

National 4 chemistry



substances

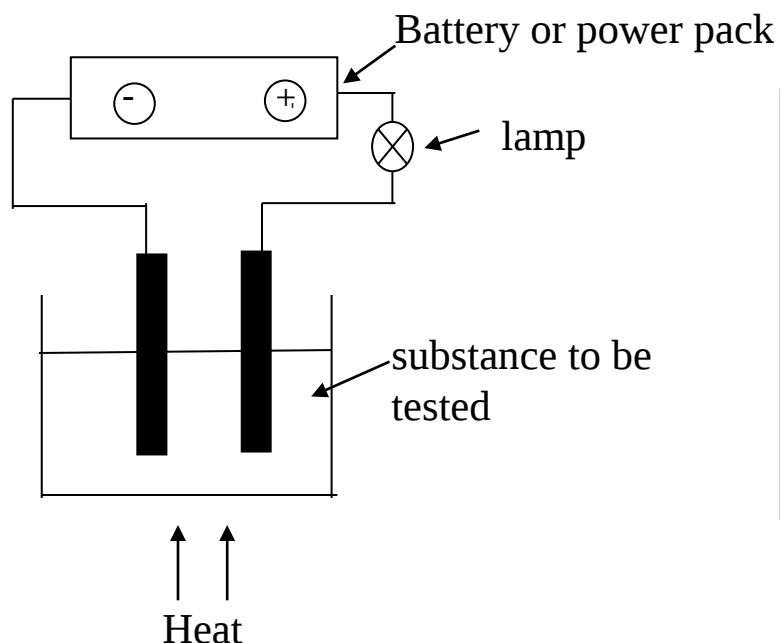
and their

properties

Conduction of elements in different states

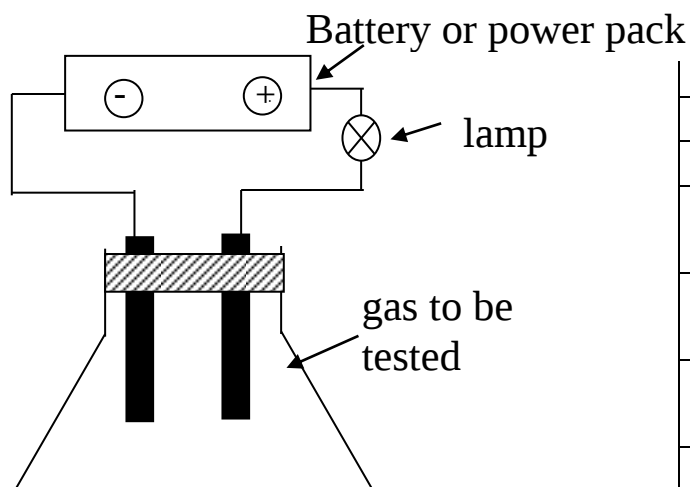
Read

A pupil tested several elements using the apparatus shown.



He had to heat some of the substances to melt them.

He also tested a sealed flask of oxygen and nitrogen gas to test whether they conducted electricity.



Substance	state	what happened
Iron	solid	lamp lit up
Iron	molten	lamp lit up
Sulphur	solid	lamp did not light
Sulphur	molten	lamp did not light
Phosphorus	solid	lamp did not light
Phosphorus	molten	lamp did not light
Nitrogen	gas	lamp did not light
Oxygen	gas	lamp did not light

Write a heading and try the work below

1. Draw a diagram of the apparatus that is used to show whether a substance will conduct when it is a liquid.
2. Draw a diagram to show the apparatus that is used to test whether a gas will conduct electricity.
3. Do metal elements conduct when they are liquids? Explain your answer using the information on the previous page.
4. From the results on the previous page, what can you say about the conduction of non-metal elements in **all** three states of matter?
5. Which non-metal element does not fit this rule (this is memory work from earlier courses)?
6. Write a rule about the conduction of electricity for metal and non-metal elements in different states (remember to mention the exception to the rule).
7. Make a list of 5 **other** elements that do conduct and a list of 5 **other** elements that don't conduct.

