Chemical reactions

Critical teaching ideas - Science Continuum F to 10
Level: Moving to level 9

Student everyday experiences

Children will have experienced many examples of chemical change without actually realizing it. They are familiar with burning, cooking, rusting, and chemical processes that appear to involve dissolving. However at this level students don't see new materials being produced as a result of chemical change, rather existing materials have merely been modified in some way. For example they see smoke as part of the wood that is somehow released when the wood burns. Because they rarely understand the concept of a substance they don't see substances being changed. Yet an understanding of chemical change is fundamental to appreciating the role of chemistry in their lives and at this level students can begin to appreciate this.

Students frequently believe that to get something new, things just need to be mixed together. (Johnson, 2002). When a chemical reaction does take place one or other of the reactants is just modified, it hasn't really changed. For example rust is still iron/steel, It has just gone brown. Rust flaking off is not noticed, iron just disappears. Gas bubbles that are frequently produced when a tablet dissolves in water are often not seen as a new substance. Processes like cordial mixing with water, the use of colourings in food, freezing and boiling are seen in the same way as chemical changes involved in cooking eggs for example.

In combustion, children frequently believe materials like wood or paper just disappear - after all there is not much of the product left to see. In their view, air has little to do with burning. In burning carbon based materials such as wood, charcoal (carbon) appears from the burning rather than the material (See Arizona State University 2001, Student Preconceptions and Misconceptions about Chemistry www.daisley.net/hellevator/misconceptions/misconceptions.pdf)

Because so many reactions children know about are involved in things like cooking and burning, they assume that heat is always necessary for reactions to occur.

In everyday language, the word “chemical” is often used as a label for undesirable things that shouldn't be in foods or cosmetics. Hence students may regard chemicals as a group of substances found in laboratories rather than seeing all the substances in foods, for example as chemicals.

Scientific view

- All materials are made of chemicals.
- Chemical reactions involve interaction between chemicals such that all reactants are changed into new materials. The properties of the new materials are different from those of the reactants. This is distinct from other changes such as evaporation, melting, boiling, freezing and mixing where changes involve no new substances. While heat is often necessary to start reactions, this need not be the case.
- Chemical reactions are reversible (a fact often omitted in many science texts) but in practice most differ from other changes children observe such as melting etc by being very difficult to reverse.
- Although many chemical reactions proceed quickly, small, slow changes such as rusting or biological processes can take place over much longer periods of time.
- Chemical reactions involve breaking chemical bonds between reactant molecules (particles) and forming new bonds between atoms in product particles (molecules). The number of atoms before and after the chemical change is the same but the number of molecules will change
- Humans use chemical reactions to produce a wide range of useful materials; the breakdown of waste materials also involves chemical reactions that occur naturally in the environment. For some human made wastes, there are no such reactions and they cause problems as a result.

Critical teaching ideas

In teaching about chemical reactions at this level the emphasis will be on improving student understanding of the importance of chemical reactions in our lives in producing many of the things we take for granted as well as improving their recognition and understanding of what is involved in a chemical change. It is not necessary at this stage to talk about particles such as atoms or molecules or chemical bonds.

Key teaching ideas include:

- Chemical reactions involve the production of new materials which are quite different from the reacting substances. Any new materials come from the reacting substances.
- Changes that may accompany a chemical reaction include colour, appearance and production of new materials e.g. a gas
- Mixing alone may not cause a chemical reaction to take place
- While heat is often necessary to initiate a chemical reaction it may not be necessary
- Chemical reactions are used to produce most of our energy
- Chemical reactions are used extensively to test, identify and analyse a wide range of materials (pool testing kits, forensic tests from TV shows such as CSI).
- The oxygen in air is a very reactive chemical and is important in many chemical reactions such as combustion, rusting and the reactions by which we get energy from the food we eat.

In teaching about chemical reactions students will need to describe various substances, which at this level will be materials they are familiar with (the kitchen and changes involving cooking are very good starting points). They will need to be able to recognize changes in these substances with the purpose of eventually recognizing when new chemicals have been produced i.e. a chemical change has taken place. As mentioned above this is can be difficult as students often fail to see the difference between an egg white going through a change from liquid to solid and changes such as melting chocolate or boiling water which do not involve chemical change. (see problems with classifying solids, liquids and gases - Level 3). Teaching will need to be focused on what happens when new substances are formed. Environmental effects of chemical reactions can also be considered, for example how do we dispose of some chemicals once they are produced - plastic garbage bags for example.

Teaching activities

Open up discussion via a shared experience.
Initial teaching activities should aim to bring out students' existing ideas. At this stage it is important that students are encouraged to put up their ideas and discuss them in small groups. All alternatives should be considered with no resolution at this stage.

