Chemistry Project

Investigate and compare the quantitative effects of changing

(a) the rhubarb surface area and

(b) the temperature of solution

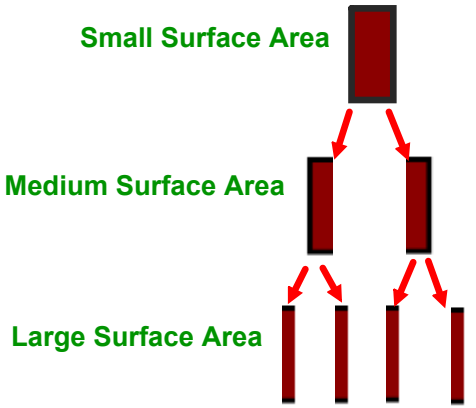
on the rate of reaction (measured by noting time for decolorisation of solution) between the oxalic acid in rhubarb and dilute potassium permanganate solution (acidified with sulfuric acid).

www.mrcjcs.com

Background

The oxalic acid in rhubarb causes the potassium permanganate to change colour from pink to clear.

We can cut the same size pieces of rhubarb in half and then in quarter to increase the surface area. Cutting up the rhubarb increases the surface area and so more oxalic acid is released for the reaction. The colour change should happen more quickly with more surface area and more oxalic acid.

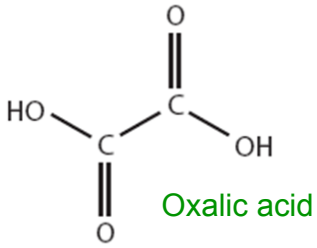


Option: Rate of reaction is usually written as 1/ time. We can divide 1 by the time taken to give more accurate/informative graphs (see graphs 3&4)

Changing the temperature of the solution should increase the speed/rate of the reaction also and make it change more quickly.

More Detailed Background

Oxalic acid reacts with potassium permanganate in acidic solution and is oxidised to carbon dioxide and water. Colourless manganese II ions are formed.



Oxalic acid

$$2MnO_4^- + 5C_2H_2O_4 + 6H_3O^+ \rightarrow 2Mn_2^+ + 10CO_2 + 14H_2O$$

Note: The potassium is a 'spectator' ion and is not included.

The potassium permanganate loses its colour, which provides an easy to measure endpoint to the reaction.

Sulphuric acid is added to the potassium permanganate to ensure the colour change is from pink to clear.

We should observe that as the surface area of the rhubarb increases, so does the rate of the reaction.

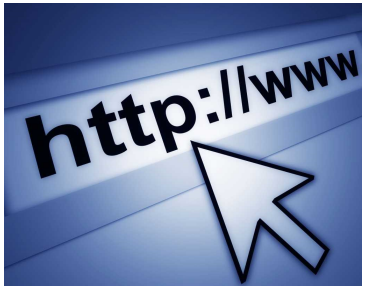
As the temperature increases so should the rate of the reaction as the molecules move around and interact more.

Part 1 (Introduction)

(i) Statement or problem to be investigated - What you are going to do **in your own words**

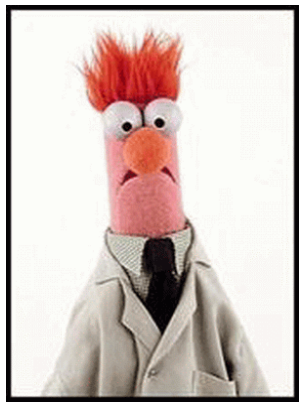
(ii) Background research undertaken - You will have to look up a few websites and books to find information for your investigation. You may even have to ask your teacher or someone at home for information. This is your background research you will need to give **at least 2 pieces** of background research and make sure for these that you mention where you got the piece of information and what you used it for.
e.g. https://www.youtube.com/watch?v=W57Lj4exLjM

Internet
(Give full link!)



