**ACTIVITY: Limestone to lime**

In this activity, students view the interactive Calcination – lime from limestone, which shows the industrial processing of limestone into lime, and use the information to complete a matching activity.

By the end of this activity, students should be able to:

* describe the effect of heat on limestone
* define the term ‘calcination’
* outline the main process steps in the production of lime from limestone
* recall the meanings of the terms ‘exothermic’ and ‘endothermic’
* write word and symbol equations for the main chemical reactions occurring
* distinguish between the terms ‘limestone’, ‘lime’ and ‘slaked lime’.

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**Introduction/background**

From the earliest of times, it was known that heating limestone to high temperatures produced a chemical with uses in building, roading and agriculture. It is the thermal decomposition of calcium carbonate within the limestone that is the key reaction in this process, known as ‘calcination’.

Temperatures above 850°C are required to decompose the limestone, and this is difficult to achieve in a conventional school laboratory. By engaging with the interactive [Calcination](https://www.sciencelearn.org.nz/image_maps/5-calcination) and reading the article [Carbonate chemistry](https://www.sciencelearn.org.nz/resources/469-carbonate-chemistry), which looks at chemical properties of calcium carbonate, students will gain a fuller understanding of the effect heat has on limestone.

A matching activity can then be used to assess students’ understanding. An additional table-completion activity can be attempted by students with an aptitude for chemistry.

**What you need**

* Access to the article [Carbonate chemistry](https://www.sciencelearn.org.nz/resources/469-carbonate-chemistry)
* Access to the interactive [Calcination](https://www.sciencelearn.org.nz/image_maps/5-calcination)
* Copies of the student handouts [Meaningful matches](#matches) and [Carbonate chemistry](#carbonate)

**What to do**

1. As a class, read through the article [Carbonate chemistry](https://www.sciencelearn.org.nz/resources/469-carbonate-chemistry).
2. View each of the parts of the [Calcination](https://www.sciencelearn.org.nz/image_maps/5-calcination) interactive and listen to each of the audio commentaries and/or read the transcript.
3. Hand out copies of the student handout [Meaningful matches](#matches) and have students complete it.
4. Optional: Hand out copies of the student handout [Carbonate chemistry](#carbonate) and have students complete it using information from the interactive and the article.

**Student handout: Meaningful matches**

Find a meaningful match for information in the ‘Calcination – lime from limestone’ interactive from the list below and enter it in the table. One answer has been filled in already.

|  |  |  |
| --- | --- | --- |
| 1 rpm | Blown air | National/local requirements for air, water, waste discharge |
| 1000°C | Calcium oxide | Particulate matter |
| 1000–1200°C | Coal from Huntly | Percentage CaCO3 |
| ~~1030°C~~ | Continuous feed | Rogue minerals |
| 11 | Conveyor belt | Rotary kiln |
| 15–50 mm | Crushed to a fine powder | Settling ponds |
| 2 hours | Drill and blast | Thickness of limestone grade quarried |
| 3 m | Endothermic | Transport to customers |
| 4 hours | Excavators and dump trucks | Vented to the air via a 30 m chimney |
| 6 GJ | Kiln samples analysed for loss on ignition | X-ray fluorescence and titration |
| 60 m | Loss on ignition |  |

|  |  |  |
| --- | --- | --- |
| **Process step** | **Information in the interactive** | **Meaningful match** |
| **Pre-extraction testing** | 97% |  |
| Silica and iron oxides |  |
| 10 m |  |
| Temperature of molten lab sample | *1030°C* |
| **At the quarry** | Method of extraction used |  |
| Size of limestone chip |  |
| Crushing plant |  |
| Quarry machinery |  |
| **Arrival at the calcination plant** | Temperature in preheater |  |
| Where to from preheater |  |
| Method of transport to preheater |  |
| Time chip held in the preheater |  |
| **Rotary kiln** | Length  |  |
| Diameter |  |
| Rate of revolution |  |
| Time in kiln |  |
| Temperature in kiln |  |
| Kiln heated by |  |
| Heat requiring reaction |  |
| 0.5–1.0% |  |
| 3.17 GJ |  |
| Actual energy needed to convert 1 tonne |  |
| **Testing in the lab** | Main methods of analysis |  |
| How many elements tested for |  |
| Two elements of concern to the steel industry |  |
| LOI |  |
| **Lime chip cooling** | How lime chip is cooled |  |
| How chip is processed |  |
| What is burnt lime? |  |
| Road or rail |  |
| **Waste management** | Venturi water system removes what? |  |
| What happens to the remaining gas? |  |
| Wastewater goes where?  |  |
| Careful monitoring |  |

