

Limiting and excess reactants: quantitative

This resource is from the **Johnstone's triangle** series, which can be viewed at: rsc.li/43jMfSn. In this series you will also find our Johnstone's triangle worksheet which introduces the triangle in the context of sulfuric acid reacting with excess copper oxide: rsc.li/49rruZz.

Learning objectives

LO	Objective	Where assessed
1	Use observation to identify an excess reactant.	Q1
2	Determine the excess and limiting reactant using a balanced chemical equation and number of moles of each reactant at the start.	Q2
3	Determine the number of moles of product that can be produced from a given number of moles of two reactants for a chemical reaction with a 1:1 reactant ratio.	Q2
4	Determine the number of moles of product that can be produced from a given number of moles of two reactants for a chemical reaction with a 1:2 reactant ratio.	Q3

How to use this resource

When to use?				
	Introduce	Develop	Revise	Assess
Use after initial teaching or discussion of this topic to develop ideas further. You can also use as a revision activity.				
Group size?				
	Independent	Small group	Whole class	Homework
Suitable for independent work either in class or at home. Or use the questions for group or class discussions.				
How long?	 → 		15–30 mins	

This resource aims to develop learners' quantitative understanding of limiting and excess reactants. The questions encourage learners to think about how information from a balanced chemical equation (symbolic understanding) and the number of moles of each reactant at the start (sub-microscopic understanding) can be used to determine the limiting reactant and the number of moles of product that could be formed. As a result, learners should develop more secure mental models to support their thinking about this topic.

Johnstone's triangle

Johnstone's triangle is a model of the three different conceptual levels in chemistry: macroscopic, sub-microscopic and symbolic. You can use Johnstone's triangle to build a secure understanding of chemical ideas for your learners.

Find further reading about Johnstone's triangle and how to use it in your teaching at rsc.li/4pmKCw8.

Johnstone's triangle and this resource

The icons in the margin indicate which level of understanding each question is developing to help prompt learners in their thinking.



Macroscopic: what we can see. Think about the properties that we 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.

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. Our approach has been to apply icons to questions based on what the learners should be thinking about.

Questions may be marked with two or all three icons, indicating that learners will be thinking at more than one level. However, individual parts of the question may require learners to think about only one or two specific levels at a time.

Support

This worksheet is ramped so that the earlier questions are more accessible. The activity becomes more challenging in the later questions. You can give extra explanations for the more challenging questions. If completing as an in-class activity it is best to pause and check understanding at intervals, as often one question builds on the previous one.

It is useful for learners to observe macroscopic properties first-hand. You could circulate examples of substances in the classroom, run a class practical of a chemical reaction or show a teacher demonstration of properties.

Additional support may be needed for any learners still lacking in confidence in the required symbolic representation, for example by sharing and explaining a diagram or a simulation that can show movement of the particles.

Answers



1. **Guidance note:** This question develops learners' understanding of what they observe in a beaker at the end of a reaction (macroscopic understanding) and how this connects to the balanced chemical equation (symbolic understanding). The right-hand side of a chemical equation shows the products that are made and not necessarily what is found in the reaction vessel at the end of a reaction. Ideas about limiting and excess reactants at a qualitative level are explored qualitatively in the 'Limiting and excess reactants' resource, available from: rsc.li/4qFzRGx.

- (a) Hydrogen is in the gas state and escapes from the beaker.
- (b) Circles around MgCl_2 and Mg
- (c) Magnesium
- (d) Hydrochloric acid
- (e) Circles around MgCl_2 and HCl
- (f) Hydrochloric acid
- (g) Magnesium



2. **Guidance note:** This question develops learners' understanding of how the number of moles of the product is limited by the number of moles of the limiting reactant (sub-microscopic understanding) and how the number of moles of product is determined by the ratio with this limiting reactant shown in the balanced chemical equation (symbolic understanding).

- (a) 0.025 moles sulfuric acid
- (b) 0.02 moles sulfuric acid
- (c) Less
- (d) The dotted rectangle represents the extra sulfuric acid that does not react.
- (e) Sulfuric acid
- (f) $0.025 - 0.02 = 0.005$ moles
- (g) Copper carbonate
- (h) 0.02 moles copper sulfate
- (i) 0.025 moles copper carbonate
- (j) Less
- (k) Copper carbonate
- (l) Sulfuric acid
- (m) 0.025 moles copper sulfate
- (n) More moles of the product copper sulfate are made in the second reaction (0.025 compared with 0.02 in the first).