State symbols (optional)

Read

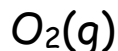
We use state symbols to show what state a substance is in

(s)	= solid
(l)	= liquid (melted)
(g)	= gas
(aq)	= dissolved in water.

So at room temperature we know that iron is a solid so its formula with state symbol would be



At room temperature oxygen is a gas so its formula with state symbol would be



Sea water is solution of sodium chloride dissolved in water so its formula with state symbol would be



But melted sodium chloride would be



Write a heading and try the following work

1. Copy the box that shows the state symbols and their meanings into your jotter.

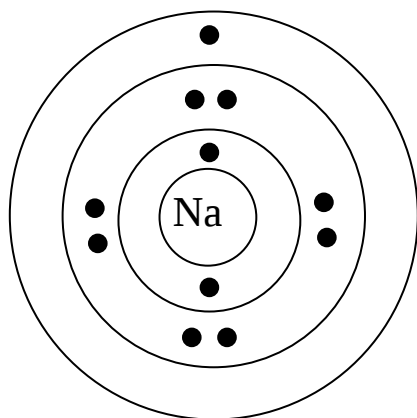
2. Write the formula showing the state at room temperature for the following
- a) zinc
 - b) mercury
 - c) potassium
 - d) carbon
 - e) hydrogen
 - f) neon
 - g) bromine
 - h) iodine
3. Choose 5 more elements and add them to your list.

Why do metals conduct? (optional)

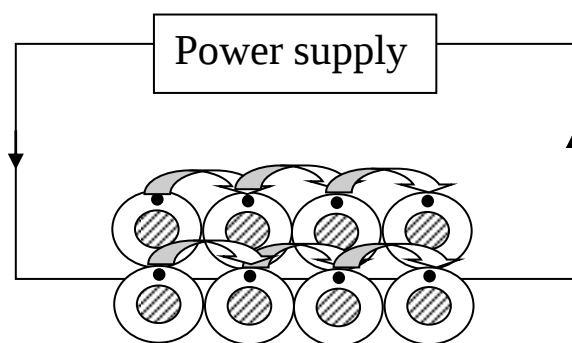
Read

For a substance to conduct electricity

- **Charged particles** must be present.
- These charged particles must be **able to move**.



You have already learned that an atom contains charged particles called protons and electrons. The protons are trapped inside the nucleus and cannot jump between atoms but the outer electrons in metals are only held loosely and can jump between the metal atoms.



When a metal is in a circuit, the battery or power supply gives the electrons a push and makes them **move** in one direction.

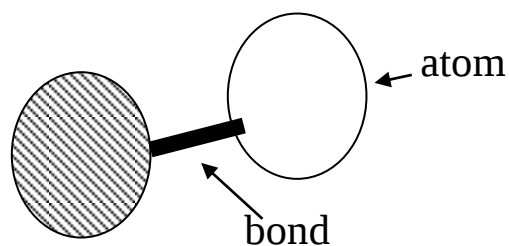
Write a heading and try the work below

1. What are the 2 conditions that must be met before a substance can conduct electricity?
2. Explain why protons cannot jump between atoms.
3. What is the name of the charged particles that move when metals conduct.
4. Why can these particles move so easily between metal atoms?
5. What is the name of the other particle that is inside atoms (revision)?

Types of compounds

Read

You already know that a compound is made when different elements join together. There are **two types** of compound depending on which types of elements react together.



The two types of compounds are called

1. **Ionic** compounds
2. **Covalent** compounds

Ionic and covalent compounds have different properties.

Write a heading and try the work below

1. What is meant by the word compound (revision)?
2. What are the two types of compound called?
3. Collect a set of compound cards and sort them into two sets; ionic compounds and covalent compounds.
 - a) Make a list in your jotter by writing two headings "ionic compounds" and "covalent compounds". Write the formulae on the cards underneath the correct heading.
 - b) Compare your lists to a periodic table and devise a rule for working out whether a compound is ionic or covalent.

c) Copy the following table into your jotter and complete it using your rule. Choose 3 more compounds to fill in the last 3 rows.

