



14–16 years

The properties of hydrogen chloride





Starter question

What is...**HCl**?

Hydrogen chloride or hydrochloric acid?

What's the difference?

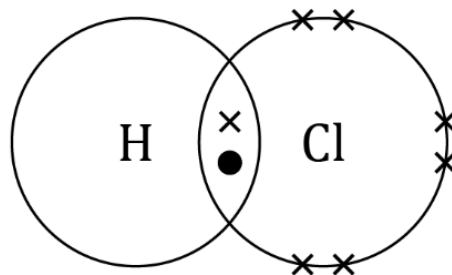


Learning objectives

1. Investigate the properties of hydrogen chloride gas
2. Investigate the properties of dilute hydrochloric acid
3. Compare the structure and bonding of HCl(g) and HCl(aq)
4. Explain how the differences in structure and bonding in HCl(g) and HCl(aq) lead to different properties

Hydrogen chloride

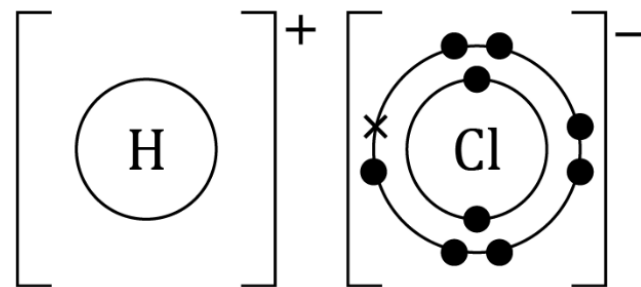
- Hydrogen chloride, HCl, exists as a **colourless gas** at room temperature and pressure.
- A molecule of hydrogen chloride is made up of a hydrogen atom **covalently bonded** to a chlorine atom.
- This can be modelled using a dot and cross diagram:



- Hydrogen chloride is **very soluble** in water. Solutions of hydrogen chloride are known as hydrochloric acid.
- Hydrogen chloride is an important **industrial compound**. It is widely used in the chemical industry as a reagent in the production of other chemicals e.g. **poly(chloroethene)**, PVC

