

Chapter 5: Chemical changes 1

Knowledge organiser

Reactions of metals

The reactivity of a metal is how chemically reactive it is. It is often related to water, some metals react with oxygen - these metals have high reactivity. Other metals will barely react with water or not, so aren't as reactive at all - these metals have low reactivity.

Reaction with water	Reaction with acid	Reactivity series	Displacement reactions
Reacts, gives off hydrogen gas	Reacts	most potassium sodium calcium magnesium aluminium zinc iron lead copper silver gold	more reactive
Reacts, gives off hydrogen gas	Reacts, gives off hydrogen gas		
Reacts, only slightly	Reacts, only slightly		
Reacts, slowly with water only	Reacts, slowly with water only		
Doesn't react	Doesn't react		less reactive than the element above

Metal extraction

Some metals, like gold, are so unreactive that they are found as pure metals in the Earth's crust and can be mined.

Most metals will be compounds in metal ores and have to be extracted from the rock. This is a process called metal extraction or the metal being extracted is a metal ore.

Metals that are less reactive than carbon can be extracted by reduction with carbon. For example:



Metals that are more reactive than carbon can be extracted using a process called electrolysis.

Salts

When acids react with metals or metal compounds, they form salts. It could be a compound where the hydrogen from an acid has been replaced by a metal. For example, when acid, HNO_3 , reacts with sodium hydroxide, NaOH , they will combine and be replaced with Na.

The table shows how to name salts.

Base	Acids (name acid)	Salts (name salt)	Other (name)
Hydroxide	HCl	NaCl	HCl
Sulfate	H_2SO_4	Na_2SO_4	H_2SO_4
Nitrate	HNO_3	NaNO_3	HNO_3
Carbonate	H_2CO_3	Na_2CO_3	H_2CO_3
Chloride	HCl	NaCl	HCl

Chapter 5: Chemical changes 2

Knowledge organiser

Reactions of acids

Reactions of acids with metals

Acids react with some metals to form salts and hydrogen gas.

Reactions of acids with metal hydroxides

Acids react with metal hydroxides to form salts and water.

The ionic equation for this reaction is always:



Reactions of acids with metal oxides

Acids react with metal oxides to form salts and water.

Reactions of acids with metal carbonates

Acids react with metal carbonates to form a salt, water, and carbon dioxide.

Balancing symbol equations

When writing symbol equations you need to ensure that the number of each atom is the same on both sides.



Alkalis and bases

Some reactive acids form water in neutralisation reactions. Some metal hydroxides dissolve in water to form alkali solutions, called alkalis.

Some metal oxides and metal hydroxides do not dissolve in water. They are bases, but are not alkalis.

State symbols

A balanced symbol equation should also include state symbols.

State	Symbol
solid	(s)
liquid	(l)
aqueous	(aq)
dissolved in water	(aq)

Displacement reactions

In a displacement reaction a more reactive element replaces the place of a less reactive element in a compound.



Iron is more reactive than copper, so it displaces the copper in copper sulfate.

Ionic equations (HIT only)

When an ionic compound is dissolved in a solution, we can write the compound as its separate ions. For example, $\text{CuSO}_4(\text{aq})$ can be written as $\text{Cu}^{2+}(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$.

The displacement reaction of copper sulfate and iron can be written as:



The SO_4^{2-} is unchanged in the reaction - it is a spectator ion. Spectator ions are removed from the equation to give an ionic equation:



Metals, metal substances, and solid ionic substances do not split into ions in the ionic equation.

Half equations (HIT only)

In the displacement reaction, iron iron atoms have lost electrons to form a cation ion.



A copper ion gains two electrons to form a copper atom:



These two equations are called half equations - they each show half of the reaction.

Reactivity and ions

A metal's reactivity depends on how easily it loses an ion by losing electrons.

Steps for writing an ionic equation (HIT only)

1. identify the species that are involved
2. identify all species that are compounds
3. write these compounds out as ions
4. remove spectator ions

Reduction and oxidation: electrons (HIT only)

Oxidation and reduction (redox reactions) can be defined in terms of oxygen, but can also be defined in terms of gain of electrons.

Oxidation is the loss of electrons, and reduction is the gain of electrons.

In the example displacement reaction:

- iron atom has lost electrons (oxidation)
- copper ion has gained electrons (reduction)

Acids and alkalis

Acids are compounds that, when dissolved in water, release H^+ ions. There are three main acids: sulfuric acid H_2SO_4 , nitric acid HNO_3 , and hydrochloric acid HCl .

Alkalis are compounds that, when dissolved in water, release OH^- ions.

The pH scale is a measure of acidity and alkalinity.

It ranges from 0 to 14.

- Acidic solutions with pH < 7 are acids.
- Neutral solutions with pH = 7 are neutral.
- Alkaline solutions with pH > 7 are alkalis.

Indicators

Indicators are substances that change colour when they are in an acid or an alkali.

- Universal indicator can show the approximate pH of a solution.
- Chemical pH indicators can give the exact pH of a solution.



Strong and weak acids

Sulfuric acid, nitric acid, and hydrochloric acid are all strong acids. This means that, when dissolved in water, every molecule of the acid splits into ions.

- $\text{HCl(aq)} \rightarrow \text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
- $\text{HNO}_3(\text{aq}) \rightarrow \text{H}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$
- $\text{H}_2\text{SO}_4(\text{aq}) \rightarrow 2\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

Ethanoic acid, citric acid, and carbonic acid are weak acids. This means that only a percentage of their molecules split into ions when dissolved in water - they are partially ionised.

For a given concentration, the stronger the acid, the lower the pH.

Concentrated and dilute acids

Concentration tells us how much of a substance there is dissolved in water.

- More concentrated acids have lots of acid in a small volume of water.
- Less concentrated acids (dilute acids) have little acid in a large volume of water.



Crystallisation

You can produce a solid salt from an insoluble base by crystallisation.

1. Choose the correct acid and base to produce the salt.
2. Put some of the acid and base into a flask. Heat gently with a Bunsen burner.
3. Add a small amount of the base and stir.
4. Heat adding the base until no more reacts - the base is in excess.
5. Filter to remove the unreacted base.
6. Add the remaining solution to an evaporating dish.
7. Use a water bath or electric heater to evaporate the water.



Section Chemical Changes Answers

Tao Wei



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Table of Contents Section Chemical Changes Answers

1. Understanding the eBook Section Chemical Changes Answers
 - The Rise of Digital Reading Section Chemical Changes Answers
 - Advantages of eBooks Over Traditional Books
2. Identifying Section Chemical Changes Answers
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Section Chemical Changes Answers
 - User-Friendly Interface
4. Exploring eBook Recommendations from Section Chemical Changes Answers
 - Personalized Recommendations
 - Section Chemical Changes Answers User Reviews and Ratings
 - Section Chemical Changes Answers and Bestseller Lists
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- Section Chemical Changes Answers Budget-Friendly Options
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 - Section Chemical Changes Answers Enhanced eBook Features
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 - Highlighting and Note-Taking Section Chemical Changes Answers
 - Interactive Elements Section Chemical Changes Answers
- 8. Staying Engaged with Section Chemical Changes Answers
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Section Chemical Changes Answers
- 9. Balancing eBooks and Physical Books Section Chemical Changes Answers
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Section Chemical Changes Answers
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Section Chemical Changes Answers
 - Setting Reading Goals Section Chemical Changes Answers
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Section Chemical Changes Answers
 - Fact-Checking eBook Content of Section Chemical Changes Answers
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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