Name	What is it made of	Covalent or ionic?
Sodium chloride	Metal and non-metal	ionic
Carbon hydride		
Potassium oxide		
Carbon monoxide		
Silicon fluoride		
Calcium sulphide		
Silicon tetrachloride		
Nitrogen dioxide		
Hydrogen oxide		
Caesium bromide		

Conduction of electricity in compounds

Read

We already know that metal elements conduct electricity and non-metal elements (except carbon) don't conduct electricity, but what about conduction of electricity in different types of compounds? You are now going to test some compounds to see whether they conduct electricity.

Write a heading and try the work below

1. Copy and complete the following sentence to show your hypothesis.

I think that ionic compounds **will/won't** conduct.

I think that covalent compounds **will/won't** conduct.

2. Copy the table below for your results.

Name of compound	formula	Type of compound (ionic/covalent)	state	Conduction (yes/no)

Collect a conduction tester and two leads. Go to the display of compounds and test whether they conduct electricity to complete your table.

3. Which type of compound is always solid at room temperature?
4. Which type of compound can be solid, liquid or gas at room temperature?
5. Do covalent compounds conduct in any state?
6. Do these results allow us to make any decisions about ionic liquids - why?
7. What would we need to do to the ionic compounds to test whether they conduct when they are liquids?

Conduction of electricity in molten compounds

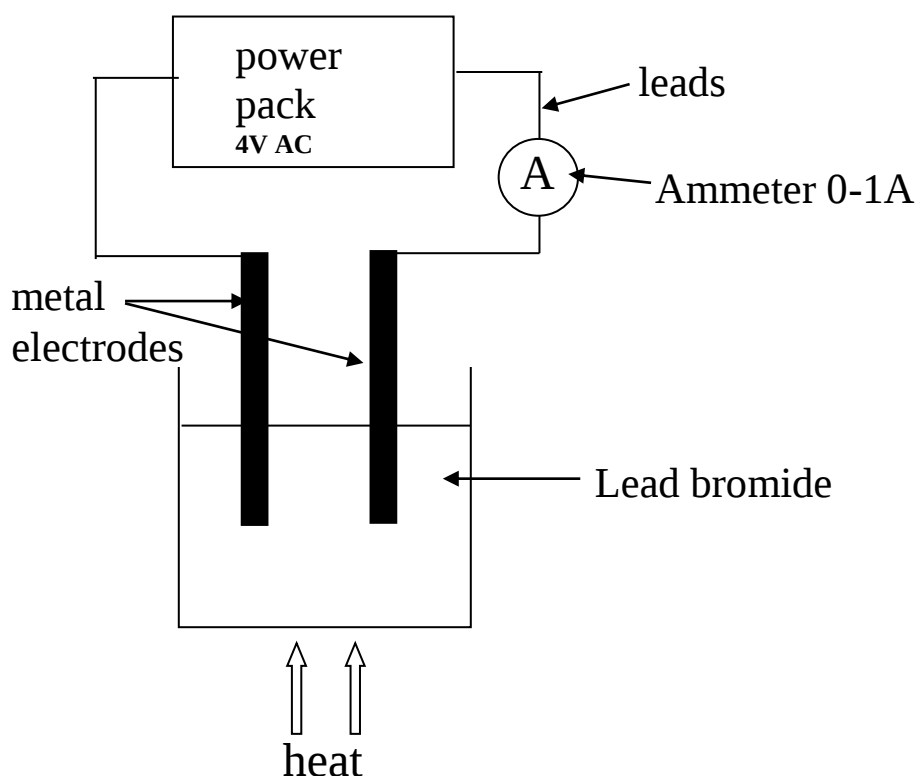
Read

We have looked at covalent compounds in all three states of matter: solids, liquids and gases and know that covalent compounds **do not conduct** in any state. However, we have only looked at ionic compounds at room temperature and they are **always solid at room temperature**.

The aim of the next experiment is to find out if ionic substances will conduct when they are liquid.

To turn an ionic solid into a liquid we need to heat it up until it melts. The word **molten** means melted.

Watch while your teacher shows you what happens when lead bromide is melted.