Hydrochloric acid

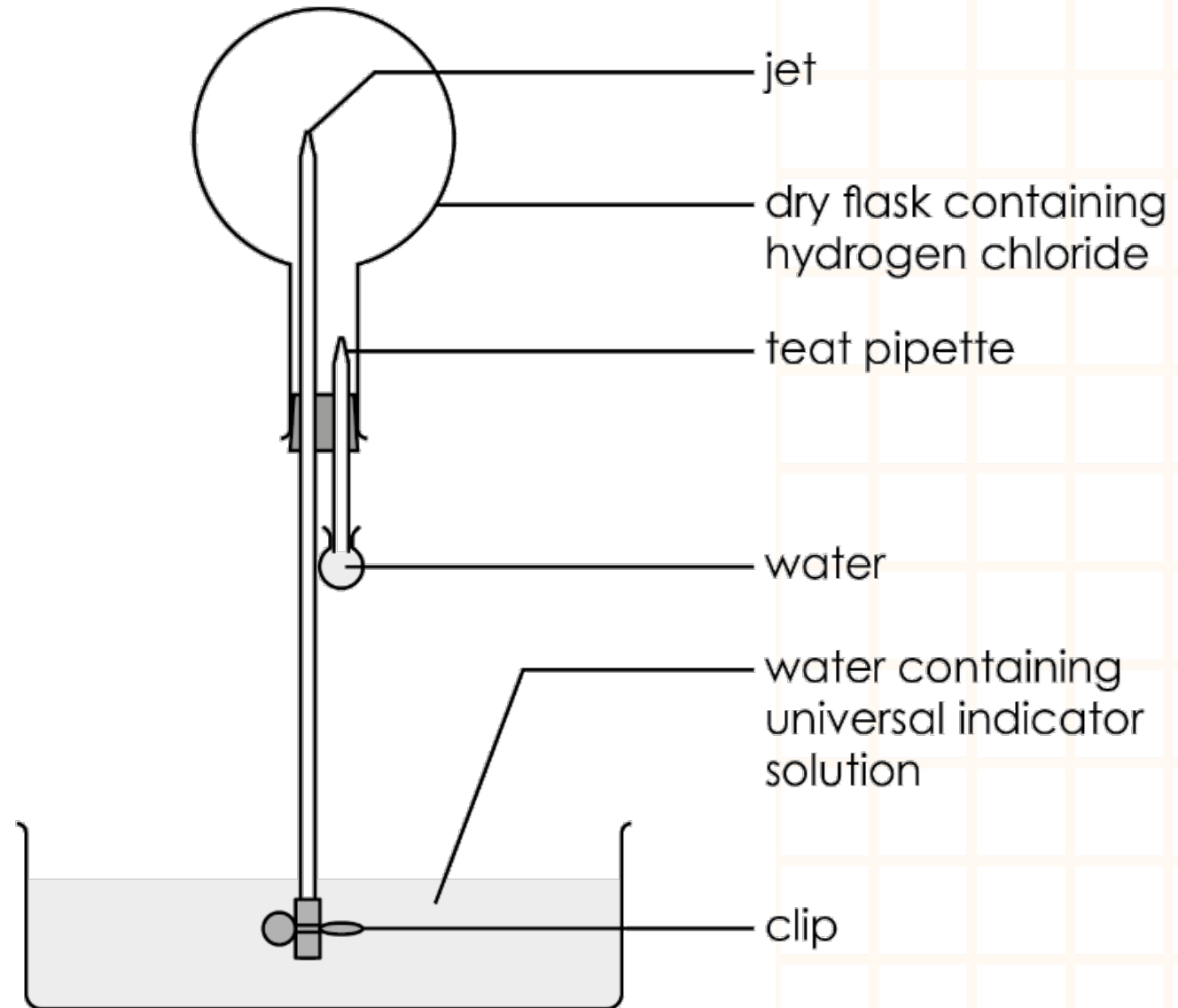
- Hydrochloric acid, HCl, exists as a **colourless solution** at room temperature and pressure. It has a distinctive smell.
- Hydrochloric acid contains **H⁺ and Cl⁻ ions** dissolved in water
- This can be modelled using a dot and cross diagram:



- Hydrochloric acid is a **strong acid**.
- Hydrochloric acid has extensive uses including the **synthesis** of many organic and inorganic compounds; **purification of table salt** and sugar. It also plays an important role in the **digestive system** by activating the enzyme pepsin and **killing any bacteria** entering the stomach.

The fountain demonstration

Watch the teacher demonstration.



The fountain demonstration – follow-up questions

1. State the formula of hydrogen chloride.
2. Describe the colour of the universal indicator:
 - at the start of the demonstration
 - during the demonstration
 - at the end of the demonstration
3. Name the substance present the end of the reaction.
4. Write a word equation to represent the changes that have taken place.

The fountain demonstration – answers

1. HCl
2. Record your own observations according to what you have seen.
For example:
 - at the start: green (neutral)
 - at the end: red (acidic)
3. hydrochloric acid
4. hydrogen chloride + water $\rightarrow$ hydrochloric acid

Investigating the properties of dilute hydrochloric acid

Carry out the following experiments.

Note down all your observations in the results table.

Testing for pH

1. One-third fill a test tube with the hydrochloric acid
2. Add a couple of drops of universal indicator solution
3. Using a pipette, slowly add sodium hydroxide solution. Shake to mix after each addition. Continue adding until the alkali no more changes are observed.

