

## Investigating the rate of a reaction

### 1. Preliminary work

Theory: factors affecting the rate of reaction (i.e. temperature and concentration)  
use of particle collision theory to explain these factors  
rate measured by: rate of disappearance of reactants or appearance of products  
graphical methods of determining rate of reaction

Practical: reaction between dilute hydrochloric acid and sodium thiosulphate solution (disappearing cross method).

Points to note about this assessment:

- although the equation looks complex, only the appearance of sulphur is simple to do;
- the sulphur comes from the sodium thiosulphate solution, so only the acid should be diluted if concentration is being studied; and
- it is the temperature of the reaction **mixture** that should be investigated, not the temperature of either component before mixing.

### 2. Planning

Students should opt initially for **either** temperature **or** concentration.

They should make their own **predictions** about the effect of their chosen factor on the rate of the reaction (suggest they write these in their books). Predictions should be in the form of:

- what will happen to the rate of reaction as the concentration of acid is reduced?
- what will happen to the rate of reaction as the temperature of the reaction mix is increased?
- in each case, the prediction should be explained in terms of the particle collision theory.

Students to begin completing Planning Sheets. Emphasise that these are not marked as such, but allow the students to get their ideas organised. Boxes in **bold** must be completed individually, the others may be completed during a class “brainstorming”.

Title: Yours, or one of their own.

**Box A:** This depends upon their chosen factor.

**Box B:** Copy, or summarise, their predictions.

**Box C:** Reasons for their predictions (this must involve particle collision theory to gain high marks). Emphasise that predictions without (scientific) reasons will not attract a mark.

Box D: All variables, e.g.

- volume of hydrochloric acid
- volume of sodium thiosulphate solution
- concentration of hydrochloric acid
- concentration of sodium thiosulphate solution
- temperature of reaction mixture
- type of apparatus used (including the cross used to watch the appearance of sulphur)
- the time taken for the cross to disappear

**Box E:** Variables to change. The contents of this box will depend on whether they have chosen to investigate temperature of reaction mixture or concentration of hydrochloric acid.

**Box F:** Variables to keep the same (fair test). Again, the contents of this box depend upon the factor chosen, but must include the factor not chosen (e.g. they will use a constant temperature if they are changing the concentration, and *vice versa*).

Note: This leaves one dependent variables (helps to remind them for Box G):

- time taken for the cross to disappear

**Box G:** Observations and measurements, e.g.

- where a volume, temperature or time is involved, what apparatus will be used?
- how will they warm the hydrochloric acid?
- how will they dilute the hydrochloric acid?
- how many different concentrations or temperatures should they do (min. of 5)?
- how many replicates should they do to get reliable results?

Take in completed planning sheets for checking.

### 3. Carrying out experiment

They can do this individually or in pairs (but satisfy yourself that each student in a pair is doing enough). Emphasise **safety** (no marks for an unsafe procedure, e.g. not wearing goggles, boiling the acid, and so on). Be on the look out for improper measurements or faked results (temperatures below about 20°C, or exact multiples of 10°C, are good tell-tales). Results to be written directly into the blank tables at the end of the plan.

Students **must** keep to their plan – any changes must be checked with you.

Take in work for checking at the end of each session. Work is not to be taken home by the students.

### 4. Analysis and Evaluation

This must be an individual activity. As with planning, enabling comments/questions are allowed, but do not lead them. If you have to tell them something to get them going, make a note of this so that they do not gain credit for your ideas! A quantitative treatment of the results is important for access to high marks in this assessment.