Books
(Author and Publisher Page and Details)

Teacher



Part 2 (Preparation and Planning)

(i) Variables

1. **Independent** Variables
   What I will change? **Surface area of rhubarb or the temperature of solution**

2. **Dependent** Variable
   What I measure? **Rate (speed) of reaction (by colour change) in seconds.**

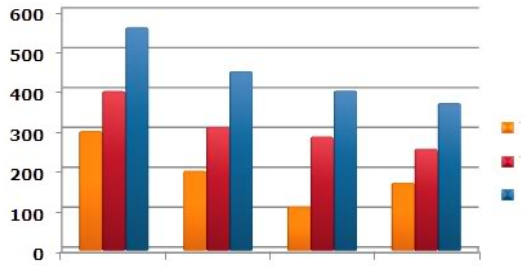
3. **Controls**
   What I will keep the same?
   - **Use the same batch (concentration) of potassium permanganate**
   - **Use same rectangular sized and shaped pieces of rhubarb**
   - **Stir/Swirl the solutions constantly at a slow speed - if at all.**

(ii) Equipment: List every piece of equipment you use.
e.g. Safety glasses, gloves, acidified potassium permanganate solution, rhubarb stalks (no leaves), knife, 3 beakers, 3 glass rods, thermometer, water bath or heating plate, 3 white tiles, stopwatch, pen and paper for results.

(iii) Tasks: ***This is the list of jobs (to do list) that need to be done in order.***

e.g.

- We will cut the rhubarb into 3 x 5 cm pieces (as similar in size as possible).
- We will cut up 2 of the pieces even further (see next section).
- Place each piece into a separate beaker with the acidified $KMnO_4$ at 20^oC.
- Place each beaker on a white tile.
- Start the timer/stopwatch and note when each solution changes from pink to clear.
- Repeat 3 times to get an average time at 20^oC.
- Repeat these steps at 40^oC and 60^oC.
- Write your results in a table and present in a graph.

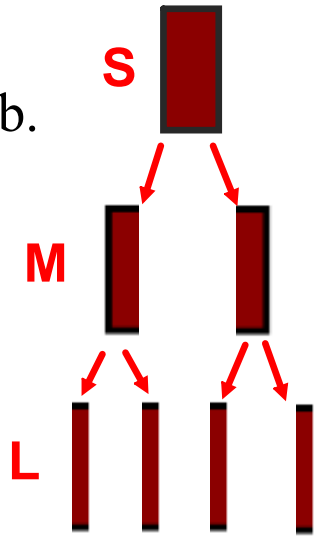


Part 3 (Procedures, apparatus etc.)

(i) Safety - We wear gloves and goggles when using acidified potassium permanganate. This is harmful if swallowed, harmful to skin and clothes. Take care using knife when cutting rhubarb. The leaves of the rhubarb are dangerous to eat as they contain a lot of oxalic acid.

(ii + iii) Procedure with diagram - Write it like a recipe.

1. Set up the same amount of the acidified $KMnO_4$ into each of the 3 beakers at room temperature (20°C) and place on white tiles.
2. Remove all leaves. Cut 3x5cm rectangular pieces of rhubarb.
3. **One** of the pieces will be placed into the first beaker. Cut the next piece of rhubarb in half lengthways and **two** pieces will be placed into another beaker. Finally cut the last piece in half and then in half again lengthways. These **four** pieces will be placed into the third beaker. Cutting increases the surface area for the oxalic acid.



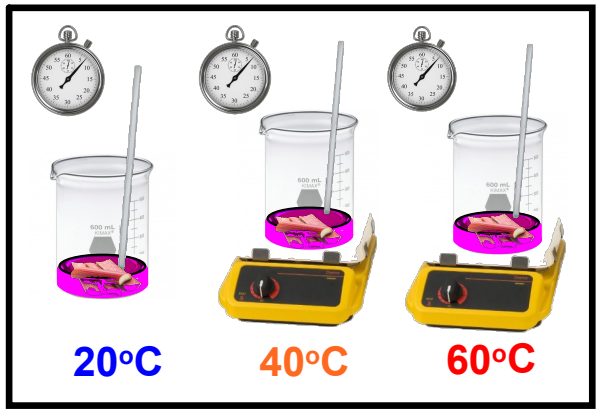
(ii + iii) Procedure with diagram

4. Carefully add the rhubarb into each of the beakers and start the stopwatch. Stir each solution slowly and constantly with a glass rod. Note the time at which the solutions changes colour from pink to clear. The white tiles help to see the colour change.

