Finding the concentration of a potato cell essay sample

Science, Chemistry

Aim

The aim is to find the concentration (mole/dm3 (M)) of solute in a potato cell by using the process of osmosis and different concentrations of sucrose solution.

Background information

Osmosis is diffusion of water across a partially permeable membrane. It moves from a solution with less solute concentration (high water potential) to a solution with more solute concentration (low water potential). The one with a high water concentration is called a hypotonic solution and the low water concentration is called hypertonic solution, but these only depend on what type of concentration is on the other side of the partially permeable membrane. When more water passes through to one side of the membrane it is called net movement.

(Toole + Toole " Essential AS level Biology")

This is an example of the net movement through a partially permeable membrane. The right side is the more dilute solution, which makes it the hypotonic solution. The left side is the less dilute solution, which makes it the hypertonic solution. Net movement occurs through the more dilute to the less dilute so it goes from left to right though the partially permeable membrane. As you can see, the dotted line going horizontally through the middle of the two levels of solution shows the level of the solutions at the beginning when the two sides where given equal amounts of its solution. The horizontal solid lines show the level of the two sides after it was left for 2

hours. The right side has more solution in it because of the greater net movement of water going to the right from the left side by the process of osmosis.

(Marveen “ GCSE Biology”)

This diagram is of two liquids separated by a partially permeable membrane. The left side has large molecules of solute that has dissolved (hydrated), therefore attracting other water molecules to it and reducing the water potential; it is called the hypertonic solution. On the right side there is less solute to attract the water molecules to it and so it has a higher water potential with more free water molecules; it is called a hypotonic solution. The net movement only starts when the solute attracts the water to it and dissolves into it because this lessens the amount of free water molecules in the solution and so movement of water can occur. The amount of water molecules moving into the right solution is less than the movement to the left so the most significant net movement is to the left. Levels of the water in the two sides increase or decrease respectively when the process starts. When both solutions are equal in concentration, however, the two solutions are called isotonic and no net movement occurs.

This theory of osmosis is what we have to use to find the concentration of solute in the potato. I can use this because cells become turgid if water flows into them or flaccid if water flows out of them, and so I can measure the change in their mass as the water moves though the cell’s partially permeable membrane. This is because of the stretchable cell wall on the

plant cell. I can find the solute concentration of the potato when the two sides (potato and sucrose solution) are isotonic (both solutions have the same concentrations) and there is no net movement. To get the most accurate result we have to test various concentrations of the solution and plot a graph to see were the mass on the potato has not changed. This requires us to only change the variable of the concentration of the sucrose solution (independent variable) and for everything else I have to keep it constant. The various concentrations I have chosen are 0M to 1M with some in between (generally in 0. 1 increments). This is to make a fairer and more accurate line of best fit on the final results graph, therefore making the final concentration of a potato cell much more reliable. Repeating the experiment and following a fair test can help get reliable results.

Prediction

I think that as the concentration of the sucrose solution around the potato cylinder decreases below 0. 3M the potato will gain mass as the water in the sucrose solution will enter the potato cylinder. I think this because I know roughly that a potato has a solute concentration of more than 0. 3M. As the concentration goes above 0. 6M I predict the potato cylinder will loose mass because the potato is most likely to have a smaller concentration than 0. 6M. I know the concentration of a potato roughly but all the potatoes are different so I have left a space in my concentration of a potato cell prediction as the real result will vary between these values. My prediction is that the potato’s solute concentration will be somewhere in between 0. 3M and 0. 6M. This leads me to think of the resulting graph to have a best fit line which has

negative correlation and falls as the concentration decreases. I know this because osmosis works in a way that water molecules move from a low solute concentration to a high solute concentration.

Preliminary experiment

For this I was advised to use 5cm of peeled potato (a diameter of 1. 2cm), distilled water and 1M sucrose solution. I had to make two potato cylinders and leave one in water and one in a 1M solution (each 30ml) for 15 minutes. I got the percentage change by measuring the potato's length before and after the experiment. I did this to give me a rough idea of what to expect from this experiment and to change any variables to keep constant for my main experiment, like the time or the initial length. I carried this out and got this result (on a graph):

This shows a very simple conclusion that the potato's solute concentration is 0. 6M because when the line passes 0% of an average change then there is no net movement past the semi-permeable membrane so the solutions are isotonic. It is only a prediction and the actual concentration might be more or less than this, because this is only a best fit line against only two high and low points so it is not accurate enough. I also did a control test (look at method) with this and there was no average change.