### 5. Sheets available for this assessment

- N-Sc1-04-01 Planning
- N-Sc1-04-02 Analysis and Evaluation
- N-Sc1-04-03 Planning (standalone Skill O or emergency plan)
- N-Sc1-04-04 Emergency Results
- N-Sc1-04-05 Marking Guidelines
- N-Sc1-04-06 Skill P (standalone assessment)
- N-Sc1-04-07 Analysis and Evaluation (standalone skills)

## GCSE Chemistry Coursework: Investigating the rate of a reaction

Your task is to plan, and carry out, an experiment to discover how to change the rate the reaction between sodium thiosulphate solution and dilute hydrochloric acid. These react according to the equations below:

sodium thiosulphate + hydrochloric acid → sodium chloride + water + sulphur dioxide + sulphur



Your teacher will demonstrate a simple way to measure the rate of this reaction.

To help you, the mark scheme used by teachers is shown below.

Marks	The pupil can:
2	P.2a outline a simple procedure
4	P.4a plan to collect evidence which will be valid
	P.4b plan the use of suitable equipment or sources of evidence
6	P.6a use scientific knowledge and understanding to: <ul style="list-style-type: none"><li>● plan and communicate a procedure</li><li>● to identify key factors to vary, control or take into account</li><li>● to make a prediction where appropriate</li></ul>
	P.6b decide a suitable extent and range of evidence to be collected
8	P.8a use detailed scientific knowledge and understanding to: <ul style="list-style-type: none"><li>● describe a plan to get precise and reliable evidence</li><li>● explain a prediction, when one has been made</li></ul>
	P.8b use information from preliminary work, where appropriate, to refine the plan

To get high marks, your plan should be about two sides of A4, and include the headings shown below:

### Aims

A brief description of what you are trying to find out. Write a **prediction** of how the rate of reaction will change if you dilute the acid or change the temperature. **Explain** your predictions using scientific knowledge.

“I think ..... will happen because .....”

### Apparatus

Write a **detailed list** of all the apparatus you will use. If you specify measuring apparatus, say what it is for.

“Measuring cylinder (to measure the volume of acid)”

### Methods

- Write a **clear** description of the safe method you will use. Include labelled diagrams if you want to.
- Write down what you will **measure** and **observe**.
- Write down **how many** measurements and observations you will need to make your results **reliable**.
- “I will make sure my results are reliable by .....”
- Write down how you will make sure your results are **valid** (a **fair test**).
- “I will make sure my results are valid by keeping the following variables the same ..... and by changing this variable .....”

### Results

Draw a **neat**, blank **results table** (so you can write your results straight into it during your experiment).

## Investigating the rate of a reaction: Skills A and E

### Analysis

Teacher checklist for Skill A: Analysing evidence	
The student can:	Marks
• explain simply what the results show	2
• show the results in simple diagrams, charts or graphs • find trends or patterns in the results	4
• draw and use diagrams, charts, graphs (with a line of best fit), or calculate answers from the results (working out averages doesn't count) • draw a conclusion that fits the results and explain it using scientific knowledge	6
• use detailed scientific knowledge to explain the conclusion • explain how the results agree or disagree with a prediction made earlier	8

Consider these points as you write your Analysis:

- Have you shown your Results in a suitable form, e.g. in a clear **table**?
- Have you had a go at drawing a **graph** of your results?
- Can you do a **line or curve of best fit** on your graph?
- Can you see any **pattern** or **trend** in your Results, and can you explain it using scientific ideas?
- Compare your Results with your Predictions:
  - were you right, or were you wrong?
  - if you were wrong, try to explain why you were wrong (a text book might help, but remember to write down the title of any book you use at the end of your conclusions)

### Evaluation

Teacher checklist for Skill E: Evaluating evidence	
The student can:	Marks
• make a relevant comment about the method or the results	2
• comment on the quality of the results, pointing out any anomalous ones • comment on whether the method was a good one • suggest changes to improve the method, if necessary	4
• look at the evidence and: <ul style="list-style-type: none"><li>• comment critically on how reliable it is</li><li>• explain whether it is good enough to support a firm conclusion</li><li>• explain any anomalous results</li></ul> • describe in detail how they would do further work to get more results that would be <b>relevant</b> to the investigation	6

