**10.1 Rates – Iodine Clock LEARNER**

**Introduction**

Peroxodisulfate(VI) ions, S2O82–, and iodide ions, I–, react together in solution to form sulfate ions, SO42–, and iodine, I2.

S2O82–(aq) + 2I–(aq) → 2SO42–(aq) + I2(aq)

The reaction can be carried out in the presence of a fixed amount of aqueous thiosulfate ions, S2O32–(aq), which reduces the iodine back to iodide.

2S2O32–(aq) + I2(aq) → S4O62–(aq) + 2I–(aq)

When all the S­2O32– ions have been used up, the iodine will react with starch solution, producing a blue-black colour.

You will time how long it takes from the start of each experiment for the blue colour to appear. The initial rate of disappearance of I–(aq) can be determined from this time.

You are going to plan and carry out an experiment to find the order of this reaction with respect to I–(aq) and also to find the rate constant for the reaction.

**Aims and *Skills***

* to determine the rate of reaction using a ‘clock’ method
* *to apply investigative approaches and methods to practical work*
* *to use appropriate software to process data*

**Intended class time**

* 1 hour

**Chemicals**

|  |  |  |  |
| --- | --- | --- | --- |
| **Label** | **Identity** | **Hazard information** | |
| 1.00 mol dm–3 KI(aq) | 1.00 mol dm–3 aqueous potassium iodide, KI(aq) | Currently not classified as hazardous | |
| 0.0400 mol dm–3 K2S2O8(aq) | 0.0400 mol dm–3 aqueous dipotassium peroxodisulfate(VI), K2S2O8(aq) | HSE long term health hazard symbol | DANGER  May cause respiratory irritation  May cause allergy or asthma symptoms or breathing difficulties if inhaled. |
| 0.0100 mol dm–3 Na2S2O3(aq) | 0.0100 mol dm–3 aqueous sodium thiosulfate, Na2S2O3(aq) | Currently not classified as hazardous | |
| Starch | 1% aqueous starch indicator | Currently no hazard classification | |
|  | De-ionised or distilled water |  | |

**Equipment**

In this experiment you will select the appropriate apparatus for the procedures. Your teacher will inform you of the apparatus available. You should record the apparatus that you select.

**Health and Safety**

* Wear eye protection throughout.
* Dispose of your chemicals as directed by your teacher.

**Procedure**

Before starting your practical work, read the information below.

Decide how you will organise your practical work, and which observations you need to make and/or which measurements you need to take. Ensure that you record all of your results in a suitable format.

1. Measure out 5.00 cm3 KI(aq), 2.00 cm3 S2O32–(aq) and 1.00 cm3 starch solution into a suitable container. Mix the contents.
2. Measure out 2.00 cm3 of K2S2O8(aq).
3. Add the 2.0 cm3 of K2S2O8(aq) to the mixture containingKI(aq), 2.00 cm3 S2O32–(aq) and 1.00 cm3 starch and **immediately** start the stop clock.   
   Mix the contents thoroughly.
4. Stop the clock when the blue-back colour is **just** visible.
5. Record the time, *t*.
6. Carry out further experiments in the same way but varying the concentration of KI(aq).   
   The total volume used in each experiment must be the same.

**Possible extension**

Carry out a further series of experiments to show the relationship between the rate of reaction and the concentration of peroxodisulfate(IV) ions, S2O82–(aq).

**Processing data**

1. Set up a spreadsheet with columns to record for each experiment:

* the volumes of KI(aq), H2O(aq), S2O32–(aq), starch and S2O82(aq)–
* the total volume
* [I–(aq)], using the formula: [I–(aq)] =  mol dm–3
* time for the mixture to turn blue
* initial rate, using the formula: initial rate = × mol dm–3 s–1

1. Enter the data you recorded in the experiments.
2. Use the spreadsheet program to plot your data points of initial rate against iodine concentration.

**Analysis of results**

1. Use your graph to determine the order of reaction with respect to I–(aq) ions.
2. Determine the gradient of the best-fit line through your data points.
3. The rate equation for this reaction is:

rate = *k*[I–(aq)][S2O82–(aq)]

Work out the concentration of S2O82–(aq) that you used in each of your experiments.

1. Rearrange the rate equation so that you can find the rate constant, with units, for the reaction. You will need both the concentration of S2O82– ions and the gradient of your graph.

**Extension Opportunities**

1. Look back at the procedure and introduction to the task.
2. The initial rate of reaction is shown as × mol dm–3 s–1

Show that this corresponds to the rate of disappearance of I– ions in each experiment.

1. The concentration of iodide ions, [I–(aq)], is shown as  mol dm–3

Show that this formula is correct.

1. What evidence is there that the reaction takes place in more than one step?
2. Propose a possible two- or three-step mechanism for this reaction assuming that the first step is the rate-determining step.

**Records**

As evidence for the Practical Endorsement, you should have recorded evidence of all your measurements and any relevant observations in a suitable format. You should also include a record of the equipment that you used, and any adaptations you made to your method while you completed the activity. You should save your spreadsheet with processed data, which will provide a record of the volumes of solutions you used for each experiment. If you keep hardcopy records, you may want to include a printout of your spreadsheet data there too. **All work should be clearly dated.**

In addition, in preparation for the assessment of practical work in the written examinations and to help you develop your understanding of the underlying chemical theory, you should complete the questions in the Analysis and Extension Opportunities sections. For calculations, you should show full workings and give final answers to the appropriate number of significant figures.