line graph using these results with the number of bubbles of Carbon Dioxide per minute on the y-axis and the temperature in ºC on the x-axis. In both cases, I ranged from 10 – 50. I drew a best-fit line instead of a dot to dot.
The gradient of the line is around 2. (8÷4)
On the graph from 10 º C - 30 º C, the amount of Carbon Dioxide production is increasing at a steady pace with a few bumps on the way. However at 40ºC when the yeast is denatured the amount of carbon dioxide produced falls quite rapidly but not enough so to fall lower than the amount made at 30º C but nevertheless, quite close to it. This is why the graph is roughly shaped like this:



The curve at 40º C is where the enzyme has been denatured because of the high temperature and therefore the reaction has slowed down. However, the reaction did not slow down suddenly but quite slowly, which is why it is shown on a graph as a curve and not a straight line going straight from 40º C.

2. Conclusions

The rate of carbon dioxide production is increasing at a steady pace from 10ºC - 30ºC because the enzyme is trying to work so that every 10ºC raise its rate of reaction doubles, in my case it wasn't quite like that but it was working by the same principle. Every time the temperature raised 10 º C, the enzyme worked harder as it should because as the temperature gets higher the more energy the get and the faster the molecules move around. Due to that fact, they move faster they

have more of a chance of colliding with one another with enough energy in each of them to cause a reaction. Now my results did double its rate of reaction but not extremely accurately.

At 40 º C, there is a dip in the line because this is where the enzyme denatured by the heat. The enzyme denatured because the heat energy caused the enzyme molecules to change shape so that they could no longer cause the reaction to happen. Eventually the enzyme would have stopped working altogether but I did not test high enough temperatures to see this happen on my graph. The dip in the curve is meant to happen at around 40ºC, as it is a scientific fact that "all enzymes denature at 40 º C"

Looking back at my prediction, I have found that my results support my prediction. My results to kind of increase at a doubling rate as the temperature increases by 10º C and the rate of Carbon Dioxide bubbles given off per minute does decrease at 40º C. Although my results do support my prediction fully I could have obtained results that are slightly more accurate so that I was absolutely sure that the prediction I made was correct. However, I believe that my results are just about reliable enough to do so.

Evaluation

General Comment

The experiment that I held went quite well although it my results weren't totally correct and didn't fully support the fact the every time the temperature is raised by 10ºCthe rate of work is doubled. However it did support the fact that if the temperature is increased the rate of work increases as well. It also supported the fact that "enzymes denature at 40ºC", which is good as this is a scientific fact and if this didn't show up on my graph there would have been something that was seriously wrong.

Anomalous Results

In my results table I found a two anomalous results, which are in bold. They are anomalous as they are not close to the other two results that I collected for the corresponding temperature:

	Number of Bubbles per minute/mins		
Temperature/ºC	1st Minute	2nd Minute	3rd Minute
10ºC	3	2	2
20ºC	9	10	11
30ºC	20	21	**24**
40ºC	**43**	49	49
50ºC	26	23	25

The reason I think I have some anomalous results is because it was very easy to miss a few bubbles while counting resulting in adding the amount of bubbles which you think that you missed and this number being wrong. However, I do not think anything can be done about this; the only thing that could make it more accurate was to take down more readings for each temperature. I could also keep an eye on the bubbles more closely and if I did miss any bubbles I would not add

how many I thought I missed and just carry on. This would certainly make the experiment and results slightly more accurate but not fully.

Due to having anomalous results here, the average of the two temperatures with the anomalous results will be swayed by the inconsistent result and therefore may be slightly "off" when plotted on the graph with a best-fit line. I found that this happened with my graph but not a lot.

Accuracy and Reliability

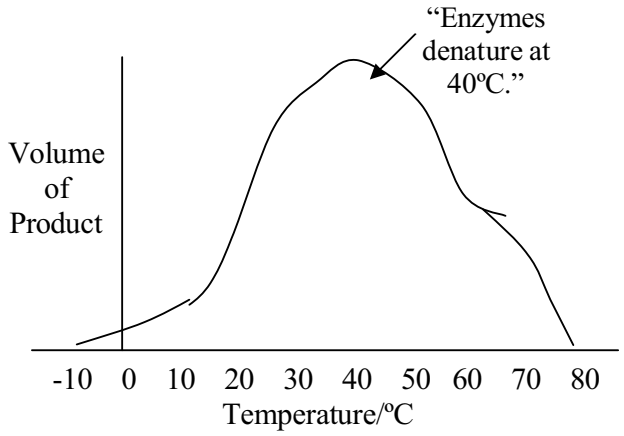
I think that one way I could have achieved more accurate results and make the experiment more reliable by concentrating more on the bubbles, the temperature of the water and the level of the water. Sometimes I let these points slip, but that was just me getting lazy. However, I do think that to make the experiment a bit easier it would help if there were a way to measure the volume of the gas, maybe by using the downward displacement method, which can sometimes be slightly inaccurate but sometimes work very well. Another way of being more accurate would have been to plot more points on the graph, which would mean collecting more results but time was the key factor here, and the problem was that we did not have much of it. I do not think that my results were at all random areas but instead I think they were systematic errors, which meant that there was a constant fault in the equipment that I used the materials or the technique.

"Safety of Conclusion"

I do not think that my results were sufficiently accurate to draw an excellent conclusion but I think that they are good enough to prove some of the points that we are trying to make. I do not think that my results were bad compared to anyone else's; I think that they were around the same. Repetition did improve the accuracy of my results a lot and I am sure that if enough time was given and I repeated the results over and over again I would get almost perfect accuracy.

Further Work

As my further work, I predicted what would happen beyond 50ºC. I worked out that it should just drop off but I have yet to prove this. I do not think it would be possible to do the experiment much lower than 10ºC, because although enzymes do not denature at cold temperatures, they stop working so therefore if you were meant to draw the graph using lower results then 10ºC and higher than 50ºC, the graph would look like this.



As well as looking at what would happen if I extended the range, I also looked at another method that could be used to do the experiment that would be more reliable. I thought that the downward displacement method would have been more reliable because it would have been possible to measure the actual volume of gas instead of having to count the bubbles. This would have been more accurate as when counting the bubbles it was possible to miss a few or miscount but when using this method it was pretty hard to miscalculate as all that would have to be done would be to read the reading on the side of the measuring cylinder which is a lot easier than counting bubbles.