Consider these points as you write your Evaluation:

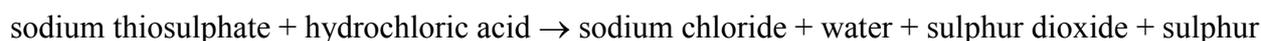
- Discuss how well your investigation went:
  - Did you take enough readings, and were they accurate enough?
  - Were any of the Results **anomalous** – did they seem out of place or just plain wrong?
  - If you have any anomalous Results, can you explain why you got them?
  - If you had to do the investigation again (you won't!), how would you improve it, and why?
- What other experiments might you do to test your conclusions?

## GCSE Modular Science – Chemistry Skill O Assessment

### The reaction between sodium thiosulphate and hydrochloric acid

#### Background

Sodium thiosulphate solution and dilute hydrochloric acid are both clear, colourless liquids. They react together according to the equation below:



The sulphur produced makes the reaction mixture go cloudy. The faster the reaction, the faster the reaction mixture goes cloudy. You will investigate the effect of changing the concentration of sodium thiosulphate on the rate of reaction. To get high marks, make sure that you:

- work safely and carefully (including keeping your apparatus and bench clean);
- take time to get your measurements right (your teacher will want to check on you here); and
- record your results clearly and accurately, and repeat any results that look out of place.

#### Apparatus

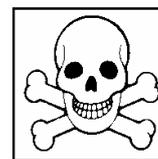
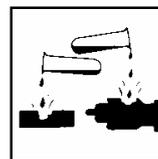
Goggles	Stop clock	50cm <sup>3</sup> measuring cylinder
Bench mat	Square of paper	0.1M sodium thiosulphate solution
Teat pipette	250cm <sup>3</sup> conical flask	2M hydrochloric acid
Thermometer	10cm <sup>3</sup> measuring cylinder	

#### Method

Read the Methods, then make a suitable results table to record your readings **before** you start.



Eye protection must be worn



1. Draw a dark cross on the piece of paper.  
Put the paper on the bench mat, and put the conical flask on top of the paper.
2. Measure 10cm<sup>3</sup> of sodium thiosulphate solution and put it into the conical flask.
3. Measure 40cm<sup>3</sup> of water and put it into the conical flask. Swirl the flask to mix the contents.
4. Measure 10cm<sup>3</sup> of acid. Pour the acid into the flask, start the stop clock, and swirl the flask. Time how long it takes for the cross to disappear, and take the temperature of the mixture.
5. Wash out the flask thoroughly.

Repeat the experiment using the other volumes of sodium thiosulphate and water in the table on the right. Keep the volume of acid the same each time.

Volume of sodium thiosulphate (cm <sup>3</sup> )	Volume of water (cm <sup>3</sup> )
10	40
20	30
30	20
40	10
50	0

#### Analysis of results

Plot a graph of time taken for the cross to disappear (vertical axis) against the volume of sodium thiosulphate used (horizontal axis). Check that you have sufficient results to draw a firm conclusion, then explain what your results tell you about the reaction between sodium thiosulphate and hydrochloric acid.

## Investigating the rate of a reaction

### Emergency Results

If you were unable to do the experiment for some reason, you will not be able to get a mark for Skill O (Obtaining Evidence). However, you can do Skills A and E (Analysing and Evaluating evidence) by using the Emergency Results in the table below.

#### Results

These were obtained using 50cm<sup>3</sup> of 0.08M sodium thiosulphate and 5cm<sup>3</sup> of 1.0M hydrochloric acid:

Temperature of reaction mixture (°C)	Reaction time (s)		
	Experiment 1	Experiment 2	Experiment 3
40	24	25	25
50	22	20	20
60	17	16	16
70	12	11	11
80	7	7	8

## Investigating the rate of a reaction

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## Investigating the rate of a reaction – marking guidelines

### Skill Area P (Planning)

The demand of this activity is sufficient to award P8, but only if they have used **detailed** scientific knowledge and a preliminary experiment. If they don't use detailed scientific knowledge, or they haven't used preliminary data, limit to P6, e.g. if they fulfil P.8a but not P.8b, award P7.

