# Clock Reaction: Chemistry 30
# A Study of the Rates of a Reaction
## TEACHER NOTES

You will need to make up the starch solution for this lab one day ahead so that it can cool to room temperature

You will need about 200 – 300 mL of each solution per lab group. The instructions below may have to be expanded or reduced depending on how many lab groups you have

- Heat the distilled water first.
- Then for every 1 L of distilled water , add a paste of 4 g starch mixed in a small amount of cold water to it.
- Let the mixture boil for about 10 minutes to suspend the starch in the solution.
- Let this solution cool and keep for the next day. This is the main ingredient for solution B.
- Next Day: Make the solutions: Remember this recipe is for l litre quantities and you may need more than this.

| | |
|---|---|
| Solution A: | 4.3 g of $KIO_3$ per litre of water |
| Solution B: | 0.20 g of $Na_2S_2O_{5(s)}$ to the 1 litre of starch solution & 5 mL of 1.0 mol/L $H_2SO_{4(aq)}$ **** add the sulfuric acid about 1 – 2 h before you plan to use the solutions!!!!! |

Test the solutions yourself to check the length of time until the blue colour appears. For part A you would like the time for the reaction to be between 10 and 15 seconds. If it is not in this ballpark, adjust the solutions as given below

- If the solutions require MORE than 15 seconds to react, add a bit more $Na_2S_2O_3$ or a little more acid to Solution B
- **If the solutions react too quickly (less than 10 seconds), then dilute solution A by adding some distilled water.**

**Prelab:** Use oxidation numbers to balance each reaction below. Clearly identify the OA and the RA for each reaction. (6 marks)

- Reaction 1 $IO_3^-{}_{(aq)} + HSO_3^-{}_{(aq)} \leftrightarrow I^-{}_{(aq)} + SO_4^{2-}{}_{(aq)}$
  - Oxidation $H_2O + HSO_3^- \rightarrow SO_4^{2-} + 3H^+ + 2e^-$
  - Reduction $6H^+ + 6e^- + IO_3^- \rightarrow I^- + 3H_2O$

Redox reaction $3HSO_3^- + IO_3^- \rightarrow 3SO_4^{2-} + 3H^+ + I^-$

- Reaction 2 $2I^-{}_{(aq)} + IO_3^-{}_{(aq} <\text{----}> I_{2(s)}$

- Oxidation $2I^- \rightarrow I_2 + 2e^-$
- Reduction $2IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$

| | |
|---|---|
| Redox reaction | $10I^- + 2IO_3^- + 12H^+ \rightarrow 6I_2 + 6H_2O$ |

Identify control variable(s) that will be used in this experiment. (1 mark)

- The concentration and temperature of solution B is unchanging
- The total volume of each reaction is kept at 20 mL.
- The same stop watch and time measuring person should be kept constant.

**Background:**

When the hydrogen sulfite ions are used up in reaction 1, the iodide ions react with the remaining iodate ions to produce iodine. The molecular iodine forms a blue substance with the starch present in solution 2 to give a visible blue indication that the reaction has proceeded to reaction 2.

In order to make this happen, which reagent is the excess reagent and the limiting reagent in Reaction 1? (1 mark)

- The excess reagent should be $IO_3^-$ ….. it must still be present to make reaction 2 start
- The limiting reagent should be $HSO_3^-$

## Observation Tables:

Part A:

| Trial | Volume of A (mL) | Volume of B (mL) | Time to colour change |
|---|---|---|---|
| 1 | 10 | 10 | |
| 2 | 10 | 10 | |
| 3 | 10 | 10 | |

**Most of the class should have similar results here. If not ,,,, the stopwatches may be the issue**

Part B

| Trial | Volume of A (mL) | Volume of B (mL) | Time to colour change |
|---|---|---|---|
| 1 | 9.0 | 10.0 | |
| 2 | 9.0 | 10.0 | |
| 1 | 7.0 | 10.0 | |
| 2 | 7.0 | 10.0 | |
| 1 | 5.0 | 10.0 | |
| 2 | 5.0 | 10.0 | |
| 1 | 3.0 | 10.0 | |
| 2 | 3.0 | 10.0 | |

**The time for the reaction should increase as the concentration goes down. The relationship is NOT linear however. It should form an increasing parabolic curve.**

Part C

| Trial | Volume of A (mL) | Temperature of solution A | Volume of B (mL) at room temperature | Time to colour change |
|---|---|---|---|---|
| | 10 | | 10 | |
| | 10 | | 10 | |
| | 10 | | 10 | |
| | 10 | | 10 | |

**This is always interesting! Ideally the time for the reaction increases as the concentration goes down. But with many groups contributing data …. There are often conflicting bits of evidence. The students must be prepared to deal with this.**
**They should do a manual 'line of best fit' and can use their calculators to give an equation if you want them to.**
**They should know how to use regression programs in their calculators to help with this.**

**Analysis:**

1. If the concentration of potassium iodate in solution A is 0.020 mol/L, find the diluted concentration(s) of solution A that you prepared in PART B.
(2 marks)

| Volume of solution A (mL) | Volume of water added (m) | Concentration of Solution A mol/L |
|---|---|---|
| 9.0 | 1.0 | $V_1C_1 = V_2C_2$<br>9 mL x 0.020 mol/L = 10 mL x $C_2$<br>$C_2$ = 0.018 mol/L |
| 7.0 | 3.0 | $V_1C_1 = V_2C_2$<br>7 mL x 0.020 mol/L = 10 mL x $C_2$<br>$C_2$ = 0.014 mol/L |
| 5.0 | 5.0 | 5 mL x 0.020 mol/L = 10 mL x $C_2$<br>$C_2 = V_1C_1 = V_2C_2$<br>$C_2$ = 0.010 mol/L |
| 3.0 | 7.0 | $V_1C_1 = V_2C_2$<br>3 mL x 0.020 mol/L = 10 mL x $C_2$<br>$C_2$ =0.0060 mol/L |

2. Make a summary of all the observations made by your classmates for Part C. Look for a pattern. If there are 'exceptions' to the pattern, be prepared to discuss why this has happened.
**Look for problems with a pattern. You have many different groups using different equipment …. So this can be exciting stuff**

3. Then plot concentration/time graph for PART B and a temperature/time graph for PART C. Remember to put the **manipulated variable** on the x axis and the **responding variable** on the y axis. (3 marks for each graph)
**Graphs must have titles, scale, description of units on both the x and y axis. They must show a 'line of best fit' rather than a disjointed line connecting all the points. Both these graphs will make a curve rather than a line!**

**Conclusions:**
Give generalization(s) based on your observations for PART B. and Part C. Be sure to support these generalizations with accepted scientific theory. (2 marks)

Part A
As solutions are diluted, the likelihood that molecules will have a successful collision goes down. Therefore when the concentration decreases, the length of time for colour change should increase. (inverse relationships)

Part B
The kinetic molecular theory states that with an increase in temperature, molecules will move with more energy. They will therefore be more likely to have a 'successful collision' and advance through the two steps of the reaction in a shorter time. So as temperature increases, the length of time to colour change will decrease. ( inverse relationship)