# Chemistry PAG 8: Measuring the rates of reaction

# Combined Science PAG C5: Measuring the rates of reaction

# Suggested Activity 3: Investigating reaction energetics

## Instructions and answers for teachers and technicians

These instructions cover the learner activity section which can be found on [page 11](#_PAG_8:_Measuring). This Practical activity supports OCR GCSE Chemistry and Combined Science.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

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| --- |
| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

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| Royal Society of Chemistry | This resource is adapted from the Practical Chemistry project, developed by the Nuffield Foundation and the Royal Society of Chemistry – <http://www.rsc.org/learn-chemistry/collections/experimentation/practical-chemistry> specifically the practical ‘Exothermic or endothermic?’ – <http://www.rsc.org/learn-chemistry/resource/res00000406/exothermic-or-endothermic> |
| Nuffield Foundation logo |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

Learners measure temperature changes of four reactions, and classify the reactions as exothermic or endothermic.

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Chemistry**](http://www.ocr.org.uk/Images/323481-gcse-chemistry-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

By doing this experiment, learners have an opportunity to develop the following skills:

**1** [*1*]Use of appropriate apparatus to make and record a range of measurements accurately, including: (iii) temperature

**3** [*8*] Use of appropriate apparatus and techniques for: (i) conducting and monitoring chemical reactions

**5** [*10*] Making and recording of appropriate observations during chemical reactions including: (i) changes in temperature

**6** [*11*] Safe use and careful handling of gases, liquids and solids, including: (i) careful mixing of reagents under controlled conditions (ii) using appropriate apparatus to explore chemical changes and/or products

### Aims

To investigate a series of chemical reactions and determine whether they are exothermic or endothermic

### Intended class time

30–50 minutes depending on planning time.

### Links to Specifications:

### Gateway Science (Suite A) – including Working Scientifically (WS)

C3.1a use chemical symbols to write the formulae of elements and simple covalent and ionic compounds

C3.1f describe the physical states of products and reactants using state symbols (s, l, g and aq)

C3.2a distinguish between endothermic and exothermic reactions on the basis of the temperature change of the surroundings

C3.3d describe neutralisation as acid reacting with alkali or a base to form a salt plus water

C3.3f recall that carbonates and some metals react with acids and write balanced equations predicting products from given reactants

WS1.2a use scientific theories and explanations to develop hypotheses

WS1.2b plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena

WS1.3a Apply the cycle of collecting, presenting and analysing data, including: presenting observations and other data using appropriate methods

W1.3f Apply the cycle of collecting, presenting and analysing data, including: presenting reasoned explanations

WS2a carry out experiments

WS2b make and record observations and measurements using a range of apparatus and methods

WS2c presenting observations using appropriate methods

WS2d communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions.

### Twenty First Century Science (Suite B) – including Ideas about Science (IaS)

C1.2.1 distinguish between endothermic and exothermic reactions on the basis of the temperature change of the surroundings

C1.2.7 describe how you would investigate a chemical reaction to determine whether it is endothermic or exothermic (*separate science only*)

C2.4.1 use chemical symbols to write the formulae of elements and simple covalent and ionic compounds

C2.4.4 describe the physical states of products and reactants using state symbols (s, l, g and aq)

C5.4.4 describe neutralisation as acid reacting with alkali to form a salt plus water including the common laboratory acids hydrochloric acid, nitric acid and sulfuric acid and the common alkalis, the hydroxides of sodium, potassium and calcium

C6.1.1 recall that acids react with some metals and with carbonates and write equations predicting products from given reactants

IaS1.1 in given contexts use scientific theories and tentative explanations to develop and justify hypotheses and predictions