5. Repeat these steps 3 times and calculate the average for each beaker.

6. Set up 2 water baths.
   One should be at 40°C and the other to 60°C.

7. Repeat the above steps at each temperature and work out the averages for each beaker at each temperature. Option - Divide 1 by each time to calculate the rate of reaction. See Tables 1,2,3.



8. Write your results into tables and represent them on graphs.

(iv) Data and observations -

Record all the results from each experiment in a table like below.

Make a data table **before** you start your experiment so you can record your measurements as soon as you observe them.

Since we are looking at surface area, we can call the **1 Piece = Small, 2 Pieces = Medium and 4 Pieces = Large**.

Make sure to give your tables and graphs a name or number.

e.g.

Option

Table No. 1 - 20°C Temperature

	Trial 1	Trial 2	Trial 3	Average	Rate
1 Piece - **S**	388 sec	384 sec	380 sec	384 sec	1/384
2 Pieces - **M**	192 sec	184 sec	200 sec	192 sec	1/192
4 Pieces - **L**	88 sec	104 sec	96 sec	96 sec	1/96

Do another table like this for the 40°C and 60°C

Table No. 2 - 40°C Temperature

Option

	Trial 1	Trial 2	Trial 3	Average	Rate
1 Piece - **S**	94 sec	96 sec	98 sec	96 sec	1/96
2 Pieces - **M**	40 sec	56 sec	48 sec	48 sec	1/48
4 Pieces - **L**	24 sec	20 sec	28 sec	24 sec	1/24