Investigating the properties of dilute hydrochloric acid

Testing with magnesium

1. One-third fill a test tube with the hydrochloric acid
2. Add a strip of magnesium.
3. Hold an inverted test tube over the reaction test tube for a several seconds, to collect the gas
4. Place a burning splint at the mouth of the inverted test tube

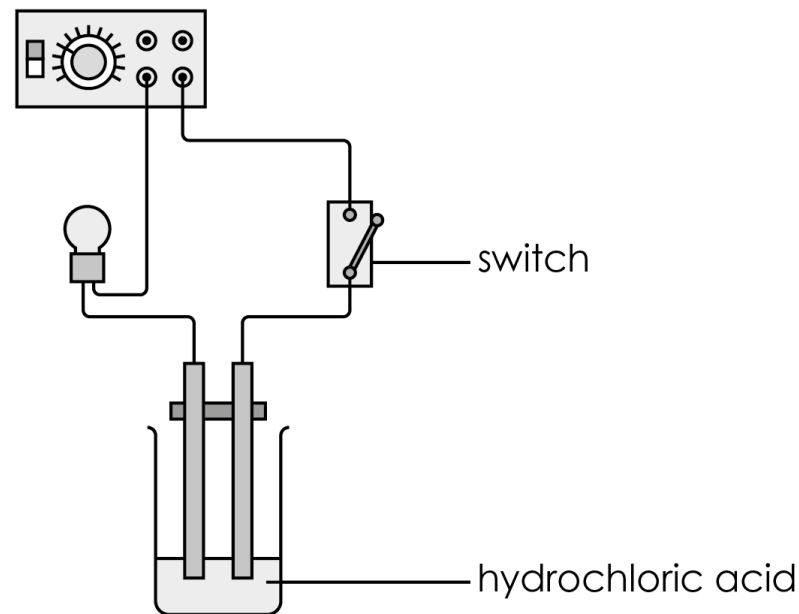
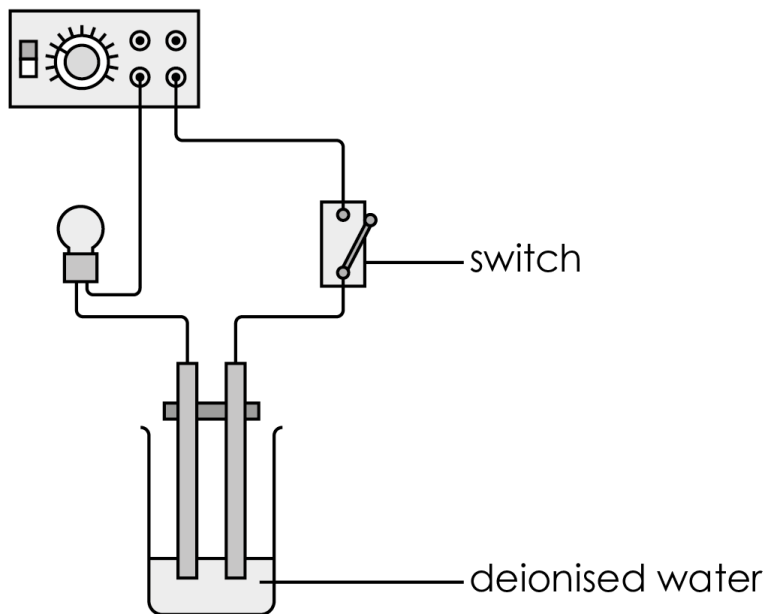
Testing with marble chips (calcium carbonate)

1. One-third fill a test tube with the hydrochloric acid
2. Add a few marble chips
3. Add a few drops of limewater to clean test tube
4. Using a dropper, transfer some of the evolving gases into the limewater.

Investigating the properties of dilute hydrochloric acid

Testing for conductivity

Set up the circuits



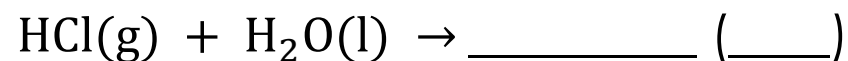
Press down the switch to complete the electric circuits and note down your observations.