IaS2.1 present observations and other data using appropriate formats

IaS2.11 in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions

### Mathematical Skills covered

No defined mathematical skill is covered in this experiment.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Technical Requirements – PER GROUPChemicals  | **Identity** | **Approximate quantity required or produced PER GROUP** | **Hazard information** | | **Risk information** | | --- | --- | --- | --- | --- | | magnesium ribbon | 1 × 4 cm strip | Not currently classified as hazardous in this form. | | Magnesium ribbon is flammable. Pre-cut the ribbon and supervise its distribution. Do not have the stock roll in the laboratory. | | magnesium powder | access to small pot | **Flammable hazard** | DANGER: Flammable solid. Self-heating in large quantities (> 1kg); may catch fire. In contact with water releases flammable gases. | Portion out in small pots. Ensure there are no naked flames in the laboratory. | | citric acid solid, | access to small pot | HSE warning symbol | WARNING  Irritant (skin, eyes)  Irritant (respiratory) | Ensure learners wash hands / clean up spills promptly | | 0.4 mol/dm3 copper(II) sulfate solution | c. 20 cm3 | HSE warning symbol  **Corrosive/irritant hazard** | DANGER  Corrosive (eyes)  Irritant (skin) | | 0.4 mol dm–3 aqueous hydrochloric acid, HC*l*(aq) | c. 20 cm3 | Currently not classified as hazardous at this concentration | | | 0.4 mol dm–3 sodium hydroxide solution | c. 20 cm3 | HSE warning symbol | WARNING  Irritant (skin, eyes) | | 0.4 mol/dm3 sulfuric(VI) acid, H2SO4(aq) | c. 20 cm3 | Currently not classified as hazardous at this concentration | | | 0.4 mol dm–3 aqueous sodium hydrogen carbonate, NaHCO3(aq) | c. 20 cm3 | Currently not classified as hazardous at this concentration | |  | | hydrogen gas, H2(g) **PRODUCED** | c. 25 cm3 | **Hazard logo - extremely flammable** | DANGER: Extremely flammable | Wear eye protection. Ensure laboratory is well ventilated. Ensure there are no naked flames. |  Equipment  * eye protection * polystyrene cup * beaker (250 cm3) * thermometer (–10°C to 110°C) * measuring cylinder (10 cm3) * spatula * paper towels |

### Health and Safety

Eye protection should be worn at all times.

Ensure that there are no open flames in the laboratory

Ensure that no learner is allowed to remove magnesium from the laboratory

### Method

Learners will plan their own method to carry out these reactions. They should recognise that they need to take a temperature measurement before mixing the reagents and afterwards. Therefore, placing a liquid reagent in the polystyrene cup first is preferred. They should recognise the need to carefully rinse and dry the cup between reactions to prevent any unexpected reactions.

**Sample method:**

1. Place the polystyrene cup in the beaker to stabilise the cup, and provide some insulation.
2. Add 20 cm3 of hydrochloric acid into the cup.
3. Measure and record the temperature of the solution.
4. Add 20 cm3 of sodium hydroxide into the cup.
5. Stir the mixture with the thermometer and note the highest temperature.
6. Dispose of the reaction mixture down the sink with plenty of water.
7. Rinse and dry the cup.
8. Repeat for the remaining mixtures.

**Sample table:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Reaction | Final temperature / °C | Initial temperature / °C | Change in temperature / °C | Exothermic or endothermic reaction |
| hydrochloric acid + sodium hydroxide |  |  |  |  |
| sodium hydrogen carbonate solution + citric acid solid |  |  |  |  |
| copper sulfate solution + magnesium powder |  |  |  |  |
| sulfuric acid + magnesium ribbon |  |  |  |  |

### Images from trials

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| --- |
| A sample experimental set up  A sample experimental setup |

### Analysis of results – trial

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reaction** | **Final temperature / °C** | **Initial temperature / °C** | **Change in temperature / °C** | **Exothermic or endothermic reaction** |
| 20 cm3 hydrochloric acid  + 20 cm3 sodium hydroxide | 21 | 18 | + 3 | exothermic |
| 20 cm3 sodium hydrogen carbonate solution  + 4 spatulas citric acid solid | 16 | 18 | – 2 | endothermic |
| 20 cm3 copper sulfate solution  + 2 spatulas magnesium powder | 39 | 19 | + 20 | exothermic |
| 20 cm3 sulfuric acid  + 4 cm magnesium ribbon | 30 | 19 | +11 | exothermic |

|  |  |  |
| --- | --- | --- |
| **1.** | Which reactions are neutralisation reactions? **[2 marks]** |  |
|  | sodium hydroxide and hydrochloric acid ✓  sodium hydrogen carbonate and citric acid✓ |  |

|  |  |  |
| --- | --- | --- |
| **2.** | Which reactions are displacement reactions? **[2 marks]** |  |
|  | copper sulfate and magnesium ✓  sulfuric acid and magnesium ✓ |  |