Write a heading and try the work below.

1. What state are ionic compounds at room temperature?
2. Explain what molten means.
3. Copy the diagram to show how you would test the conduction of a molten compound.
4. Copy and complete the table to show what happened.

State	did it conduct?
Solid	
Molten	

5. Copy and complete the sentence below.

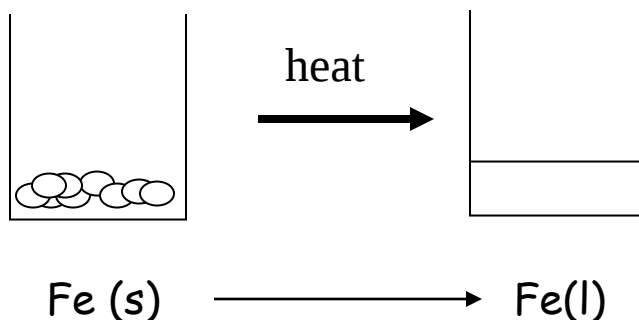
Ionic compounds do not conduct when _____ but do when _____.

6. Imagine the ammeter broke and the teacher needed to show this again. What could be used instead of the ammeter?

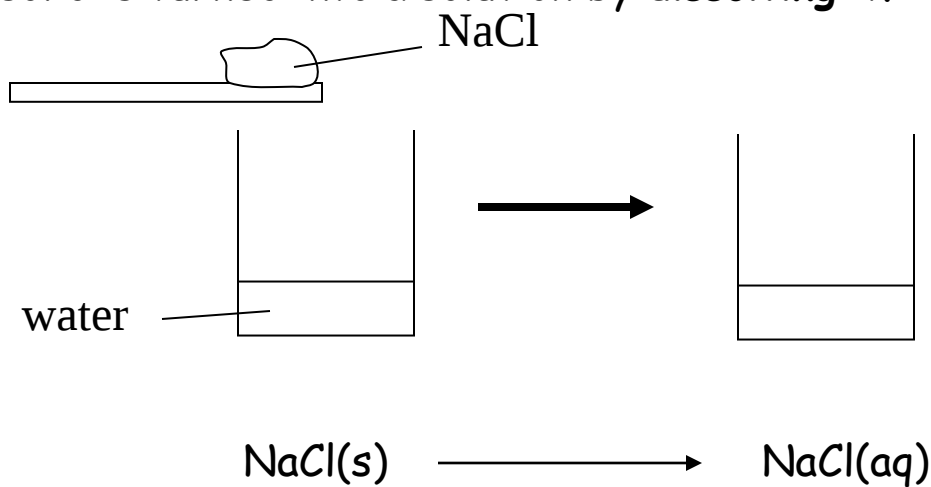
Liquids and solutions

Read

A solid is turned into a liquid by **melting** it.



A solid is turned into a solution by **dissolving** it.

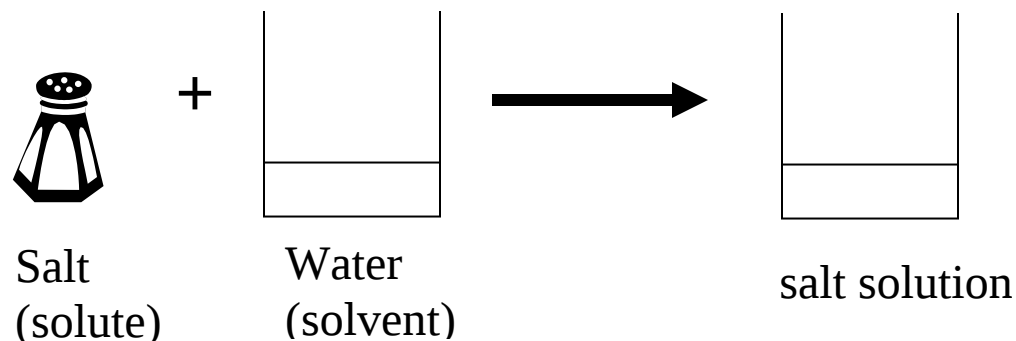


You should know from previous courses, that a **soluble** substance is one that **will dissolve** and an **insoluble** substance is one that **will not dissolve**. Other definitions you should know are shown in the box below.