I changed some variables for my real experiment once I looked into more accuracy and ease. The first thing I changed was to use the weight of the potato for the percentage change. It is much easier because an electric balance is much more accurate than measuring the length as this can lead to

errors in judgement. I also changed the diameter of the potato cylinder, the length of the potato cylinder, and the time the potato cylinder had to be in the solution for. These were mostly because it made the results much more accurate and reliable (time and weight), but I chose some to be changed while I was doing the experiment (diameter and length of the potato cylinder).

Method

Apparatus list:

Potatoes

Cutting tile

Boiling tubes

Test tube rack

Measuring cylinder

Cork borer

Electric balance (to the nearest 2 decimal points)

Scalpel

1. 0 M sucrose solution

Distilled water

Stopwatch

I started off the experiment by getting all the equipment and using the cork borer to cut a cylindrical area of the potato. The size of the borer was a 12 gauge and I used the scalpel to make the length of each piece 4cm each time. I had to also take off all of the remaining skin on the potato piece because that is a stronger and different permeable membrane that I wanted to test. I wanted the all the surface area of the potato to be the same type of membrane and changing it will change the results. I did the cutting on a cutting tile to refrain the scalpel from cutting the table. Then I used the balance to weigh the potato cylinder in grams (to the nearest 2 decimal places).

The amount I measured for each test tube was 30ml of solution. To make the various concentrations I had to dilute it with a curtain amount of distilled water (e. g. 15ml of solution and 15ml of distilled water to make a 0. 5M solution). The range of concentrations I tested were 0M (water), 0. 1, 0. 2, 0. 5, 0. 6, 0. 7, 0. 8 and 1M. Once I put the potato cylinder in with the sucrose solution in the boiling tube, I started timing and put the boiling tube in the test tube rack. The time limit for the potato to be in the solution was 30 minutes because this is enough time for some significant change to happen and to get a good graph.

When the 30 minutes was up I took the potato cylinder out of the boiling tube and weighed it again, making sure I dabbed the potato piece to get rid of excess solution so I don’t weigh the solution with the potato. From the

results (initial mass (at the beginning) and final mass (at the end)) I could work out the percentage change. This is because I could not make every potato piece the exact same weight and percentages are much easier to work with because when it is on a graph it is easier to see the trends and it is so widely used. I used this formula to work it out and round it up to the nearest 2 decimal places if required:

% Change = Mass after adding solution – Mass before adding the solution x 100

Mass before adding the solution

OR

Percentage (%) Change = Initial Mass – Final Mass x 100

Initial Mass

A control is necessary for this experiment to find out if there are any other variables in the air changing the weight of the potato by any other way. If there is no change when the potato is in the air for 30 minutes I then know the variables in the room are constant enough for a fair test.

I had to make sure I took the right safety precautions as well. I was working with a scalpel so I had to be careful when I am cutting the potato cylinders and when I am walking around the room with it. The balance was electric so I had to take care when handling the solution and distilled water around it.

Fair test

To make a reliable and accurate test I had to conduct a fair test. The first thing that should always be done after an initial test is a retest to find out an average of the two so I could straighten out any anomalous results. I also made notes on what I used in the experiment, like what cork borer gauge I used and the length of each piece so when I repeat the test again and I can keep these variables constant. This is important as I want to only change the concentration of the sucrose solution and if I don’t keep the other variables constant I will have very unreliable results with unexpected outcomes. The only thing I changed was the concentration of the sucrose solution and nothing else that I did not mean to change, e. g. different potatoes. Variables that I kept constant were the potato, temperature, and gauge of cork borer. The temperature is important because it can damage the cell membrane if it is too high or it can reduce the activity of the water if it is too cold, so doing all the experiments in the same room and as close as possible is important. Changing the cork borer can also change the surface area and thickness which are both important variables to keep constant.

Different potatoes could have different concentrations of water so if I change the potato it could affect the result but sometimes there is not enough in one potato to use so I had to change potatoes but only when I really needed to. No experiment is ever perfect and sometimes I can put different amounts than the intended of the liquid in the solution. This can happen but it does not make a significant change if I do some repeat experiments and try to keep the other variables constant. The way I avoided this was to carefully

measure out the solutions with a measuring cylinder to the drop, so I got near exact measurements.