### Extension opportunities

|  |  |  |  |
| --- | --- | --- | --- |
| **1.** | Write word and symbol equations for the different reactions that have occurred:   1. Reaction 1 **[2 marks]** | |  |
|  |  | sodium hydroxide + hydrochloric acid → sodium chloride + water ✓  NaOH(aq) + HC*l*(aq) → NaC*l*(aq) + H2O(l) ✓ |  |

|  |  |  |  |
| --- | --- | --- | --- |
|  | 1. Reaction 2 **[2 marks]** | |  |
|  |  | copper sulfate + magnesium → magnesium sulfate + copper ✓  CuSO4(aq) + Mg(s) → MgSO4(aq) + Cu(s) ✓ |  |
|  | 1. Reaction 3 **[2 marks]** | |  |
|  |  | sulfuric acid + magnesium → magnesium sulfate + hydrogen ✓  H2SO4(aq) + Mg(s) → MgSO4(aq) + H2(g) ✓ |  |
|  | 1. Reaction 4 (just word equation) **[1 mark]** | |  |
|  |  | sodium hydrogencarbonate + citric acid → sodium citrate + water + carbon dioxide ✓ |  |

**Document updates**

v1.1 February 2017 Published on qualification page

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# Chemistry PAG 8: Measuring the rates of reaction

# Combined Science PAG C5: Measuring the rates of reaction

# Suggested Activity 3: Investigating reaction energetics

## Learner Activity

### Introduction

During a chemical reaction, energy is transferred between the system and the surroundings. An exothermic reaction transfers energy to the surrounding, while an endothermic reaction gains energy from the surroundings. When energy transfers as heat, the change in the temperature can be measured using a thermometer. In this experiment, you will measure the temperature change in a series of chemical reactions in order to determine whether they are exothermic or endothermic.

### Aims

To investigate a series of chemical reactions and determine whether they are exothermic or endothermic

### Intended class time

10-20 minutes planning time + 20-30 minutes practical time

### Chemicals and equipment (per group)

* eye protection
* polystyrene cup
* beaker (250 cm3)
* thermometer (-10°C to 110°C)
* measuring cylinder (10 cm3)
* spatula
* paper towel
* magnesium ribbon
* magnesium powder (DANGER: Flammable)
* citric acid solid (WARNING: Irritant)
* 0.4 mol dm–3 copper(II) sulfate (DANGER: Corrosive and irritant)
* 0.4 mol dm–3 hydrochloric acid
* 0.4 mol dm–3 sodium hydroxide (WARNING: Irritant)
* 0.4 mol dm–3 sulfuric acid
* 0.4 mol dm–3 sodium hydrogen carbonate

### Health and Safety

* Eye protection should be worn at all times.
* Ensure that there are no open flames in the laboratory
* **DO NOT** remove any chemical from the classroom.

### Method

Using the equipment available to you, plan an experimental method to investigate the reaction energetics of the following reactions:

1. sodium hydroxide solution + hydrochloric acid solution
2. copper sulfate solution + magnesium powder
3. sulfuric acid solution + magnesium ribbon.
4. sodium hydrogen carbonate solution + citric acid solid

Consider the measurements that you will need to make to determine the temperature **change** of the reaction, and hence determine whether the reaction is **exothermic** or **endothermic**.

Write down your method, draw an appropriate table to collect and analyse your data, and have your teacher approve these before you start any experimental work.

### Method

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### Results

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Your ability to analyse your observations may depend on how much of the GCSE Chemistry/Combined Science course you have studied. Your teacher will let you know which questions you should focus on:

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| --- | --- | --- | --- |
| **1.** | Which reactions are neutralisation reactions? **[2 marks]** | |  |
|  |  | |
|  |  |  |  |
| **2.** | Which reactions are displacement reactions? **[2 marks]** | |  |
|  |  | |  |

### Extension opportunities

|  |  |  |  |
| --- | --- | --- | --- |
| **1.** | Write word and symbol equations for the different reactions that have occurred: | |  |
|  | 1. Reaction 1 **[2 marks]** | |  |
|  |  |  |  |
|  |  |  |  |
|  | 1. Reaction 2 **[2 marks]** | |  |
|  |  |  |  |
|  | 1. Reaction 3 **[2 marks]** | |  |
|  |  |  |  |
|  | 1. Reaction 4 (just word equation) **[1 mark]** | |  |
|  |  |  |  |

### DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet ([**Chemistry**](http://www.ocr.org.uk/Images/295630-gcse-chemistry-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) you may be able to tick off the following skills:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Chemistry** | | | |  | ***Combined Science*** | | | |
| 1-iii | 3-i | 5-i | 6-i |  | *1-iii* | *8-i* | *10-i* | *11-i* |
| 6-ii |  |  |  |  | *11-ii* |  |  |  |