P.2a	Describes a simple method is simple which is likely to work, e.g. adding some hydrochloric acid to some sodium thiosulphate solution, and timing how long it takes for the cross to disappear.
P.4a	Plans to collect results that will be valid (e.g. some indication of how it will be a fair test). Some attempt made to vary the concentration of one of the reagents, e.g. bench acid v acid diluted with water. Shows some understanding that the volumes and temperatures need to stay the same.
P.4b	Chooses suitable apparatus (i.e. a complete apparatus list or apparatus mentioned in the text) <b>and</b> says what they will do with it, e.g. thermometer to measure the temperature of the mixture.
P.6a	Predicts the likely effect on rate or reaction or reaction time on diluting the acid and explains why in terms of the relative number of particles and collisions. States the variables, and identifies which need to be changed and which need to be kept constant. Describes method in detail, including all volumes and dilution factors. Implies or states how the experiment will be done safely ( <i>this is not a Specification point</i> ).
P.6b	Chooses a suitable number and range of measurements, e.g. five concentrations, repeated at least once; temperature of reaction mixture; time taken for cross to disappear.
P.8a	Predicts a <b>quantitative</b> effect on rate or reaction or reaction time on diluting the acid and gives a <b>detailed quantitative</b> explanation in terms of the number of particles and collisions. States the variables, and identifies which need to be changed and which need to be kept constant. Describes method in full detail, including all volumes, dilution factors, measurements and precautions needed to get precise and reliable results.
P.8b	Has carried out preliminary experiments and gives the results of these experiments. <b>Uses</b> these results to finalise their plan, e.g. choice of volumes, concentrations, apparatus, etc.

### Skill Area O (Obtaining Evidence)

Pupils should be observed to make sure that they carry out all practical work **safely**.

Detailed, tabulated and repeated observations are needed to get O6, otherwise award fewer marks.

Look at their graph before awarding O8. Do not award O8 if there are anomalous points and the student has not taken additional readings to compensate, or if their results are not on a good line.

O.2a	Worked safely (annotate script to say this) and did some experiments.
O.4a	Performed at least four experiments, e.g. two dilutions twice, four dilutions once, etc.
O.4b	Recorded their results (need not be a table). Includes time for cross to disappear, volume of acid used and temperature of reaction mixture.
O.6a	Five dilutions of acid used, each repeated at least once. If no repeats, award O.4a instead.
O.6b	Recorded results in a clear table, which must have units in the column headings. Times should be in seconds, not minutes and seconds. If they have times like 1.59 minutes and none above .59, it's a misuse of the decimal point – award O.4b instead.
O.8a	Precise measurements made (annotate script to show that you know they did it carefully and skilfully). Three replicate made for each dilution and/or extra repeats made where the results are very variable (look at their graph to see if they have tried to do this).

### Skill Area A (Analysing)

A.2a	States simply what their results show, e.g. the reaction time changes if the acid is diluted.
A.4a	Draws a graph of reaction time against volume of acid (or concentration of acid).
A.4b	Identifies a trend in the results, e.g. <i>the reaction time increases as the acid is diluted.</i>
A.6a	Calculates 1/time for each reading. N.B. Means do not count for this marking point. Plots a graph of 1/time against volume of acid (or concentration of acid). Line of best fit.
A.6b	Draws a conclusion in terms of <b>rate</b> of reaction, e.g. <i>the rate xxxx as the acid concentration xxxx.</i> Explains their conclusion in terms of particles and their collisions (need only be qualitative but must be restated – do not allow if they just refer you to their plan).
A.8a	Results must be good to support their conclusion – draws a conclusion in terms of <b>rate</b> of reaction, e.g. <i>the rate xxxx as the acid concentration xxxx.</i> Detailed explanation in terms of particles and their collisions (should be quantitative and must be restated – do not allow if they just refer you to their plan).
A.8b	Compares their results with their original predication, quoting values from their graph to explain how these support or undermine their prediction.

