

# Word equations

## Target level

These materials are designed for use with 11–14 year old students who have been taught to use word equations. The materials will also be useful for 14–16 year olds students who need to revisit this topic.

## Topic

Using word equations to represent chemical reactions.

## Rationale

Many students find it difficult to write word equations, which require an appreciation of the nature of chemical change (including conservation of matter), and familiarity with chemical names and the patterns of common reaction types. These materials provide probes for exploring whether students can complete word equations, and a set of practice exercises.

These ideas are discussed in Chapter 9 of the Teachers' notes.

In the pilot teachers judged the materials 'excellent', 'very useful' and 'helpful for revision'. Some teachers found the responses of some of their pupils to be 'disappointing' (or even 'shocking'). The probes were thought to provide an interesting 'look into [students'] minds' and to lead to useful classroom discussion.

Although teachers found it useful that students were asked to give reasons for their answers, some of the students did not like having to try to explain their reasons. (Some teachers may wish to ask students to just complete the equations in the probes, and to leave the spaces for making notes when going through the answers.) Students were reported to find the materials helpful and easy to follow, and were considered to have greater understanding afterwards.

## Instructions

These materials may either be used with students who should have mastered word equations as a pre-test (to identify students needing practice), a remedial exercise, and a post-test; or as end-of-topic review material with students meeting word equations for the first time.

The materials include:

■ **Completing word equations (1)**

A probe to explore whether students can complete word equations.

■ **Word equations**

A study exercise including an information sheet providing practice in completing word equations for five common types of reaction. This exercise could be set as a private study (homework) task.

■ **Completing word equations (2)**

A probe to explore whether students can complete word equations.

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## Resources

- Student worksheets
  - Completing word equations (1)
  - Word equations
    - Information sheet
    - The reaction between acids and alkalis
    - The reaction between acids and metals
    - The reaction between acids and metal carbonates
    - Displacement reactions
    - Synthesis reactions
  - Completing word equations (2)

## Feedback

Teachers' answer sheets are included for each of the probes, and the study activity.

# Word equations – answers

## Completing word equations (1)

Teachers will have their own ideas about what is an acceptable explanation for students' completions, depending upon the age of the students and the depth to which ideas about reactions have been studied. Suggested explanations are provided.

1. nitric acid + potassium hydroxide → **potassium nitrate** + water  
In this type of reaction a salt is formed from an acid and an alkali.  
The reactants include elements which must also be present in the products.  
As the reacting alkali is potassium hydroxide, then the product will be a potassium salt.  
As the reacting acid is nitric acid, then the salt produced will be a nitrate.
2. zinc + **copper nitrate** → zinc nitrate + copper  
In this type of reaction a more reactive metal displaces a less reactive metal from its salt.  
The reactants include elements which must also be present in the products.  
As the displaced metal is copper, then the reacting salt must have been a copper salt.  
As the product was a nitrate, then the reacting salt will also be a nitrate.
3. **sulfuric acid** + zinc carbonate → zinc sulfate + water + carbon dioxide  
In this type of reaction an acid reacts with a carbonate to give a salt, water and carbon dioxide.  
The reactants include elements which must also be present in the products.  
As the product is a sulfate then the reacting acid must be sulfuric acid.
4. calcium + chlorine → **calcium chloride**  
In this type of reaction a binary compound is prepared from two elements.  
The reactants include elements which must also be present in the products.
5. magnesium + hydrochloric acid → **magnesium chloride**  
In this type of reaction an acid reacts with a metal to produce a salt and hydrogen.  
The reactants include elements which must also be present in the products.  
As the reacting acid is hydrochloric acid, then the salt produced will be a chloride.  
As the reacting metal is magnesium, then the product must be a magnesium salt.

## Word equations – the reaction between acids and alkalis

1. Potassium chloride  
Sodium nitrate
2. Potassium hydroxide

## Word equations – the reaction between acids and metals

1. Iron nitrate  
Zinc sulfate  
Magnesium chloride, Magnesium nitrate
2. Calcium

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## Word equations – the reaction between acids and metal carbonates

1. Copper chloride, Copper sulfate  
Zinc chloride, Zinc nitrate  
Iron nitrate, Iron sulfate
2. Magnesium chloride

## Word equations – Displacement reactions

1. Iron
2. Zinc sulfate
3. Magnesium, copper
4. Copper sulfate
5. Zinc chloride, iron
6. Iron sulfate
7. Zinc, copper nitrate
8. Copper
9. Iron nitrate, copper

It may be worth pointing out that the order of the reactants or products in the equation is irrelevant.

