Chemistry > Big idea CPS: Particles and structure > Topic CPS4: Understanding chemical reactions

Key concept (age 11-14)
CPS4.2 Conservation of mass

What's the big idea?

A big idea in chemistry is that during a chemical reaction, atoms are rearranged to form a new substance (or substances).

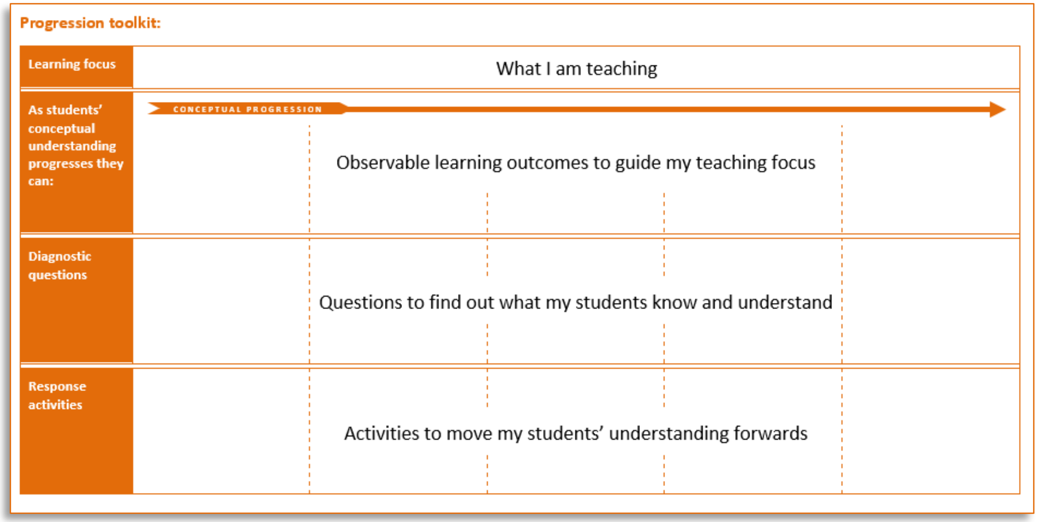
How does this key concept develop understanding of the big idea?

This key concept develops the big idea linking the symbolic representation of a chemical reaction (a chemical equation) with the rearrangement of atoms.

The conceptual progression starts by checking understanding of the rearrangement of atoms during chemical reactions. It then supports the development of a quantitative interpretation of chemical equations in order to enable understanding of observed measurements of mass of chemical reactions.

Using the progression toolkit to support student learning

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.



Progression toolkit: Representing reactions

Learning focus	During a chemical reaction no atoms are created or destroyed. Mass is conserved.				
As students' conceptual understanding progresses they can: (CONCEPTUAL PROGRESSION →)	Select a particle diagram to correctly show the rearrangement of atoms during a chemical reaction.	Interpret the quantitative meaning of a chemical equation.	Check a chemical equation to find out if the number of atoms in the reactants is the same as in the products.	Predict and explain conservation of mass during a chemical reaction.	Use a symbolic chemical equation to predict and explain an apparent change of mass in an open system where a product is in the gas state.
Diagnostic questions	Reaction diagrams	Interpreting chemical equations	Chemical equation checking	What mass?	Mass prediction
Response activities		Sulfur reaction diagram	Counting atoms	Product mass	Final mass

Key:

P Prior understanding from earlier stages of learning

B Bridge to later stages of learning

What's the science story?

During a chemical reaction, atoms are rearranged. No atoms are created or destroyed so the mass of the reactants is equal to the mass of the products. A chemical equation must therefore always be balanced.

If a reaction takes place in an open system and a product is in the gas state, then this product is able to escape. The measured mass will therefore decrease.

What does the research say?

Research (Al-Kunifed, Good and Wandersee, 1993) found that some students considered a chemical equation to be simply a 'shorthand' way of describing a reaction. These students had a poor understanding of the quantitative aspects of a chemical equation. This has implications for student understanding of a chemical reaction at the sub-microscopic level in terms of a rearrangement of atoms in which the number of each type of atom is conserved.

A review of empirical research (Taskin and Bernholt, 2012) describes student misunderstandings in translating chemical formulae into particle diagrams. The addition of multiplying coefficients, as used in a chemical equation, caused further difficulties. This is consistent with ideas presented by Johnstone (1991) which describe student difficulties in switching between macroscopic, sub-microscopic and symbolic ways of thinking. The review (Taskin and Bernholt, 2012) summarises research findings that concluded that these misunderstandings are a contributory factor to student difficulties in balancing chemical equations.

The learning outcomes therefore start with the quantitative interpretation of sub-microscopic representations (particle diagrams) of the rearrangement of atoms during a chemical reaction and symbolic chemical equations. The learning outcomes then consider macroscopic understanding of mass measurements made during a chemical reaction and the sub-microscopic and symbolic models that may be used to explain these observations.

Guidance notes

The understanding in this key concept supports ideas in key concept CCR2.2: Combustion. It is important for students to understand that even if the observed mass increases during combustion the total mass of reactants (including oxygen) is still equal to the total mass of the product.

References

Al-Kunifed, A., Good, R. and Wandersee, J. (1993). Investigation of high school chemistry students' concepts of chemical symbol, formula and equations: Students' prescientific conceptions. ERIC Document ED376020.

Johnstone, A. H. (1991). Why is chemistry difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning,* 7**,** 75-83.

Taskin, V. and Bernholt, S. (2012). Students' understanding of chemical formulae: A review of empirical research. *International Journal of Science Education,* 36(1)**,** 157-185.