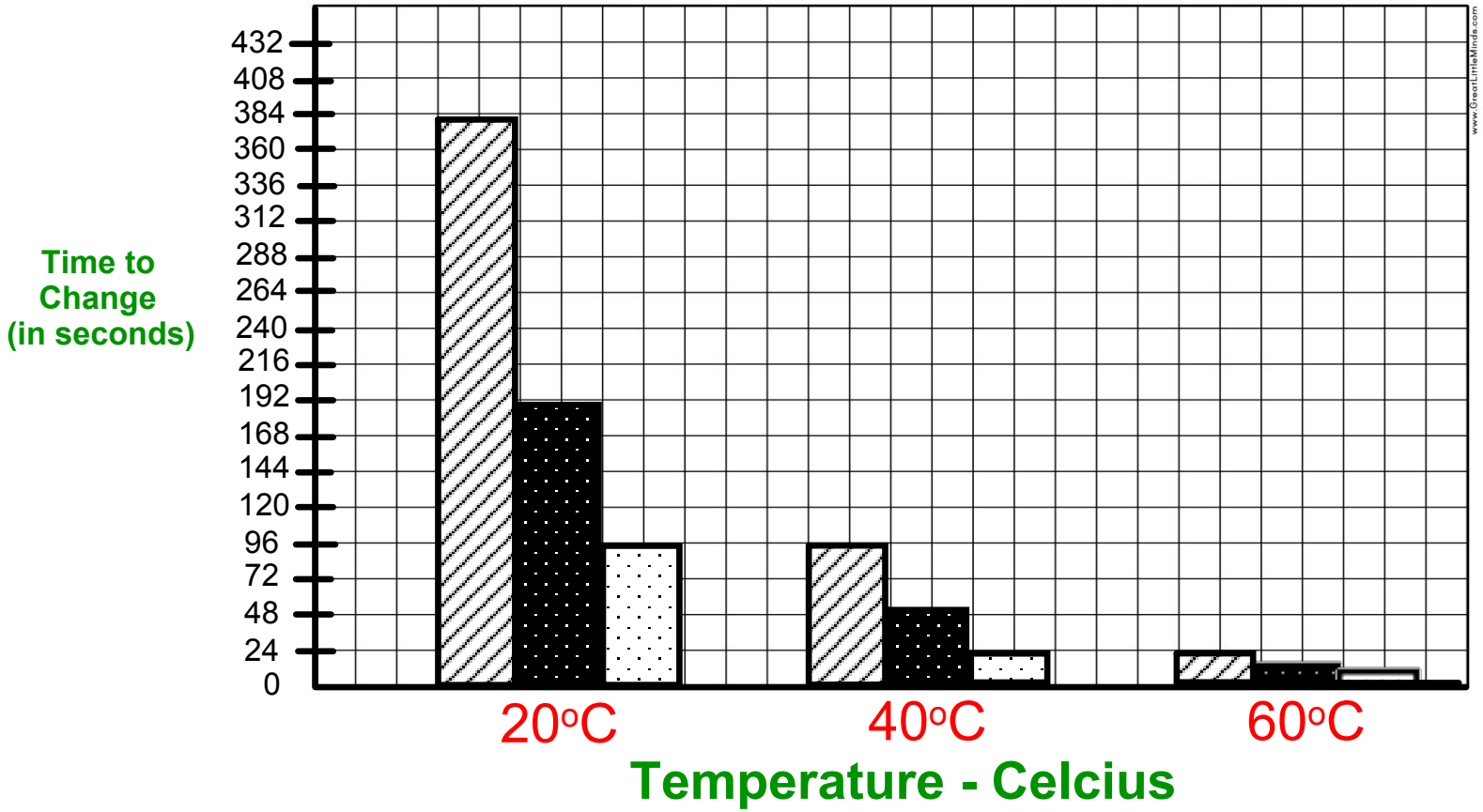
Table No. 3 - 60°C Temperature

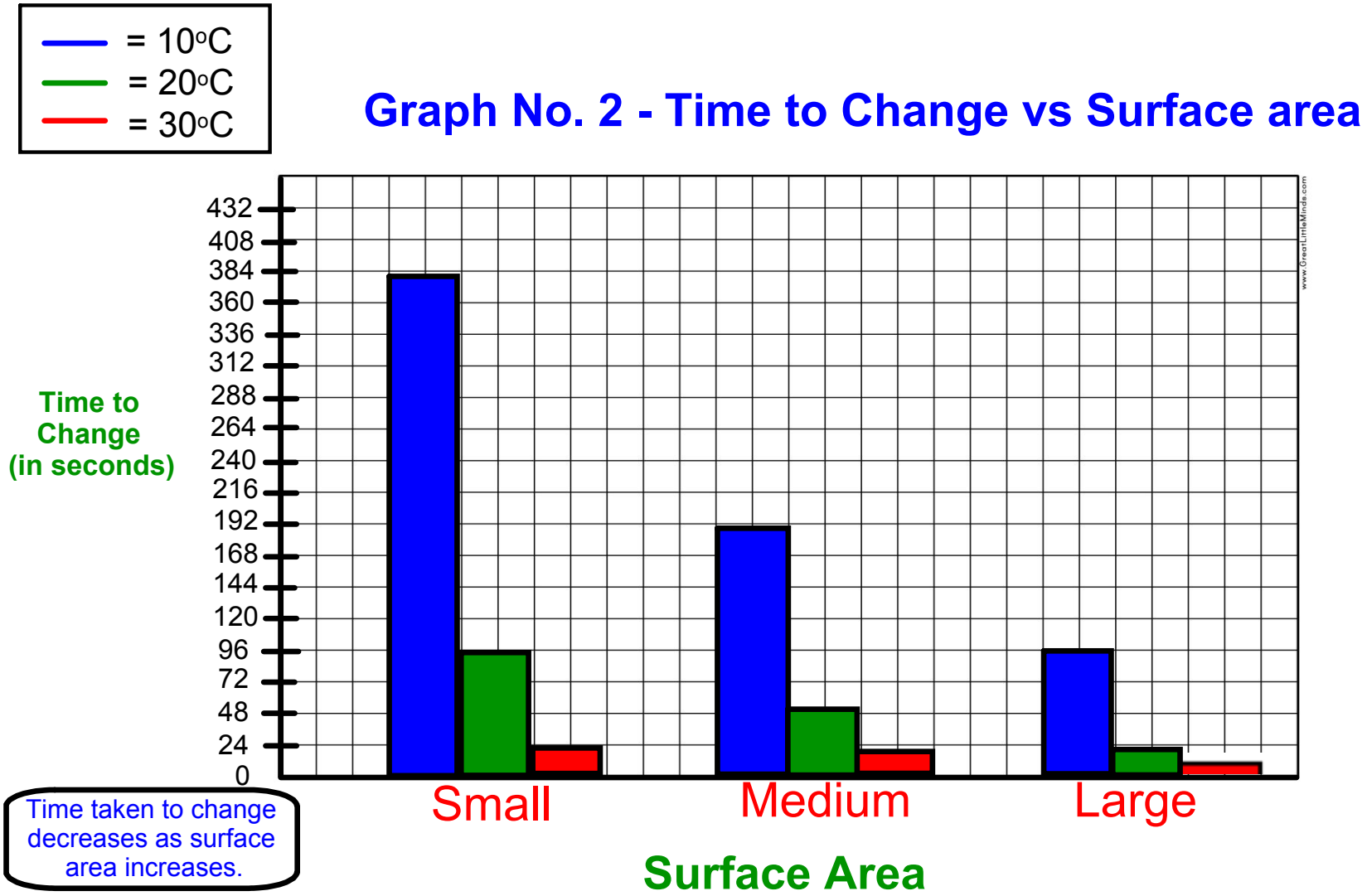
Option

	Trial 1	Trial 2	Trial 3	Average	Rate
1 Piece - **S**	18 sec	24 sec	30 sec	24 sec	1/24
2 Pieces - **M**	14 sec	10 sec	12 sec	12 sec	1/12
4 Pieces - **L**	6 sec	5 sec	7 sec	6 sec	1/6