Results table

Test	Observations	Conclusions
Testing for pH		
Testing with magnesium		
Testing with marble chips		
Testing for conductivity		

Follow-up questions

1. Describe the appearance of hydrogen chloride.
2. Draw a dot and cross diagram to show the bonding electrons in a molecule of hydrogen chloride.
3. Hydrogen chloride is very soluble in water.
 - a) State the meaning of the term **soluble**
 - b) Describe a simple test that would support the above statement
 - c) Complete the equation:



- d) Describe how the chemical bonding in HCl changes as hydrogen chloride molecules dissolves in water
4. When sodium hydroxide is added to hydrochloric acid a chemical reaction takes place.
 - a) State the type of reaction
 - b) Write a word or symbol equation for the reaction

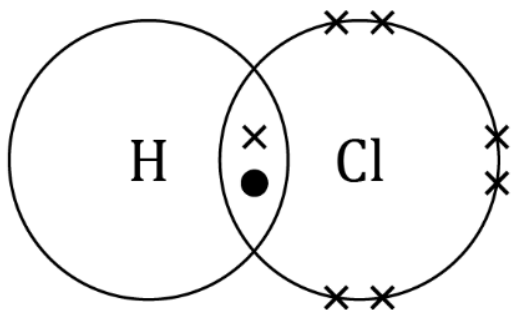
Follow-up questions

5. When zinc is added to hydrochloric acid, a gas is produced.
- a) Name the gas
 - b) Describe a test that could confirm your previous answer
 - c) Write a chemical equation for the reaction
6. When washing soda, Na_2CO_3 is added to hydrochloric acid, a gas is produced
- a) Name the gas
 - b) Describe a test that could confirm your previous answer
 - c) Write a chemical equation for the reaction
7. Suggest a reason why hydrochloric acid is a good conductor of electricity but hydrogen chloride is not.

Answers

1. Hydrogen chloride is a **gas** at room temperature. It is **colourless**.

2.



Answers

3.

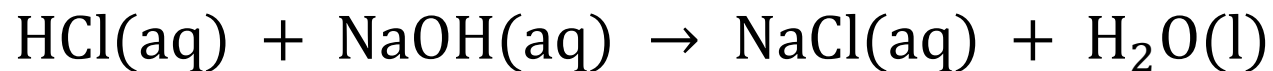
- a) A substance that is soluble will dissolve in a suitable solvent.
- b) Bubble hydrogen chloride into water and test for conductivity. If it conducts electricity then the hydrogen chloride has dissolved.
OR Bubble hydrogen chloride into water and test the pH. If it is acidic then the hydrogen chloride has dissolved.
- c) $\text{HCl(g)} + \text{H}_2\text{O(l)} \rightarrow \text{HCl(aq)}$
- d) A hydrogen chloride molecule consists of a hydrogen atom **covalently** bonded to a **chlorine** atom. They share an **electron** pair. When hydrogen chloride dissolves in water, each chlorine atom **takes** an electron from each hydrogen atom, forming a **negatively** charged chloride ion and a **positively** charged hydrogen ion. The new solution is called **hydrochloric** acid. When sodium hydroxide is added to hydrochloric acid a chemical reaction takes place.

Answers

4.

(a) neutralisation

(b) hydrochloric acid + sodium hydroxide → sodium chloride + water

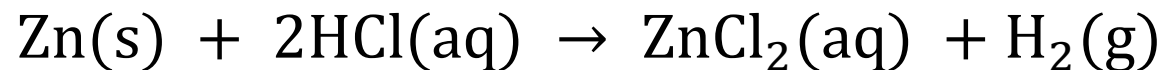


5.

(a) hydrogen

(b) Light the gas with a splint and if it pops, hydrogen is present.

(c) zinc + hydrochloric acid → zinc chloride + hydrogen



Answers

6.

- a) Carbon dioxide
- b) Bubble the gas through limewater and if it goes cloudy, carbon dioxide is present.
- c) Sodium carbonate + hydrochloric acid → sodium chloride + water + carbon dioxide



7. Hydrogen chloride is a covalently bonded **molecule**. There are no free **electrons** in the structure to act as charge carriers. Therefore it **cannot** conduct electricity. When hydrogen chloride dissolves in water, **H⁺** and **Cl⁻** ions are produced, forming hydrochloric acid. Hydrochloric acid can conduct electricity because the **ions** are free to move in the solution and act as **charge carriers**.