Table of Results

As you can see I have done 16 experiments including repeat ones and put them on this graph as a whole. I have worked with percentage change most of the time and found out the average. For the control, the mass did not change and so I know that the variables in the room for those 30 minutes of the experiment were constant. The graphs I have done are an average percentage against concentration and my other one is all the results from all my experiments (including repeats, but not average %) against concentration and added error bars to analyze the accuracy of my repeat results to my first results.

Concentration (M) Initial mass (grams) Final mass (g) Change in mass (g) Percentage Change (%) correct to 2 d. p Average percentage change (%)

0. 0 (water) 9. 4 9. 6 0. 2 2. 13 2. 075

9. 9 10. 1 0. 2 2. 02

0. 1 10. 0 10. 1 0. 1 1. 28 1. 195

9 9. 1 0. 1 1. 11

0. 2 8. 7 8. 8 0. 1 1. 15 1. 1

9. 5 9. 6 0. 1 1. 05

0. 5 10. 1 9. 8 -0. 3 -2. 97 -4. 01

9. 9 9. 4 -0. 5 -5. 05

0. 6 9. 3 9. 0 -0. 3 -3. 23 -3. 915

8. 7 8. 3 -0. 4 -4. 60

0. 7 9 8. 9 -0. 1 -1. 11 -2. 12

9. 6 9. 3 -0. 3 -3. 13

0. 8 9. 1 8. 8 -0. 3 -3. 30 -4. 28

9. 5 9. 0 -0. 5 -5. 26

1. 0 10. 3 9. 7 -0. 6 -5. 83 -5. 855

10. 2 9. 6 -0. 6 -5. 88

Control Initial mass (g) Final mass (g) Change in mass (g)

2. 7 2. 7 0

Conclusion

On my average graph the main trend correlation is negative. The percentage change falls as the concentration rises and this makes the two approximately proportional when the best fit is added in. The best fit line passes through the concentration (M) line at approximately 0. 25M. This is the concentration of a potato cell that I was trying to achieve (the isotonic point), where the

concentration of the sucrose solution is the same as the potato’s solute concentration. It means that the potato cell has a solute concentration between 0. 20M and 0. 30M approximately. I can say that the sucrose concentrations below 0. 25M is the hypotonic solution and sucrose concentrations above 0. 25M is the hypertonic solution (approximate values) when it is put in with a potato.

The error bar graph shows how different each repeat experiment was and this tells me how accurate I was in my experiment on each concentration. Each point has a line with a marker at the end (to identify when it starts and ends), which is to represent the error margin, and the further away the these lines are from each other then the less accurate the experiment. These are not very far away on the smaller concentrations like 0M up to 0. 2M (very accurate results), but higher up on the concentration scale the results seems to be varied a bit more, but the lines are still touching on some concentrations (some variation on the results). It is definitely because of one or more variables changing. This could be because of different conditions, different potatoes or anyone of those. There were some anomalous on the graph in this same area as well. They still fit in the trend but do vary quite a lot around the mid point of each concentration.

My prediction was nearly right in thinking that the range of concentration was between 0. 3M and 0. 6M. The actual concentration was 0. 25M so I was near the range of results. I was right about the trend of the best fit line being in a negative correlation.

Evaluation

My procedure in the experiment showed up as good in the error bars, but there are some variables that I should have controlled better. I should have chose a smaller gauge for the potato cylinder to keep the results fair because I had to change the potato more often than if I was to use a smaller gauge (not enough potato to do all the initial and repeat experiments). I could have tested more concentrations like the ones in between 0. 2M and 0. 5M (0. 3M and 0. 4M) or maybe even more (0. 25M) to get a better best fit line. Cutting the potatoes was the hardest part of the procedure as I had to get the length exactly right and make sure I took off all the skin as well. If it was available I would have used a machine to cut it accurately as to get it the same weight and length to get a very fair experiment for all the concentrations I tested.

When I was ready to weigh the potato cylinders I could have accidentally dried some potatoes out more when they came out of the sucrose solution than others, therefore making a difference in weight. If I had the equipment and the time I could dry out the potatoes in a very fair and even way to ensure that they are all treated the same. Although the procedures could use some improving the experiment was a success.

Extension Work

For extension work I could change another variable like temperature of the sucrose solution to see how it affects water passing though a partially permeable membrane by osmosis. I could test much more concentrations (0.

05M, etc.) and take more repeat experiments. It could be left for longer in the solution to get more net movement (if there is any) and get more curtain results over a large percentage change scale.