**Skill Area O: Obtaining Evidence**

| Distance from light (cm) | Light intensity (lux) | Rate of Photosynthesis (number of bubbles/minute) | | | Average bubbles/min | Temperature ($^0$C) |
|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd (if needed) | | |
| 70 | 147 | 12 | 7 | 7 | 7+7/2=7, **7** | 20 |
| 60 | 190 | 14 | 15 | - | 14+15/2=14.5, **15** | 20 |
| 50 | 240 | 21 | 20 | - | 21+20/2=20.5, **21** | 20 |
| 40 | 355 | 26 | 26 | - | 26+26/2, **26** | 20 |
| 30 | 609 | 28 | 29 | - | 28+29/2=28.5, **29** | 20 |
| 20 | 1359 | 36 | 36 | - | 36+36/2=36, **36** | 20 |
| 10 | 4780 | 44 | 40 | 42 | 40+42/2=41, **41** | 20 |

**Secondary Data**

| Distance from light (cm) | Light intensity (lux) | Rate of Photosynthesis (number of bubbles/minute) | | | Average bubbles/min | Temperature ($^0$C) |
|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd (if needed) | | |
| 70 | 20 | 0 | 0 | - | 0+0/2=0, **0** | 20 |
| 60 | 25 | 3 | 5 | - | 3+5/2=4, **4** | 20 |
| 50 | 35 | 8 | 12 | - | 8+12/2=10, **10** | 20 |
| 40 | 55 | 19 | 21 | - | 19+21/2=20, **20** | 20 |
| 30 | 90 | 32 | 32 | - | 32+32/2=32, **32** | 20 |
| 20 | 180 | 48 | 47 | - | 48+47/2=47.5, **48** | 20 |
| 10 | 440 | 50 | 49 | - | 50+49/2=49.5, **50** | 20 |
| 5 | 920 | 49 | 51 | - | 49+51/2=50, **50** | 20 |

**Skill Area A: Analysing Evidence and Drawing Conclusions (Continued from graphs)**

**Trend/Pattern**

The graphs show me that from A – B as the light intensity increases so does the rate of photosynthesis. However from B – C the rate of photosynthesis starts to level off. I think that if I'd done another measurement at 5cm the rate of photosynthesis would have levelled off completely.

**Secondary Data**

My secondary data is the results that another boy in my class got. From the graphs I can see that his graph of, the rate of photosynthesis against light intensity, backs my graph up very well as they both have a very similar shape. This means that my graph probably does look how it is supposed to, so I probably didn' t make any major mistakes.

However the shape of his 'rate of photosynthesis against distance' graph does look quite different to that of my own. My graph just curves slowly all the way

down whereas his graph starts off flat, then curves down in the same way as mine, but towards the end it then starts to level off again. The flat section at the top of his graph probably occurs because of the extra measurement he took at 5cm that gave the enzymes the light needed to work at their optimum rate which would then explain why the rate of photosynthesis levelled off. The way that the line levels off at the end of his graph will have happened because the rate of photosynthesis will have started to slow down sooner than it did on my graph. This probably means that at these longer distances the light intensities were not the same for each of us, or that his pondweed was less sensitive to light over a longer distance than mine was.

**Conclusion**

From this pattern/trend I can work out that until a point, as the light intensity increases, the rate of photosynthesis will also increase because as the lamp gets closer to the pondweed (i.e. the light intensity increases), the pondweed is able to take in more light, which then means that its enzymes will have more energy to do their job of splitting water molecules into hydrogen atoms and oxygen molecules, which therefore means that the rate of photosynthesis will increase. However the reason why the rate of photosynthesis starts to level off is that the enzymes will reach their optimum rate, which means that they physically can't work any faster, so the rate o photosynthesis can't increase any more.

My conclusion does support my prediction quite well, as I predicted that as the light intensity increased the rate of photosynthesis would also increase which did happen. I also predicted that the rate of photosynthesis would start to level off because of limiting factors (e.g. the enzymes working at their optimum rate), this also happened, due to the enzymes working at their optimum rate, so they physically couldn't work any faster, which lead to the rate of photosynthesis to start to level off. However my conclusion does also undermine my prediction at times. For example I predicted that if I were to double the light intensity, the rate of photosynthesis would also double i.e. they would be directly proportional to each other. But this wasn't the case as when the rate of photosynthesis was increasing at a steady rate, it would double more quickly than the light intensity would. For example when the light intensity increased by a third, from 147 - 190, the rate of photosynthesis doubled, from 7 - 14.5, which shows that the rate of photosynthesis increased a lot quicker than the light intensity, until the rate of photosynthesis started to level off towards the end of the experiment.