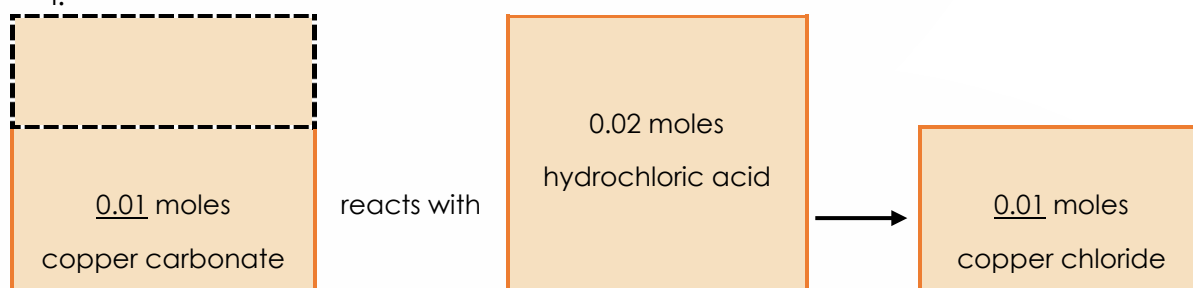
3. *Guidance note:* This question develops learners' understanding of how to determine the number of moles of product (sub-microscopic understanding) when the balanced chemical equation of the reaction has a ratio of reactants that is 1:2 (symbolic understanding). This question uses bar diagrams to support learners in recognising the limiting reactant which is a necessary step in determining the number of moles of the product. The last part of the question requires learners to recognise that the number of moles of product relates to the mass of product formed (macroscopic understanding).

(a) The balanced chemical equation shows that copper carbonate reacts with hydrochloric acid in a ratio 1:2. This means that 0.01 moles of copper carbonate reacts exactly with 0.02 moles of hydrochloric acid so there is no acid left in excess at the end of the reaction. All the copper carbonate will react so that is not in excess either.

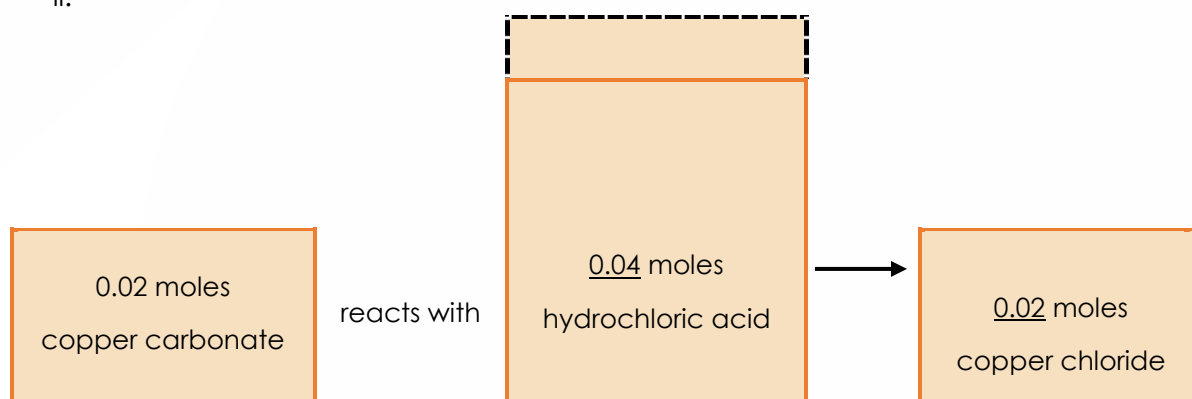
(b) The balanced chemical equation shows that for every mole of copper carbonate that reacts (assuming enough hydrochloric acid) one mole of copper chloride is formed. So, 0.01 moles of copper carbonate produces 0.01 moles of copper chloride.

(c)

i.



ii.



(d) Learner B made the most moles, and therefore the greatest mass of copper chloride.