## Skill Area E (Evaluating)

Remember that E6 is supposed to be as hard as P8, O8, A8, so don't give it away!

Look for clear evidence that they understand in detail what is involved in the experiment.

E.2a	Makes a <b>relevant</b> comment about the method used or the results obtained.
E.4a	Comments on the accuracy of the times measured (look for more than just one sentence). Identifies anomalous results (if there are any – if they get beautiful results they should say so).
E.4b	Comments on the suitability of the method used (look for more than just one sentence), <b>and</b> suggests changes to improve it.
E.6a	Recognises possible sources of experimental error (not personal error!) Discusses <b>in detail</b> whether their evidence is good enough to support a firm conclusion. <b>Explains</b> anomalous results (not misreading – look for, e.g. <i>the rate was xxxx for this one because its temperature was xxxx than the others</i> ). Particularly look for a sign that they realise that long times are inaccurate because you can't be sure that the cross has/hasn't just disappeared, or that short times are inaccurate because you haven't got long to mix and time.
E.6b	<b>Detailed</b> description of further work in this area, e.g. extend the range of concentrations, different temperatures, alternative ways to time the reaction (e.g. a colorimeter).

## Annotations

- Remember that marking works from bottom up, i.e. there must be evidence for 2 marks before we can give 4 marks, etc. In cases where part of a description is met, consider awarding 1, 3 or 5 marks. If in doubt, you must refer to the Specifications. The bottom line is ... would somebody else broadly agree with your judgement? Consider writing **why** you awarded the marks on the script.
- You should indicate clearly on each script the point at which the pupil gains, has some evidence for, or fails to gain, a certain mark in a skill. The convention should be (e.g. for P.6a):  
✓ **P.6a** if they get it ... (**P.6a**) if there is some evidence for it ... and ... **X P.6a** if they don't get it.
- The final marks in each skill should be written across the top of the front page.
- It also helps in standardising if a couple of lines are added at the end to justify the overall marks.

## Notes

- Only enter a zero if the pupil was given the opportunity to do something but failed to do anything credit worthy. Unless a pupil was absent for part of the assessment, this is a whole investigation.

## GCSE Chemistry Coursework Skill P

### Investigating the rate of a reaction

#### Background

You have studied rates of reaction using these three reactions:

- decomposition of hydrogen peroxide;
- calcium carbonate with dilute hydrochloric acid; and
- magnesium with dilute hydrochloric acid.

You know about how the rate of a reaction can be changed by:

- changing the temperature of the reactants;
- changing the concentration of reactants in solution;
- changing the pressure of gaseous reactants;
- changing the surface area of solid reactants; and
- adding a catalyst.

You also know how to explain this using the idea of reactant particles colliding with each other.

#### Your task

Your task is to plan an experiment to discover how to change the rate of a reaction.

The reaction you will study is between sodium thiosulphate solution and dilute hydrochloric acid.

These react according to the equations below:

sodium thiosulphate + hydrochloric acid → sodium chloride + water + sulphur dioxide + sulphur



Your teacher will demonstrate a simple way to measure the rate of this reaction.

You can investigate the effect of:

- changing the temperature of the reaction mixture, **or**
- changing the concentration of the dilute hydrochloric acid.

If you want, you can describe how to investigate **both** variables, but you can still get top marks by designing a good investigation of only **one** of them.