= S - 1 Piece
= M - 2 Pieces
= L - 4 Pieces

Graph No. 1 - Time vs Temperature

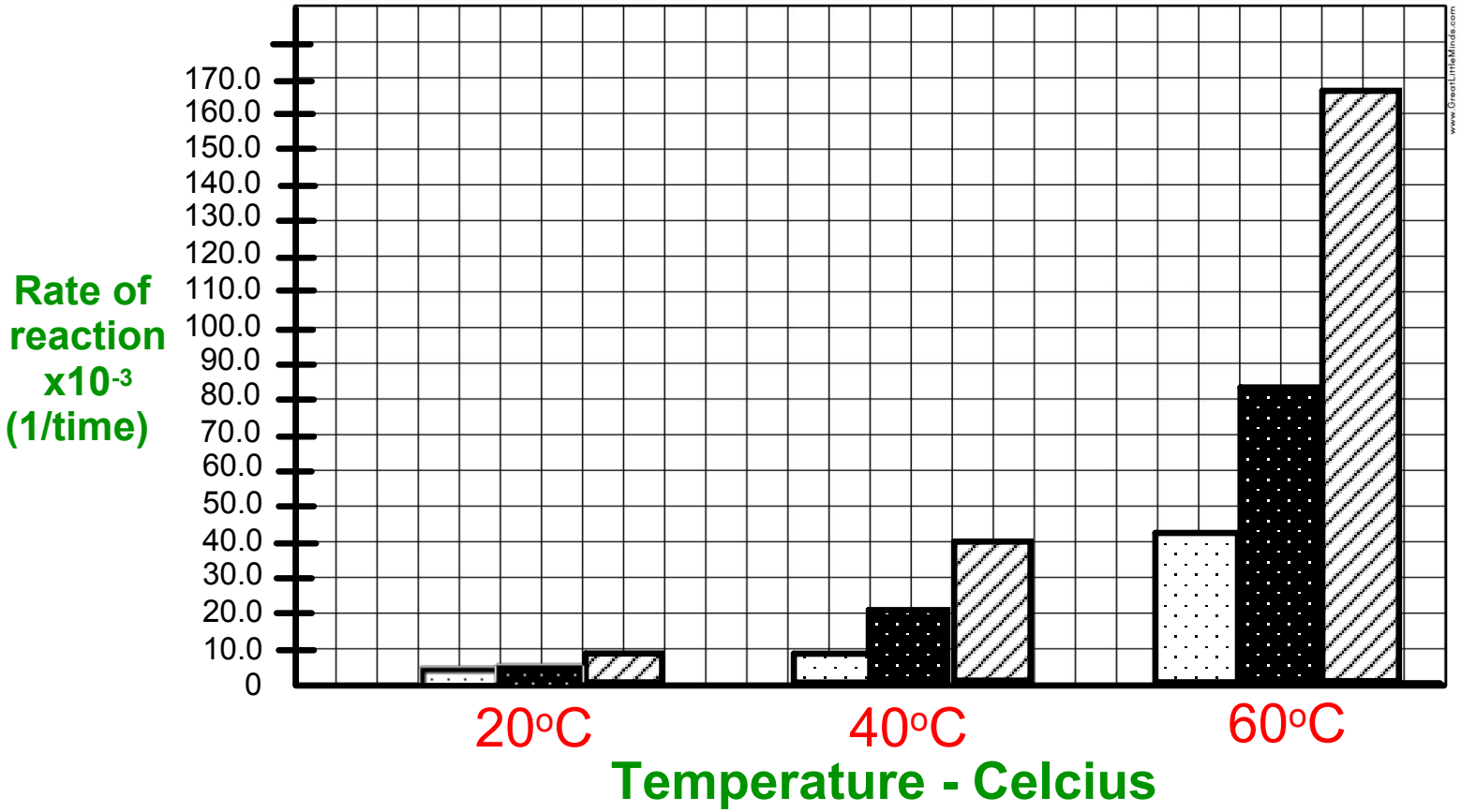



= 10°C
= 20°C
= 30°C
Graph No. 2 - Time to Change vs Surface area
Time to Change (in seconds)
432
408
384
360
336
312
288
264
240
216
192
168
144
120
96
72
48
24
0
Small
Medium
Large
Surface Area
Time taken to change decreases as surface area increases.