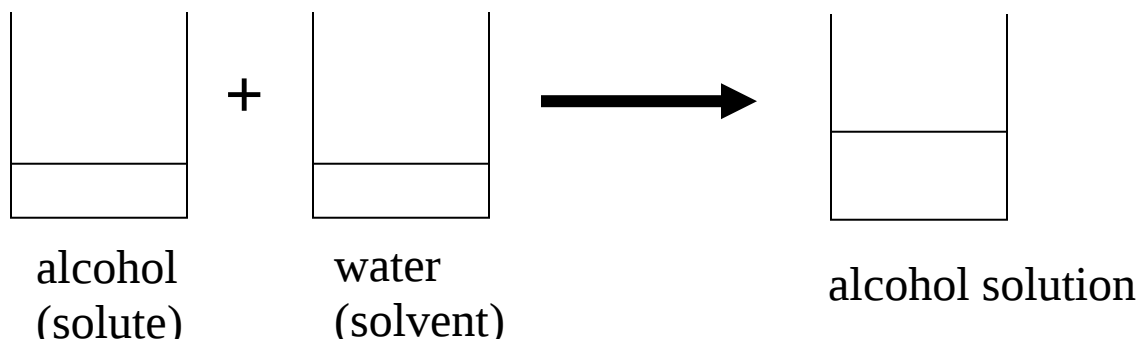
A **solute** is the substance that dissolves in a liquid.

A **solvent** is a liquid that can dissolve other substances.

A **solution** is the mixture that is formed once the solute has dissolved in a solvent.



Alcoholic drinks are solutions containing dissolved alcohol.



Gases can also be soluble. You already know that sulphur dioxide and carbon dioxide are gases that dissolve in water to form acidic solutions - this is how acid rain is formed from car exhaust fumes.

Write a heading and try the work below.

1. If you see (aq) beside the formula for a chemical, what does this mean about the chemical?
2. Copy the definitions box on the previous page.
3. What page in the data book would you look at to check if a substance was soluble or insoluble?
4. Choose 3 very soluble and 3 insoluble compounds from the data book and list them in your jotter.
5. What is the name of a compound that is soluble and not very soluble?

Conduction of solutions

Read

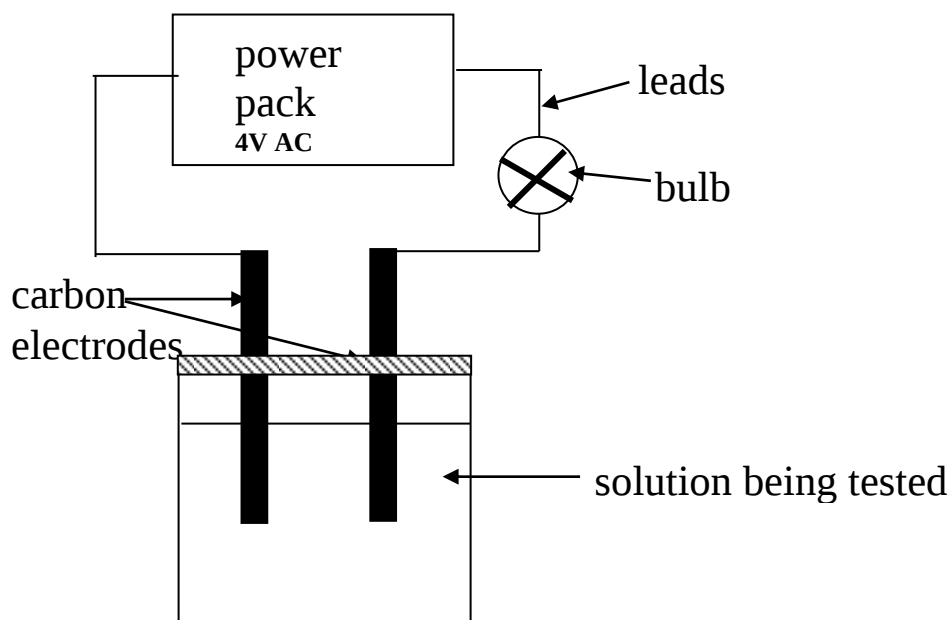
We know that covalent solids, liquids and gases do not conduct and that ionic compounds do not conduct when solid but do when melted, but what about if we dissolve covalent and ionic compounds in water?

