**Rates and rhubarb**

**Aim**: To investigate variables that influence the rate of a chemical reaction.

**Part A:** Rate and temperature

**Background**

Potassium permanganate is a purple solution. The manganese atom has a high oxidation state in this compound. There are a range of reductants that can reduce the manganese and one of these is oxalic acid found in rhubarb and chocolate.

Oxalic acid – C2H2O4

Half equation

C2H2O4(aq) + 2H+(aq) 🡪 2CO2(g) + 2H2O(l) + 2e

Potassium permanganate is KMnO4

As the MnO4- is reduced, it forms the colourless Mn2+.

Note: In this experiment trends are evident but is difficult to draw precise quantitative results because there is more than one reaction occurring. There is also the complication that the Mn2+ produced in the reaction also acts as a catalyst for the reaction.

**Materials**

Rhubarb – from the fruit and vegetable shop!

(\*\*Remove the leaves of the rhubarb plant – they are toxic if eaten)

* 1. M potassium permanganate
1. M sulfuric acid

hot plate

knife

thermometer

Prepare an acidified permanganate solution by adding 500 mL of 2 M sulfuric acid to 500 mL of 0.1 M KMnO4

**Part A:** Rate and temperature

**Procedure**

**1.** Add 30 mL of acidified permanganate to a 100 mL beaker.

**2**. Cut a 6 cm piece of rhubarb stalk. Cut this piece into 10 pieces.

**3.** Record the temperature of the permanganate

**4**. Add the rhubarb to the permanganate and time how long it takes for the permanganate to

 go colourless. Stir gently.

**5**. Repeat the procedure but this time heat the solution to 40 °C before adding the rhubarb

**6**. Repeat the procedure but heat the solution to 60 °C before starting.

**Part B: Rate and surface area**

**Procedure**

**1.** You already have one reading for this section – it is the first reading in Part A when you

 used a 6cm piece of rhubarb cut into 10 pieces

**2.** Repeat this procedure (30 mL of acidified permanganate) but cut the 6 cm piece of rhubarb

 into about 30 pieces

**3.** Repeat this procedure (30 mL of acidified permanganate) but cut the 6 cm piece of rhubarb

 into 2 pieces only.

**Part C**: **Rate and concentration**

**Procedure**

**1.** Prepare a rhubarb solution by cutting two stalks of rhubarb, covering them in distilled

 water and boiling the mixture for about 10 minutes. The rhubarb should fall apart in this

 time. Filter the liquid to use for this experiment.

**2**. Add 30 mL of permanganate solution to a beaker.

**3**. Add 4 drops of the rhubarb solution and time how long it takes for the contents to go clear.

**4**. Repeat the procedure using 8 drops of rhubarb solution

**5**. Repeat the procedure using 12 drops of rhubarb solution

 6 marks allocated for the appropriate presentation of all results.

This is 2 marks for each Part.

**Questions**

**1. a**. Write a balanced half equation for the reduction of MnO4- to Mn2+ in acid conditions.

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 **b.** Write a balanced overall equation for the reaction.

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 **c**. What is the oxidation number of manganese in MnO4-?

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 **d**. Why is it necessary to add sulfuric acid to the MnO4-?

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 2 + 2 + 2 + 2 = 8 marks

**2**. Explain how you know when this reaction is complete

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1 mark

**3**. Plot a graph of time for the solution to go colourless against the temperature (temperature

 on the horizontal axis)

4 marks

**4**. What conclusion can you draw from this graph?

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2 marks

**5**. The time for the solution to go colourless is not really the rate.

 Calculate the reciprocal of each time value. Plot a graph of reciprocal against temperature.

3 marks

**6**. Why is this graph a better representation of how rate varies with temperature?

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2 marks

**7**. Explain why the rate of a reaction will change with temperature

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2 marks

**8.** Rhubarb is an organic substance. Is the rate of this reaction changing in the same way as

 most organic processes that have enzymes acting as catalysts? Explain your answer.

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2 marks

**Part B**

**9**. How did you change the surface area of the rhubarb?

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 2 marks

**10**. If you chop the first 6 cm piece of rhubarb into 2 and the second 6 cm piece of rhubarb

 into 4, what ratio have you changed the surface area by?

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 1 mark

**11**. What conclusion can you draw in Part B from the changes you made to the surface area?

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 2 marks

**12**. Do you think it would make any difference whether you cut across the rhubarb or along

 the rhubarb.? Discuss.

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 2 marks

**13**. Give an example of a process where the surface area impacts the rate of a reaction i.e.

 cooking time for chips compared to fries.

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**Part C**

**14**. What conclusion can you draw in Part C from the changes you made to the

 concentration?

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 2 marks

**15**. Why does the rate change with concentration in a reaction?

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 2 marks

**16**. Give an example of a process where the concentration impacts the rate of a reaction i.e.

 the effectiveness of a cleaning agent as its concentration is varied.

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 2 marks

**17.** If the leaves of the rhubarb plant are used instead of the stalk, the reaction rate is faster

 still. What conclusion might you draw from this?

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 2 marks

**18**. Summarise what you have learnt about reaction rates in this experiment

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 3 marks