## Word equations – synthesis reactions

1. Sulfur  
Fluoride
2. Magnesium sulfide, Magnesium chloride  
Iron fluoride, Iron chloride  
Zinc oxide, Zinc sulfide, Zinc fluoride  
Copper oxide, Copper sulfide, Copper chloride
3. Sodium iodide  
Nickel sulfide  
Calcium

## Completing word equations (2)

Teachers will have their own ideas about what is an acceptable explanation for students' completions, depending upon the age of the students and the depth to which ideas about reactions have been studied. Suggested explanations are provided.

1. sulfuric acid + sodium hydroxide → **sodium sulfate** + water  
In this type of reaction a salt is formed from an acid and an alkali.  
The reactants include elements which must also be present in the products.  
As the reacting alkali is sodium hydroxide, then the product will be a sodium salt.  
As the reacting acid is sulfuric acid, then the salt produced will be a sulfate.
2. iron + **copper chloride** → iron chloride + copper  
In this type of reaction a more reactive metal displaces a less reactive metal from its salt.  
The reactants include elements which must also be present in the products.  
As the displaced metal is copper, then the reacting salt must have been a copper salt.  
As the product was a chloride, then the reacting salt will also be a chloride.

3. **hydrochloric** acid + magnesium carbonate → magnesium chloride + water + carbon dioxide  
In this type of reaction an acid reacts with a carbonate to give a salt, water and carbon dioxide.  
The reactants include elements which must also be present in the products.  
As the product is a chloride, then the reacting acid must be hydrochloric acid.
4. zinc + oxygen → **zinc oxide**  
In this type of reaction a binary compound is prepared from two elements.  
The reactants include elements which must also be present in the products.
5. calcium + nitric acid → **calcium nitrate** + hydrogen  
In this type of reaction an acid reacts with a metal to produce a salt and hydrogen.  
The reactants include elements which must also be present in the products.  
As the reacting acid is nitric acid, then the salt produced will be a nitrate.  
As the reacting metal is calcium, then the product must be a calcium salt.

# Completing word equations (1)

Word equations are used to describe chemical reactions. Look at the word equations below. In each case complete the word equation by adding the name of the missing substance. (Explain your answers.)

1. nitric acid + potassium hydroxide → \_\_\_\_\_ + water

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2. zinc + \_\_\_\_\_ → zinc nitrate + copper

I think this is the answer because

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3. \_\_\_\_\_ + zinc carbonate → zinc sulfate + water + carbon dioxide

I think this is the answer because

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4. Calcium + chlorine → \_\_\_\_\_

I think this is the answer because

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5. magnesium + hydrochloric acid → \_\_\_\_\_ + hydrogen

I think this is the answer because

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# Word equations – information sheet

Word equations are a shorthand used to describe chemical reactions.

Although there are many millions of possible chemical reactions you are not expected to know about them all.

It is useful to remember that many reactions are of similar types.

## 1. Metal + acid

One type of reaction is that between a metal and an acid. When a metal reacts with an acid the reaction produces a salt, and hydrogen gas is released. The salt produced depends upon the metal and the acid. If magnesium reacts with hydrochloric acid, then the salt produced is magnesium chloride.

**metal + acid → salt + hydrogen**

## 2. Metal carbonate + acid

Metal carbonates also react with acid, to give a salt. When a carbonate reacts with acid the gas carbon dioxide is given off. The salt produced depends upon which acid, and which metal carbonate react. If zinc carbonate reacts with sulfuric acid, then the salt produced is zinc sulfate.

**metal carbonate + acid → salt + carbon dioxide + water**

## 3. Acid + alkali

When an alkali and an acid react the product is a salt solution. The particular salt produced depends upon which acid and which alkali reacted. When nitric acid reacts with potassium hydroxide the salt produced is potassium nitrate.

**acid + alkali → salt + water**

## 4. Metal + salt solution

When a reactive metal is placed in the solution of a salt of a less reactive metal, a 'displacement' reaction occurs. The more reactive metal is said to displace the less reactive metal from solution. For example zinc is added to copper nitrate solution the copper is displaced and the solution will contain zinc nitrate.

## 5. Element + element

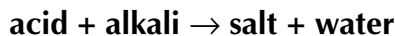
When two elements react together to form a compound the compound is given a name to show which elements reacted. So if calcium reacts with chlorine the compound is called calcium chloride.

These examples show you the patterns that are found in five important types of reaction. If you look for patterns you should find it easier to work out how to complete word equations.

In this worksheet you will find some examples to help you practice thinking about word equations.

# Word equations – the reaction between acids and alkalis

When an acid reacts with an alkali, a salt and water is produced:



for example



The salt that is produced depends upon which acid and which alkali react. The following table provides a summary of the name of the salt produced by different reactions between acids and alkalis.