Write a heading and try the work below.

1. Copy and complete the sentence below to show **your** hypothesis/prediction for what you think will happen.

I think that the ionic solutions will/won't conduct and the covalent solutions will/won't conduct.

2. Copy the diagram of the apparatus that is used to test whether a solution can conduct.



3. Copy the table below before you start the experiment.

Solution name	solution formula	Type of compound (ionic/covalent)	Conduction (yes/no)
Alcohol	C_2H_5OH		
Potassium iodide	KI		
Copper sulphate	$CuSO_4$		
Glucose	$C_6H_{12}O_6$		
Zinc chloride	$ZnCl_2$		
Antifreeze	$C_2H_6O_2$		

Go to the display of solutions and test each one to see if it conducts electricity.

4. How did you know whether the solutions conducted or not?

5. Write a rule for conduction of solutions.

6. What could have been used instead of a power supply?

Why are atoms reactive???

Read

Before we think about what happens when atoms react, we need to think about which atoms are reactive and which are not and the reasons for this difference.

The noble gases in column 8/0 of the periodic table are extremely unreactive because they have **stable electron arrangements**. We can find these electron arrangements in a data book.

Noble gas	electron arrangement
Helium	2
Neon	2,8
Argon	2,8,8
Krypton	2,8,18,8,
Xenon	2,8,18,18,8
Radon	2,8,18,32,18,8

How covalent and ionic compounds are formed

Atoms react to form compounds because they have **unstable electron arrangements**. When atoms form ionic and covalent compounds they must **collide** (bang into each other) and electrons are either transferred completely between atoms or shared between atoms.

- If the outer electrons are **transferred** between atoms an ionic compound is made.
- If the electrons are **shared** between atoms a covalent compound is made.

When other elements in the periodic table react they are trying to get **an electron arrangement that is the same as one of the noble gases.**

Write a heading and try the following questions.

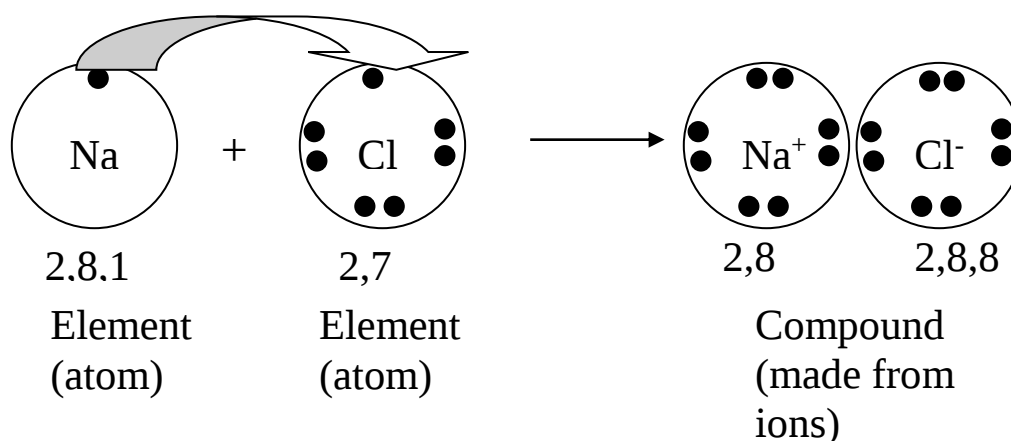
1. What column of the periodic table contains extremely unreactive gases?
2. What is the name of this family of gases.
3. Look at a data book
 - a) Which page in the data book contains the electron arrangements?
 - b) Choose 3 elements from column 8/0 and write down their electron arrangements
4. Why are these atoms so unreactive?
5. Why do other atoms react to form compounds?
6. Choose 3 elements from column 1 and write down their electron arrangements.
7. What happens to the electrons when
 - a) Ionic compounds are made?
 - b) Covalent compounds are made?

