PHILIP XIU

Determination of the water potential of potato tissue by a gravimetric method.

1. Explain the theory behind the experiment.

Water potential, Ψ_w, is a measure of the ability of water molecules to move from one region to another. The more water molecules there are per volume of the cell the more likely that by random movement they will collide with the cell's plasma membrane, and travel out of it. Pure water has a Ψ_w of 0. As all solutions have less water molecules per volume than pure water they have a lower Ψ_w; therefore all solutions have negative water potentials. The net movement of water molecules is always from a region of high water potential to one of lower water potential, they move down a water potential gradient until equilibrium is reached it will be reached when the water potentials on both sides of the plasma membrane are the same.

When the potato is placed in water or a hypotonic solution its cells will swell, although they will not burst due to the cell wall, as water molecules enter the cell down a water potential gradient. The cells become turgid, with the protoplast pushed up against the cell wall, therefore gaining in length and mass.

When the potato is immersed in a hypertonic solution the prot oplast shrinks and the plasma membrane pulls away from the cell wall. The cell wall is freely permeable and the plasma membrane, partially. Therefore the space between the shrunken protoplast and the cell wall fills with the surrounding solution so it remains in contact with the plasma membrane.

Osmosis occurs until equilibrium is reached; therefore the water potential of a potato tissue can be determined by balancing it with an external solution which produces no mass or volume change in the tissue. The os motic potential can be determined by balancing it with an external solution that produces incipient plasmolysis. Incipient plasmolysis is when $\Psi_p = 0$, so $\Psi_w = \Psi_s$.

Therefore when the potato is placed in a solution with higher water potential, closer to zero, than the potato cells, then it will gain mass. They will lose mass when placed in one with a lower water potential, as in both cases water molecules move down a water potential gradient.

When a graph is plotted of gain or loss in mass of the potato chips (g) against water potential of sucrose solution the line will intercept the X -axis, water potential of sucrose solution. This intercept is the water potential at which there was no gain or loss in mass and is th erefore the water potential of the potato. By this method a quantitative value for Ψ_{potato} is obtained.

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2. From the graph determine the molarities of sucrose where no change in mass occurs.

Chips: 0.33M Ψ = -8.2 Atms

Disks: 0.22M Ψ = -5.5 Atms

3. What are the sources of error in this experiment?

The equipment used places limits on both precision and accuracy. The lack of precision of the instruments is reflected in the number of decimal places the data can be recorded to.

Balances: The digital balance reads to two decimal places. This is quite precise but as the masses of potato tissue were so small there can be a high percentage error. Even if there was an machinery error it was kept constant by using the same balance throughout the procedure.

Pipette: Very accurate, to the nearest 0.05cm^3 but error none the less.

The tissue sample was all from the same region of the potato but was still very varied. This will have rendered the results more inaccurate as the water potential of each tissue sample could have been different, depending on the proportions of each type of tissue it contained. I.e. the inner part is more dense suggesting there might be more solutes inside therefore affecting its water potential.

The tissue sampled was also less dense than the solutions it was immersed in, (for the 1M and 0.8M). This meant that the potato chips floated in the solution and hence a small portion of each chip was not immersed in the solution (I estimate about 2%). These cells will not have been as affected as the immersed cells, although water will have diffused into or out of them through the immersed cells. So osmosis will have occurred at a slower rate, and thus to a lesser extent over the same time period. The mass of these cells will therefore have contributed to the initial mass and remained almost constant, making the final and change in mass less accurate.

I used tap water to dilute sucrose solutions down to my selected values. Tap water often contains ions and other molecules such as chlorine, fluoride, sulphur, minerals, salts, and heavy metals such as copper, lead and iron. However the majority of the contaminants in tap water are large, and often insoluble, molecules which have a lesser effect on Ψ_w than small soluble molecules. The use of tap water may well have had an effect on the accuracy of the results. The contaminants each volume of tap water contains will be constant so the effect will be mostly constant.

4. How would you improve your procedure to get a more accurate determination of the molarity where no mass change occurs?

I would do the experiment along the 0.2M to 0.4M region with a difference of 0.05M so I can get a very accurate account of exactly at what molarity the mass change is zero. I would also do a lot of repeat experiment s to average out any errors and to make sure I get concordant results. This is important as in dealing with very slight changes to the molarity, the accuracy has to be paramount.

5. What other differences did you notice between the discs after equilibrating in different solutions?

I noticed that the discs was smaller both in length and in width in the higher molarity solution, whilst in the lower concentrations I found that the discs tended to be bigger size wise. This is not surprising as at high molarities the water would osmosis out and so that amount of mass would be lost, also since water would be used as a sort of su pport medium i.e. to remain turgidity, the lost water would mean the cells would be flaccid so means that there would be a less cellular volume therefore the discs/chips would be smaller.

At lower molarities the disc's size increased as water would osmosi s in and so that amount of mass would be gained, also since water would be used as a sort of support medium i.e. to remain turgidity, the gained water would mean the cells would be turgid so means that there would be a larger cellular volume therefore the discs/chips would be bigger.

6. What suggestions can you make to account for any difference in water potential determined in disc and chips.

Surface area of discs: $\pi r^2 + 2\pi r = \pi 0.25^2 + 0.2(2\pi 0.25)$

$= 0.51 \text{cm}^3$

Surface area of chips: $2(0.8 \times 0.8) + 4(2 \times 0.8) = 7.68 \text{ cm}^3$

We can see that there is a 15 times difference in the surface area of the chip against the discs.

And according to Fick's law which states that the rate of diffusion is proportional to the (surface area $\times$ concentration difference) over the distance between the 2 areas.

We can see that the concentration difference would be the same for a given concentration and the distance i s roughly the same, so the only difference would be in the surface area. Which decides how fast the water molecules can diffuse out/into the cells. This would suggest that the chip would have a higher percentage change in mass against a disc for a given time and concentrations as diffusion rate is faster. And so we see a difference there.

Also we see that the chip has a larger volume than the disc. This means that it has much more water in it than the disc, and also suggests that the chip can hold more water than the disc. This means that proportionally a small mass change in the chip can be detected more and so suggesting the true value for no mass change as it accentuates the other values. Whilst the disc shows less accentuated changes.