## 1. Complete the table (Hint – look for the patterns)

Name of acid	Name of alkali	
	Sodium hydroxide	Potassium hydroxide
Hydrochloric acid	Sodium chloride	
Nitric acid		Potassium nitrate
Sulfuric acid	Sodium sulfate	Potassium sulfate

Salts produced when acids react with alkalis

## 2. Complete the following word equation

(acid + alkali → salt + water)

nitric acid + \_\_\_\_\_ → potassium nitrate + water



# Word equations – the reaction between acids and metals

When an acid reacts with metal, a salt and hydrogen are produced:

**acid + metal → salt + hydrogen**

for example

**nitric acid + calcium → calcium nitrate + hydrogen**

The salt that is produced depends upon which acid and which metal react. The following table provides a summary of the name of the salt produced by different reactions between acids and metals.

## 1. Complete the table (Hint – look for the patterns)

Name of metal	Name of acid		
	Hydrochloric acid	Nitric acid	Sulfuric acid
Iron	Iron chloride		Iron sulfate
Zinc	Zinc chloride	Zinc nitrate	
Magnesium			Magnesium sulfate

## 2. Complete the following word equation

(acid + metal → salt + hydrogen)

hydrochloric acid + \_\_\_\_\_ → calcium chloride + hydrogen

# Word equations – the reaction between acids and metal carbonates

When an acid reacts with a metal carbonate, a salt, water and carbon dioxide are produced:

**Acid + metal carbonate → salt + water + carbon dioxide**

for example

**sulfuric acid + zinc carbonate → zinc sulfate + water + carbon dioxide**

The salt that is produced depends upon which acid and which metal react. The following table provides a summary of the name of the salt produced by different reactions between acids and metal carbonates.

## 1. Complete the table (Hint – look for the patterns)

Name of metal carbonate	Name of acid		
	Hydrochloric acid	Nitric acid	Sulfuric acid
Copper carbonate		Copper nitrate	
Zinc carbonate			Zinc sulfate
Iron carbonate	Iron chloride		

## 2. Complete the following word equation

(acid + metal carbonate → salt + water + carbon dioxide )

hydrochloric acid + magnesium carbonate → \_\_\_\_\_ + water + carbon dioxide



# Word equations – displacement reactions

When a reactive metal is added to a solution containing the salt of a less reactive metal, a reaction occurs.

See if you can complete the following word equations (Hint – look for the patterns).

eg magnesium + iron chloride → magnesium chloride + iron

1. magnesium + iron nitrate → magnesium nitrate + \_\_\_\_\_

2. magnesium + \_\_\_\_\_ → magnesium sulfate + zinc

3. \_\_\_\_\_ + copper sulfate → magnesium sulfate + \_\_\_\_\_

4. zinc + \_\_\_\_\_ → zinc sulfate + copper

5. zinc + iron chloride → \_\_\_\_\_ + \_\_\_\_\_

6. zinc + \_\_\_\_\_ → zinc sulfate + iron

7. \_\_\_\_\_ + \_\_\_\_\_ → zinc nitrate + copper

8. iron + copper sulfate → iron sulfate + \_\_\_\_\_

9. iron + copper nitrate → \_\_\_\_\_ + \_\_\_\_\_

# Word equations – synthesis reactions

When a metallic element reacts with a non-metallic element a compound is produced.

The name of the compound contains the name of the metal and the altered name of the non-metal.

## 1. Complete this summary:

When oxygen reacts with a metal, the compound is called an oxide.

When chlorine reacts with a metal, the compounds is called a chloride.

When \_\_\_\_\_ reacts with a metal, the compound is called a sulfide.

When fluorine reacts with a metal, the compound is called a \_\_\_\_\_.

## 2. Complete the table below: (Hint – look for the patterns)

Name of metal	Name of non-metal			
	Oxygen	Sulfur	Fluorine	Chlorine
Magnesium	Magnesium oxide		Magnesium fluoride	
Iron	Iron oxide	Iron sulfide		
Zinc				Zinc chloride
Copper			Copper fluoride	

## 3. Complete the following word equations:

sodium + iodine → \_\_\_\_\_

nickel + sulfur → \_\_\_\_\_

\_\_\_\_\_ + bromine → calcium bromide



# Completing word equations (2)

Word equations are used to describe chemical reactions. Look at the word equations below. In each case complete the word equation by adding the name of the missing substance. (Explain your answers.)

1. sulfuric acid + sodium hydroxide → \_\_\_\_\_ + water

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2. iron + \_\_\_\_\_ → iron chloride + copper

I think this is the answer because

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3. \_\_\_\_\_ acid + magnesium carbonate → magnesium chloride + water + carbon dioxide

I think this is the answer because

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4. zinc + oxygen → \_\_\_\_\_

I think this is the answer because

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5. calcium + nitric acid → \_\_\_\_\_ + hydrogen

I think this is the answer because

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