

## TEACHER NOTES

## Decomposition of calcium carbonate: Johnstone's triangle

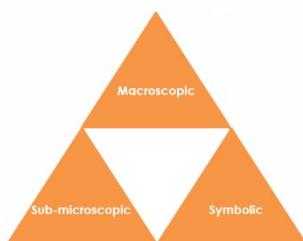
This resource is from the **Johnstone's triangle** series which can be viewed at: [rsc.li/43jMfSn](https://rsc.li/43jMfSn). It will help learners to understand the different ways you need to think in chemistry, and to build their mental models and understanding.

### Learning objectives

- 1 Understand the term 'thermal decomposition'.
- 2 Calculate relative formula mass.
- 3 Calculate the volume of a product from the mass of a reactant.

### How to use Johnstone's triangle

Use Johnstone's triangle to develop learners' thinking about scientific concepts at three different conceptual levels:



- Macroscopic – what we can see. Think about the properties you can observe, measure and record.
- Sub-microscopic – smaller than we can see. Think about the particle or atomic level.
- Symbolic – representations. Think about how we represent chemical ideas including symbols and diagrams.

For learners to gain a deeper awareness of a topic, they need to understand it at all three levels.

When introducing a topic, don't try to introduce all three levels of thinking at once. This will overload working memory. Instead complete the triangle over a series of lessons, beginning with the macroscopic level, then symbolic and then sub-microscopic.

The levels are interrelated. For example, learners need visual representation of the sub-microscopic in order to develop mental models of the particle or atomic level.

Find further reading about Johnstone's triangle and how to use it in your teaching at: [rsc.li/3Z9XbQQ](https://rsc.li/3Z9XbQQ).

### Scaffolding

Share the structure of the triangle with learners prior to use. Tell them why you are using it and how it will help them to develop their understanding. Use an 'I try, we try, you try' approach when introducing Johnstone's triangle for the first time.

### More resources

To further develop learner's thinking in all areas of Johnstone's triangle, try our **Developing understanding of reacting ratios (gas volumes)** worksheets ([rsc.li/497x2Z1](https://rsc.li/497x2Z1)). These include icons in the margin referring to the conceptual level of thinking needed to answer the question.

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**Macroscopic – what we can see**

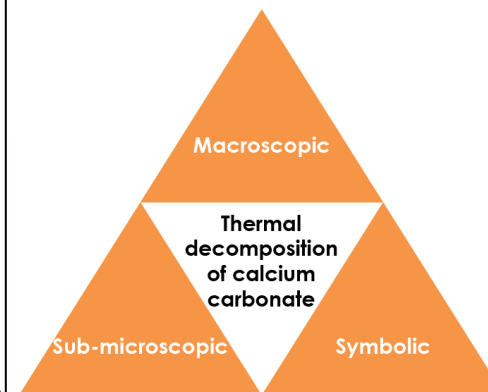
The first step in the production of cement involves heating limestone (a form of calcium carbonate) with other materials. The calcium carbonate breaks down into calcium oxide and carbon dioxide.

The process is called thermal decomposition because:

- the calcium carbonate is *heated*.
- the calcium carbonate is *broken down*.



Image ©: Shutterstock/dj\_nombeko

**Sub-microscopic – smaller than we can see**

Use the thermal decomposition equation to determine the number of moles of carbon dioxide produced from each mole of calcium carbonate.

*1 mole*

Calculate the number of moles of carbon dioxide produced from 20 kg of calcium carbonate using the following steps:

Convert 20 kg into g. 20 kg =  $20 \times 1000 = 20000$  g

Calculate the number of moles of calcium carbonate in 20kg.

$$\text{Moles} = \frac{\text{mass (CaCO}_3\text{)}}{\text{Mr (CaCO}_3\text{)}} = 20000 / 100 = 200 \text{ moles}$$

State the number of moles of carbon dioxide produced.

*200 moles*

1 mole of a gas at standard temperature and pressure has a volume of 24 dm<sup>3</sup>. Calculate the volume of CO<sub>2</sub> produced at standard conditions.

$$\text{volume} = 24 \times \text{number of moles} = 24 \times 200 = 4800 \text{ dm}^3$$

**Symbolic – representations**

The equation for the thermal decomposition of calcium carbonate is:



Give the name of each compound shown in the equation.

CaCO<sub>3</sub>      *calcium carbonate*

CaO          *calcium oxide*

CO<sub>2</sub>        *carbon dioxide*

Use the formulas to calculate the relative formula mass of each compound.

$$A_r(\text{Ca}) = 40 \qquad A_r(\text{C}) = 12 \qquad A_r(\text{O}) = 16$$

$$M_r(\text{CaCO}_3) = 1 \times 40 + 1 \times 12 + 3 \times 16 = 100$$

$$M_r(\text{CO}_2) = 1 \times 12 + 2 \times 16 = 44$$