= S - 1 Piece
= M - 2 Pieces
= L - 4 Pieces

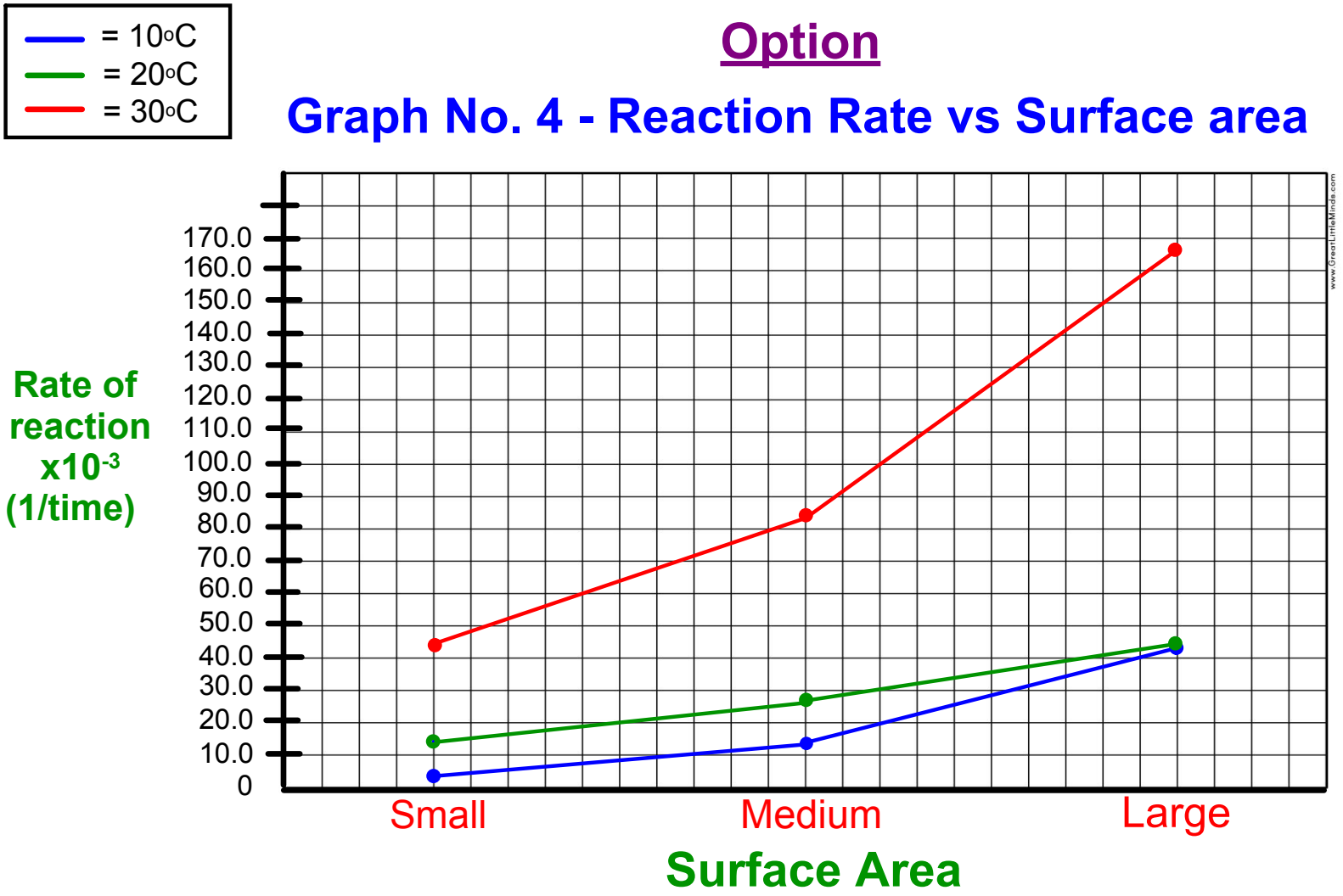
Option

Graph No. 3 - Reaction rate vs Temperature



Option

Graph No. 4 - Reaction Rate vs Surface area



Analysis

Now, analyze your data, and see if increasing the surface area helped increase the speed of the reaction (reaction rate) between the Oxalic acid and the $KMnO_4$.

We also need to check if the temperature affects the rate of the reaction.

Questions to think about...

What happens to the surface area when you half the rhubarb piece?
What happens to the surface area when you quarter the rhubarb piece?
What happens to the speed/rate when you change the surface area?
Does the rate/speed increase when you heat the solution?

Can you think of any other questions?

Part 4 (Analysis)

(i) Calculations and Data Analysis -

Make sure you outline any calculations (e.g. finding averages)

To find the average for each surface area we did the experiment 3 times and took the average result for the table and graph. We did the same for each of the different temperatures.
We can also divide the time into 1 to get the rate of the reaction. e.g 1/24 = 0.0416

(ii) Conclusion and Evaluation of result

Some useful sentence starters in this section are:

· I can see from my results that ……..
· When I changed ……..., …….. changed by……..
· From the graph I can see that …….

Answer some of the following questions in your written report.

· Do your results answer the question you were asking at the start?
· Were the results as you expected?
· Is there a trend in your results or did anything unusual happen?
· If you got an unusual result why do you think this happened?

Conclusions

Our results showed that the oxalic acid and $KMnO_4$ reacted the slowest when the rhubarb had a low surface area (Graph 2) and was at the lowest temperature of 20°C (Graph 1).

The rate of reaction increased as Surface Area increased (Graph 4) and the rate of reaction also increased as Temperature increased (Graph 3).

So the highest rate was when we had the rhubarb cut in 4 pieces (most surface area) and also at the highest temperature of 60°C.

We think that cutting the rhubarb increases the surface for the oxalic acid to react with the $KMnO_4$. Increasing the temperature lets the molecules move more quickly and react more easily, which increases the speed of the colour change.

Part 5 (Comments)

(i) Refinements, extensions and sources of error

Were you expecting these results?

Possible errors?

Was there anything that might have affected your results?

Slight differences in rhubarb thickness, or ripeness?

Some people may spot the colour change more quickly than others?

Potassium Permanganate was too concentrated?

Not enough Sulfuric acid means the solution turned brown instead of clear.

Could you develop your experiment further, how?

Use even more temperatures, more rhubarb, less rhubarb, cut different ways?

Change the concentration of the $KMnO_4$ or amount of acid?