Types of chemical reaction

Target level
This probe is primarily designed for students in the 14–16 age range who have been introduced to the range of reaction types included. It may also be useful for checking the prior knowledge of students on post-16 courses.

Topics
Types of chemical reaction: displacement, neutralisation, oxidation, reduction, thermal decomposition.

Rationale
Students in the 14–16 year age range are expected to learn to recognise certain common types of reaction. Students are likely to come across a number of reactions in their studies. Recognising that a reaction is of a certain type can help the student fit the reaction into one of a limited number of classes. (See also the materials on Word equations for the 11–14 age range.) These ideas are discussed in Chapter 9 of the Teachers' notes.

During piloting, it was found that some students found the exercise difficult, but students recognised that it was useful and helped clarify concepts. Teachers reported that the probe was quick and simple to use, led to valuable discussion, and provided useful revision - enabling students to recognise patterns and connections 'between seemingly disparate examples'.

Instructions
Each student requires a copy of the worksheet Types of chemical reaction.
In the pilot some students found it difficult to explain the reasons for their classifications. Teachers may wish to ask some groups of students to just undertake the classification. Students may then be asked to explain the correct responses when the teacher goes through the examples.

It should be emphasised that some reactions may be classified in several categories. (Note that oxidation and reduction are shown as separate classes.)

Resources
– Student worksheet
– Types of chemical reaction

Feedback for students
A suggested answer sheet for teachers is provided. Teachers may wish to go through the answers for the example on the first page of the worksheet before their students attempt the rest of the exercise.

Types of chemical reaction – answers

Example
magnesium + steam → magnesium oxide + hydrogen

$Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

This is an example of an oxidation (magnesium is oxidised) and therefore also of a reduction (water is reduced).

It can also be seen as magnesium displacing hydrogen from water to form the oxide.

1. nitrogen + hydrogen → ammonia

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

This binary synthesis reaction an example of a reduction (nitrogen is reduced) and therefore also of an oxidation (hydrogen is oxidised).

2. sodium hydroxide + nitric acid → sodium nitrate + water

$NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$

This is an example of a neutralisation reaction between an acid (nitric acid) and an alkali (sodium hydroxide).

3. copper carbonate + sulfuric acid → copper sulfate + water + carbon dioxide

$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$

This is an example of an acid-base reaction but is not normally called a neutralisation.

4. sodium + water → sodium hydroxide + hydrogen

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

This is an example of an oxidation (sodium is oxidised), and therefore also of a reduction (hydrogen from water is reduced).
This could also be considered as an example of a displacement reaction, with sodium displacing hydrogen.

5. zinc + copper sulfate → zinc sulfate + copper

$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

This is an example of a displacement reaction - with zinc displacing copper from the salt.
This is also an example of an oxidation (zinc is oxidised) and therefore also of a reduction (copper is reduced).

6. copper carbonate → copper oxide + carbon dioxide

$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$

This reaction requires heating and is an example of a thermal decomposition.

7. sodium bromide + chlorine → sodium chloride + bromine

$2NaBr(aq) + Cl_2(aq) \rightarrow 2NaCl(aq) + Br_2(aq)$

This is an example of a displacement reaction - with chlorine displacing bromine in the salt. It is also an example of an oxidation (bromide is oxidised to bromine) and a reduction (chlorine is reduced to chloride).

8. copper oxide + carbon → copper + carbon dioxide

$2CuO(s) + C(s) \rightarrow 2Cu(s) + CO_2(g)$

This is an example of a displacement reaction, with carbon displacing copper from the oxide. This is also an oxidation process (carbon is oxidised) and therefore a reduction (copper is reduced).

9. methane + oxygen → carbon dioxide + steam

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

This combustion reaction is an oxidation process (carbon is oxidised) and therefore also a reduction (oxygen is reduced). Some students may feel that hydrogen is also oxidised (as it 'gains' oxygen), although from a perspective of oxidation states hydrogen is unchanged.

10. zinc + hydrochloric acid → zinc chloride + hydrogen

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

This reaction is an example of an oxidation (zinc is oxidised), and therefore also of a reduction (hydrogen is reduced).
It may also be an considered an example of a displacement reaction with zinc displacing hydrogen.

11. sodium chloride → sodium + chlorine

$2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$

This reaction requires an input of energy, such as in electrolysis. It is an example of an oxidation process (chlorine is oxidised) and therefore also of a reduction (sodium is reduced).

12. sodium nitrate → sodium nitrite + oxygen

or sodium nitrate(V) → sodium nitrate(III) + oxygen

$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$

This reaction requires heating and is an example of a thermal decomposition.
This is also an example of a reduction process (nitrogen is reduced), and therefore also of an oxidation process (some of the oxygen in the nitrate is oxidised to elemental oxygen).
Teachers at post-16 level may wish to stress the nitrate(V) – nitrate(III) nomenclature.

Types of chemical reaction

Scientists classify chemical reactions into different types - such as oxidation and neutralisation.

This exercises provides the equations for a number of chemical reactions. For each reaction you are given a word equation, and an equation using chemical symbols:

magnesium + steam → magnesium oxide + hydrogen

$$\mathbf{Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)}$$

You should try to classify each of the examples given.

✓ type of reaction
❑ displacement
❑ neutralisation
❑ oxidation
❑ reduction
❑ thermal decomposition
❑ none of the above

For each reaction tick (✓) the box, or boxes, that describe the type of reaction. Some of the reactions may be examples of more than one type of reaction.

Some of the reactions may only occur when energy is provided (as heat, or as electrical energy), but this is not shown in the questions.

Tick (✓) 'none of the above' if the reaction does not seem to fit any of the suggestions.

Explain why you have classified the reaction the way you have.

1. **nitrogen + hydrogen □ ammonia**

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

2. **sodium hydroxide + nitric acid → sodium nitrate + water**

$NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

3. copper carbonate + sulfuric acid → copper sulfate + water + carbon dioxide
$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

4. sodium + water → sodium hydroxide + hydrogen
$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

5. zinc + copper sulfate → zinc sulfate + copper
$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

6. copper carbonate → copper oxide + carbon dioxide
$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

7. sodium bromide + chlorine → sodium chloride + bromine
$2NaBr(aq) + Cl_2(aq) \rightarrow 2NaCl(aq) + Br_2(aq)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

8. copper oxide + carbon → copper + carbon dioxide
$2CuO(s) + C(s) \rightarrow 2Cu(s) + CO_2(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

9. methane + oxygen → carbon dioxide + steam
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

10. zinc + hydrochloric acid → zinc chloride + hydrogen
$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

11. sodium chloride → sodium + chlorine

$2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____

12. sodium nitrate → sodium nitrite + oxygen

or

sodium nitrate(V) → sodium nitrate(III) + oxygen

$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$

✓ type of reaction

❑ displacement

❑ neutralisation

❑ oxidation

❑ reduction

❑ thermal decomposition

❑ none of the above

I made this classification because:

_____

_____

_____

_____

_____

_____