Ionic compounds

Read

Ionic compounds are mainly formed when **metal** atoms and **non-metal** atoms react. The metal atoms give electrons away to the non-metal atoms until both types of atoms get the same electron arrangement as one of the unreactive elements in the last column of the periodic table.

We can check this by thinking about sodium reacting with chlorine. The sodium atom gives one electron to the chlorine atom.



Look at the data book and find sodium. It has an electron arrangement of 2,8,1. Now look at column 8/0. The easiest way for sodium to get an arrangement the same as one of these elements is to lose one electron so the sodium atom passes one electron to the chlorine and the sodium becomes 2,8 (which matches neon).

The chlorine has an electron arrangement of 2,8,7. The easiest way for the chlorine to match one of the elements in

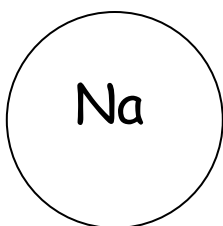
the last column is to get an extra electron so the chlorine ends up with 2,8,8 which matches Argon.

The electron passes from the metal to the non-metal until they both match one of the elements in column 8/0.

Once the atoms have given away or received the electrons they **are not neutral atoms any more**. They are called ions.

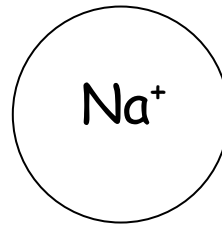
This is simplified in the following diagrams.

Sodium atom



Atomic no	= 11
No. protons	= 11
Electron arr.	= 2,8,1
No. electrons	= 11
Charge	= neutral

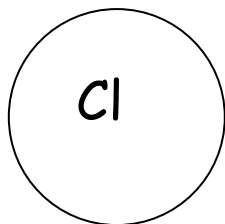
Sodium ion



Atomic no	= 11
No. protons	= 11
Electron arr.	= 2,8
No. electrons	= 10
Charge	= positive

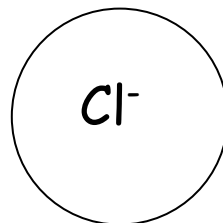
Ions have a charge because they have an imbalance of protons and electrons. **The sodium ion has too many protons compared to electrons so the sodium ion is positive.**

Chlorine atom



Atomic no = 17
No. protons = 17
Electron arr. = 2,8,7
No. electrons = 17
Charge = neutral

Chloride ion



Atomic no = 17
No. protons = 17
Electron arr. = 2,8,8
No. electrons = 18
Charge = negative

The chloride ion has too many electrons compared to protons so the chloride ion is negative.

Write a heading and try the following work.

1. What will the name of the new compound be when sodium and chlorine react (revision)?
2. Collect a copy of the diagrams showing the sodium and the chlorine atoms and ions
 - a) What is the same about the sodium atom and the sodium ion?
 - b) What is different about the sodium atom and the sodium ion?

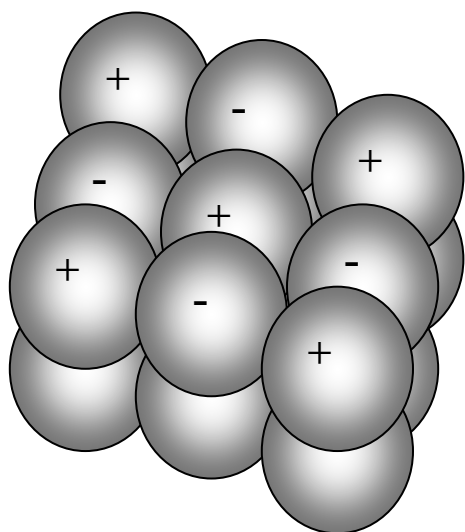
- c) What is the same about the chlorine atom and the chloride ion?
- d) What is different about the chlorine atom and the chloride ion?
- e) Explain why the sodium ion is positive but the chloride ion is negative.

