Chemistry

Big idea (age 11-14)
CCR: Chemical reactions

What's the big idea?

11-14:

During chemical reactions atoms are rearranged and new substances are formed.

14-16:

During chemical reactions atomic nuclei and electrons are rearranged and new substances are formed.

Key concepts

The big idea is developed through a series of **key concepts** at age 11-16, which have been organised into teaching topics as follows.

The numbering gives some guidance about teaching order based on research evidence on learning pathways and on effective sequencing of ideas. However, the teaching order can be tailored for different classes as appropriate.

11-14:

Topic CCR1
Chemical change

Key concepts:

CCR1.1 Formation of new substance

Topic CCR2
Understanding chemical reactions

Key concepts:

CCR2.1 Reactions in solution

CCR2.2 Combustion

Topic CCR3
Energy and reactions

Key concepts:

CCR3.1 Exothermic and endothermic reactions

Topic CCR4
Acids and alkalis

Key concepts:

CCR4.1 Neutralisation

Topic CCR5
Periodic table

Key concepts:

CCR5.1 Periodic patterns

14- 16:

Topic CCR6 **Rates of reaction** Key concepts: CCR6.1 Instantaneous rate CCR6.2 Collision frequency	Topic CCR7 **Catalysts** Key concepts: CCR7.1 Catalysis	Topic CCR8 **Chemical equilibrium** Key concepts: CCR8.1 Reversible reactions CCR8.2 Dynamic equilibrium
Topic CCR9 **Redox reactions** Key concepts: CCR9.1 Oxidation and reduction	Topic CCR10 **Acids, bases and ions** Key concepts: CCR10.1 Neutralisation process	Topic CCR11 **Quantitative chemistry** Key concepts: CCR11.1 Stoichiometry

Guidance notes

Chemistry often requires an understanding of both macroscopic observations and a sub-microscopic (particulate) model that explains what is being observed. On other occasions an understanding of the substances involved in the reaction taking place is required. For this reason, several chemistry topics consist of key concepts from more than one big idea. This is shown on key concept map.

At age 11 to 14 a chemical reaction is often described at the sub-microscopic level in terms of the rearrangement of atoms, where an atom is treated as an indivisible entity. This model is sufficient to explain, at an introductory level, ideas such as the formation of a new product which has different properties to the reacting substances.

Development of an understanding of atomic structure allows this model to be developed at age 14 to 16 to include the idea of an atomic model where an atom is considered to be made up of an atomic nucleus surrounded by electrons. This more advanced model is needed for understanding of concepts such as the neutralisation process (which involves ions) and oxidation and reduction (in terms of the loss and gain of electrons).

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Learning progression

The science story associated with the big idea develops from age 5 to age 16, and could be summarised as follows:

Science story at age 5-11

Physical and chemical change

Everyday materials are observed to change. Some materials change state if warmed or cooled. Some materials can dissolve. These are examples of physical changes since the material is still there. It has not changed into a different material.

Some materials burn. The original material is no longer present but another material, such as ash, is observed.

Science story at age 11-14

Chemical change

During a chemical reaction, a new substance or substances are formed. This can happen when the atoms of elements react (e.g., oxidation) or compounds split apart (e.g., thermal decomposition).

During a chemical reaction, atoms are rearranged. This is the reason that the products of a reaction have different properties to the reactants.

Understanding chemical reactions

Chemical reactions can take place when substances are in solution.

Observations of chemical reactions can be explained by differences in the properties of the reactants and products. For example:

- A precipitate is created when an insoluble product is formed from soluble reactants.
- A product may have a lower boiling point and therefore be in the gas state.

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.

The products of combustion arise from the rearrangement of atoms from both the reactant (e.g., the fuel) and oxygen. During combustion, a substance reacts with oxygen from the air, so the measured mass will increase.

Energy and reactions

During a chemical reaction, energy is conserved. However, the chemical energy store of the reactants may be more or less than that of the reactants. This means that energy can be transferred to and from the surroundings. This is observed as a change in temperature.

Acids and alkalis

Acids and alkalis are solutions commonly used in chemical reactions, including the making of salts. An indicator can be used to identify a solution as an acid or alkali. Universal indicator or a pH meter provide information on the pH of the solution.

Periodic Table

When the elements are listed in order of their atomic number, elements with similar chemical properties recur at periodic intervals. The Periodic Table is structured so that these elements are shown within the same vertical group.

Science story at age 14-16

Rates of reaction

The rate of a chemical reaction is a measure of the rate of formation of a product (or loss of a reactant). During a chemical reaction, the instantaneous rate of reaction changes. The instantaneous rate is fastest at the start of the reaction and then gradually decreases over time. The instantaneous rate of reaction is equal to the gradient of a graph of volume or mass of product vs time. The units of the rate of reaction correspond to the method of measurement, for example cm^3/s or g/s.

The average (mean) rate of reaction can be compared under different conditions. The effect of changing pressure, surface area or concentration on the rate of reaction can be explained in terms of the frequency of collisions of reactant particles (molecules or ions). A collision is considered to be 'successful' if a new substance is formed.

Catalysts

A catalyst increases the rate (but not yield) of a reaction by providing an alternative reaction pathway. This lowers the activation energy of the reaction. Although a catalyst participates in the chemical reaction (for example reacting molecules of a substance in the gas state may be adsorbed onto the surface of a solid catalyst) it is regenerated at the end so overall a catalyst is not 'used up' during the reaction.

Chemical equilibrium

A chemical reaction can be reversible. The system is in a state of dynamic equilibrium when the rate of the forwards and reverse reactions are at the same.

Redox reactions

At a simple level oxidation and reduction are regarded as the gain and loss of oxygen. However, in chemistry many reactions are described in terms of both oxidation and reduction where oxygen is not involved. These, so-called, redox reactions involve the loss and gain of electrons where oxidation is described as loss of electron and reduction as the gain. Oxidation and reduction may be shown using half equations. For example:

Cu^{2+} (aq) +2e^- $\rightarrow$ Cu (s) (reduction)

Fe(s) $\rightarrow$ Fe^{2+} (aq) + 2e^- (oxidation)

Acids, bases and ions

At age 14 to 16 acids and bases are often defined using the Arrhenius definition. Acids are defined as hydrogen-containing substances which form H^+ ions when they dissolve in water and bases are defined as substances that form OH^- ions. A simple explanation of the neutralisation process based on this definition is that H^+ and OH^- react to form H_2O.

Quantitative chemistry

The coefficients of a balanced chemical equation show the ratio at which substances react. This ratio relates to the number of moles of each substance. An understanding of quantitative chemistry enables the calculation of a theoretical yield and hence percentage yield.