A starting activity could be observing the burning of a candle and discussing the changes that take place. Here the distinction can be made between the melting of the wax and the appearance of new materials. Questions posed could include; What happens to the wax? What is burning? Where do you think the wax is going? Could you collect it again? Is this the same process as water evaporating? Would the candle burn if there was no air around it? Is air or part of the air used up when a candle burns? (from Devereux, Jane, Primary Science, Chapter 2; Open University Press)


Image: National Candle Association - http://candles.org/candle-science/

Promote reflection on and clarification of existing ideas.
Activities which provide problems to be explored and challenge existing ideas are useful in encouraging students to seek new explanations for things they observe. Students should investigate a number of changes and ask questions similar to those above. In all of these students should be encouraged to observe the changes that take place and to identify what products are formed. Discussion can also centre on how these are different from the starting materials. Some examples could include:

- Baking soda and vinegar in a corked glass bottle - why does the cork fly off?
- A glass containing vinegar and six currants, add baking soda why do the currants move up and down? What are the bubbles, where are they coming from?

- Making sherbet - mix, 4 parts icing sugar, 2 parts citric acid and 1 part baking soda. Students put a small amount of the mixture on their tongue. What causes the fizz? Do any of the powders on their own produce a fizz?
- Half fill a jar with steel wool (without soap), add enough vinegar to cover the steel wool. Leave for five days. Pour 1 tablespoon of the resulting liquid in to a second jar. Add one teaspoon of household ammonia and stir. (A dark green glutinous material forms. Again students should be asked to consider what is happening - the emphasis being on developing an understanding that new materials are being produced.
- Caramel - students are asked to investigate sugar - taste, appearance, smell etc. Warm a concentrated sugar solution, observing the changes along the way - sugar dissolving, then browning. Caramelizing involves a series of chemical changes. (There are many caramel recipes - butter, baking soda and salt can all be added to improve taste, appearance and texture). Students should be encouraged to look for evidence of chemical changes as opposed to melting.

Practice using and build the perceived usefulness of a scientific model or idea.
Other activities can involve chocolate making. Student can be encouraged to look for the differences between making chocolate where the chocolate melts and the production of caramel/toffee where the sugar changes into something different.

There are many other similar chemical changes that can be investigated - further cooking activities can include: making a chocolate cake, marinating meat, melting cheese until it browns and burns, making yogurt, baking bread, poaching eggs and making toast. Other changes can include the setting of two component glues like Araldite, mixing steel wool and a solution of copper sulphate (available from plant nurseries). Oxygen is a very important reactant in many chemical reactions and students can investigate changes involving this component of air.

Clarify and consolidate ideas for/by communication to others.
It is important at this stage to clarify and consolidate what students have observed and to focus on what happens in a chemical reaction which is different from melting, boiling and freezing. To achieve this students could be asked in groups to make mini posters which show the changes that take place in the one or more of the reactions they have seen, particularly comparing the products with the starting materials and demonstrating how they are different. This can be assisted by using new names for the products e.g. soot, carbon dioxide. Students then present their posters to the class. Resulting class discussion should bring out student ideas, examine alternatives and move to more accepted scientific views about chemical reactions.

Activities should be carried out which test the usefulness of the chemical reactions model and further consolidate student ideas on what constitutes a chemical reaction. More examples of chemical reactions can be used with students further encouraged to compare the products under different conditions (in air, water, salty water etc.).

Finally to further develop students' appreciation of the role of chemical change in their lives, they could research the production of metals from ores e.g. aluminium, steel, or the production of plastics and synthetic fibres. The emphasis being on the importance of chemical change in producing the materials we use every day.

Further resources

Science related interactive learning objects can be found on the FUSE Teacher Resources page.

To access the interactive learning object below, teachers must login to FUSE and search by Learning Resource ID:

- Mystery Substances: your first case – students solve police cases by identifying pure substances and components of mixtures. They carry out chemical tests on a mystery substance such as salt, baking soda or sugar and observe and record how each substance reacts with a range of liquids and to heating. They then refer to their data table of chemical properties and use it to match a mystery substance or substances found at a crime scene. This learning object is one in a series of five objects.
  Learning Resource ID: K6ZRNX

- Treasure Puzzle – students have to open the metal door to a treasure chamber by dissolving it with acids. They test everyday substances to identify which are acids: lemon juice, salt water, alcohol, vinegar, water and fizzy soft drink. They see if the substances react with egg shell, litmus paper, sodium bicarbonate or teeth.
  Learning Resource ID: 46X2PX

- Save the Lake – Fish are dying in a lake because of pollution in the water. Students test the lake water with chemical indicators to work out which industry caused the pollution problem. They then suggest changes to save the lake.
  Learning Resource ID: MW25YS