To gain high marks, your plan should include:

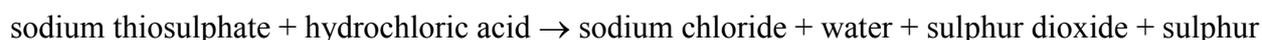
- a prediction of the effect on the rate of reaction of changing the temperature (or concentration) – this should be based on your scientific knowledge, and may be quantitative;
- a clear description of the method you will use (including details of all apparatus needed);
- details of what you will measure and/or observe;
- details of how many measurements and/or observations you intend to make;
- an explanation of how you will make it a fair test; and
- how you will carry out your investigation safely.

## GCSE Chemistry Coursework Skills A and E

### Investigating the rate of a reaction

#### Background

Sodium thiosulphate solution and dilute hydrochloric acid are both clear, colourless liquids. They react together according to the equation below:



The sulphur produced makes the reaction mixture go cloudy. The faster the reaction, the faster the reaction mixture goes cloudy. A student investigated the rate of this reaction at different temperatures. The method used and the results obtained are described below.

#### Methods

1. Put your goggles on. Draw a dark cross on a piece of paper, and put the paper on a bench mat.
2. Measure 50cm<sup>3</sup> of 0.08M sodium thiosulphate solution using a measuring cylinder and put it into the conical flask.
3. Warm the sodium thiosulphate solution using a Bunsen burner, tripod and gauze.
4. Measure 5cm<sup>3</sup> of 1.0M hydrochloric acid. Pour the acid into the flask, start the stop clock, and swirl the flask. Time how long it takes for the cross to disappear, and take the temperature of the mixture.
5. Wash out the flask thoroughly.

Repeat the experiment using the same volumes of sodium thiosulphate and acid, but vary the temperature of the sodium thiosulphate solution. Repeat experiments when necessary.

#### Results

Temperature of reaction mixture (°C)	Reaction time (s)		
	Experiment 1	Experiment 2	Experiment 3
40	24	25	25
50	22	20	20
60	17	16	16
70	12	11	11
80	7	7	8

#### Your Task

- Read through the background information, including the Methods and the Results;
- Analyse the results; and
- Evaluate the method and results

Some more information is given on the reverse of this sheet to guide you.

## Analysis

Teacher checklist for Skill A: Analysing evidence	
The student can:	Marks
• explain simply what the results show	2
• show the results in simple diagrams, charts or graphs • find trends or patterns in the results	4
• draw and use diagrams, charts, graphs (with a line of best fit), or calculate answers from the results (working out averages doesn't count) • draw a conclusion that fits the results and explain it using scientific knowledge	6
• use detailed scientific knowledge to explain the conclusion • explain how the results agree or disagree with a prediction made earlier	8

Consider these points as you write your Analysis:

- Have you shown your Results in a suitable form, e.g. in a clear **table**?
- Have you had a go at drawing a **graph** of your results?
- Can you do a **line or curve of best fit** on your graph?
- Can you see any **pattern** or **trend** in your Results, and can you explain it using scientific ideas?
- Compare your Results with your Predictions:
  - were you right, or were you wrong?
  - if you were wrong, try to explain why you were wrong (a text book might help, but remember to write down the title of any book you use at the end of your conclusions)

## Evaluation

Teacher checklist for Skill E: Evaluating evidence	
The student can:	Marks
• make a relevant comment about the method or the results	2
• comment on the quality of the results, pointing out any anomalous ones • comment on whether the method was a good one • suggest changes to improve the method, if necessary	4
• look at the evidence and: <ul style="list-style-type: none"><li>• comment critically on how reliable it is</li><li>• explain whether it is good enough to support a firm conclusion</li><li>• explain any anomalous results</li></ul> • describe in detail how they would do further work to get more results that would be <b>relevant</b> to the investigation	6

Consider these points as you write your Evaluation:

- Discuss how well your investigation went:
  - Did you take enough readings, and were they accurate enough?
  - Were any of the Results **anomalous** – did they seem out of place or just plain wrong?
  - If you have any anomalous Results, can you explain why you got them?
  - If you had to do the investigation again (you won't!), how would you improve it, and why?
- What other experiments might you do to test your conclusions?