**Skill Area E: Evaluating Evidence**

On my lux graph I have noticed that I do have one slightly anomalous result. However it is unclear which result it is. This is because if you look at this graph you can tell that either the fifth or sixth result must be an anomalous result, but the graph would make a smoother line if either of them was taken out. However I believe that the fifth result is probably the anomalous one as if it wasn't there or if it had had a quicker rate of photosynthesis the graph would have increased more steadily for longer and then it would have probably flattened off more than it has, which I believe would have been more accurate. I think that this anomalous result (the fifth result) may have occurred due to the fact that it might have needed to have a bit more time to equilibrate than the other results. This would explain why the rate of photosynthesis is a bit lower for this result than you might expect.

One thing that you must also realise about my conclusion is that it is only valid over the range of values that I investigated (i.e. the distance between the light and the pondweed being from 70cm away to 10cm away) and for the particular organisms (elodea, Canadian pondweed) and materials used in this experiment.

In my experiment I have been able to identify a few sources of error. The major error that I have found in my experiment is to do with the method by which I measured the rate of photosynthesis, because I calculated the rate of photosynthesis by counting how many bubbles of oxygen the pondweed gave off in a minute. The big problem with this method is that to think of it as an accurate way of measuring the rate of photosynthesis, you have to presume that all the bubbles of oxygen are all of the same volume, which of course they won't be. A more accurate way of calculating the amount of oxygen given off would be to collect the oxygen in a gas syringe, so you would then be able to measure the exact amount of oxygen given off.

Another source of error that I identified was to do with the accuracy of the light intensity throughout the experiment. The problem was that the light coming from my lamp wasn't the only light source in the room. Although we did shut the blinds and turn off the main lights during the experiment to cut down on the amount of unwanted light, there was sill a lot of light in the room that wasn't coming from my lamp. For example there was also light coming from other people's experiments, and from one main light in the room which we had to have on so that we could see what we were doing, and for safety purposes. However this extra light interference also means that my experiment won't be as accurate as it could've been, if there was only my light on.

I also think that I could improve my experiment by having a better, more accurate way to keep the pondweed at a constant temperature. The best way that I can think of, would be to use a proper water bath, that you can set the temperature on, this would be better as it would mean that you would be able to maintain a more accurate, constant temperature.

Another thing that I don't think helped the accuracy of my experiment was to do with the concentration of the $KHCO_3$ throughout the experiment. This is because I added it at the beginning of the experiment and the elodea will have been taking in the $CO_2$ throughout the experiment. So there would have been a higher concentration of KHCO3 at the beginning of the experiment than there would have been at the end. This is important as in my preliminary work I found out that the more CO2 there is surrounding the pondweed the quicker the rate of photosynthesis will be. This means that the experiment won't have been an entirely fair test.

To improve the reliability and accuracy of the results I would also take more values i.e. take a result every 5cm instead of every 10cm, as this would make the graph more accurate and make any anomalous points more obvious. Another thing that I'd do to improve the reliability of the results would be to repeat the results three times instead of twice, as if the pondweed hadn't fully equilibrated and you were to take two readings one after the other, you might still get similar results even though it's not full equilibrated. However if you were to take three readings one after another, you would be more likely to spot the possibility that the pondweed hasn't fully equilibrated, for the simple reason that it takes longer to do. I think that this might have helped with my anomalous result. On the same topic of 'equilibration', to improve the reliability and accuracy of the results I would also give the pondweed more time to equilibrate e.g. give it two minutes instead of one. This would also lessen the chance of getting similar results before the pondweed has finished equilibrating.

There is also some further work that I think I could do to find out more about the effect of light intensity on the rate of photosynthesis. The first thing that I think I could do would be to repeat the whole experiment again, with a different piece of pondweed, and taking measurements three times every 5cm instead as I suggested earlier; I would also make sure that my lamp was the only light source in the room and I would use a proper electric water bath. This would just double check my results again as I did with my friends results earlier on, although it would be more accurate. This is because the measurements would be taken more regularly, I would be sure that the only light in the room was coming from my lamp and the temperature would definitely be the same throughout the experiment.