**Student handout: Carbonate chemistry**

Use the list below to fill in the missing names, formulas and chemical reaction equations.

|  |  |
| --- | --- |
| Ca(OH)2 | carbon dioxide |
| Ca(OH)2(aq) + CO2(g) → CaCO3(s) + H2O | dihydrogen monoxide |
| CaCO3(s) | H2O(l) |
| calcium oxide | limestone |
| CaO(s) + H2O(l) → Ca(OH)2(aq) | slaked lime |

|  |  |  |  |
| --- | --- | --- | --- |
| **Chemical formula** | **Chemical name** | **Alternative name** | **Chemical reaction equations** |
|  | calcium carbonate |  | **Calcining**CaCO3(s) → CaO(s) + CO2(g) |
| CaO(s) |  | lime | **Slaking** |
|  | calcium hydroxide |  | **Carbonating** |
| CO2(g) |  | carbonic acid gas | **Dissolution**CO2(g) + H2O(l) → H2CO3(aq) |
|  | water |  |  |

**Answers: Meaningful matches**

|  |  |  |
| --- | --- | --- |
| **Process step** | **Information in the interactive** | **Meaningful match** |
| **Pre-extraction testing** | 97% | Percentage CaCO3 |
| Silica and iron oxides | Rogue minerals |
| 10 m | Thickness of limestone grade quarried |
| Temperature of molten lab sample | 1030°C |
| **At the quarry** | Method of extraction used | Drill and blast |
| Size of limestone chip | 15–50 mm |
| Crushing plant | Continuous feed |
| Quarry machinery | Excavators and dump trucks |
| **Arrival at the calcination plant** | Temperature in preheater | 1000°C |
| Where to from preheater | Rotary kiln |
| Method of transport to preheater | Conveyor belt |
| Time chip held in the preheater | 4 hours |
| **Rotary kiln** | Length  | 60 m |
| Diameter | 3 m |
| Rate of revolution | 1 rpm |
| Time in kiln | 2 hours  |
| Temperature in kiln | 1000–1200°C |
| Kiln heated by | Coal from Huntly |
| Heat requiring reaction | Endothermic |
| 0.5–1.0% | Loss on ignition |
| 3.17 GJ | Theoretical energy needed |
| Actual energy needed to convert 1 tonne | 6 GJ |
| **Testing in the lab** | Main methods of analysis | X-ray fluorescence and titration |
| How many elements tested for | 11  |
| Two elements of concern to the steel industry | Silicon and sulfur  |
| LOI | Kiln samples analysed for loss on ignition |
| **Lime chip cooling** | How lime chip is cooled | Blown air |
| How chip is processed | Crushed to a fine powder |
| What is burnt lime? | Calcium oxide |
| Road or rail | Transport to customers |
| **Waste management** | Venturi water system removes what? | Particulate matter |
| What happens to the remaining gas? | Vented to the air via a 30 m chimney |
| Wastewater goes where?  | Settling ponds |
| Careful monitoring | National/local requirements for air, water, waste discharge |

**Answers: Carbonate chemistry**

|  |  |  |  |
| --- | --- | --- | --- |
| **Chemical formula** | **Chemical name** | **Alternative name** | **Chemical reaction equations** |
| CaCO3(s) | calcium carbonate | limestone | **Calcining**CaCO3(s) → CaO(s) + CO2(g) |
| CaO(s) | calcium oxide | lime | **Slaking**CaO(s) + H2O(l) → Ca(OH)2(aq) |
| Ca(OH)2 | calcium hydroxide | slaked lime | **Carbonating**Ca(OH)2(aq) + CO2(g) → CaCO3(s) + H2O |
| CO2(g) | carbon dioxide | carbonic acid gas | **Dissolution**CO2(g) + H2O(l) → H2CO3(aq) |
| H2O(l) | water | dihydrogen monoxide |  |