3. Collect a copy of the sheet showing potassium and fluorine atoms and ions. Complete the sheet and stick it into your jotter.
4. Which element in column 8/0 does potassium match when it turns into an ion?
5. Which element in column 8/0 will fluorine match when it turns into an ion?
6. Why do you think that the number of protons doesn't change when an atom becomes an ion?

What holds ions together in solid ionic compounds?

Read

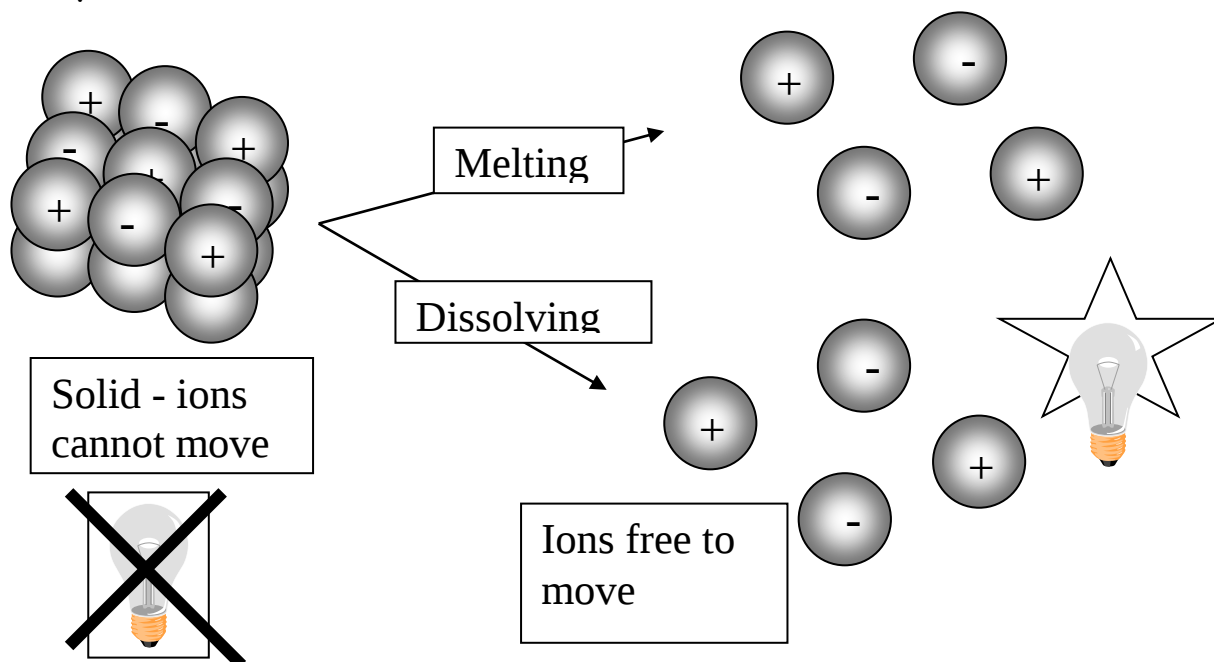
We already know that ionic compounds contain charged particles called **ions** and that ionic compounds are always **solid** at room temperature. The strong force that holds ions together is called the **ionic bond** and is the attraction between the **oppositely charged ions** (positive ions attract negative ions and negative ions attract positive ions).



If we could see inside a solid ionic compound we would see many, many ions attracting each other in three dimensions.

Melting and dissolving ionic compounds

When ionic compounds are melted or dissolved, the strong ionic bonds break and the ions can move away from each other.



Ionic bonds are **strong** so ionic compounds have high melting points and are always solid at room temperature.

Write a heading and try the work below

1. What state are ionic compounds at room temperature?
2. What is meant by an ionic bond?
3. What happens to a solid ionic compound when it melts or dissolves?
4. Draw a diagram to illustrate your answer to the last question.
5. Can an ionic compound conduct electricity when it is
 - a) solid?
 - b) liquid (melted)?
 - c) dissolved?
6. Explain why ionic compounds are always solid at room temperature.

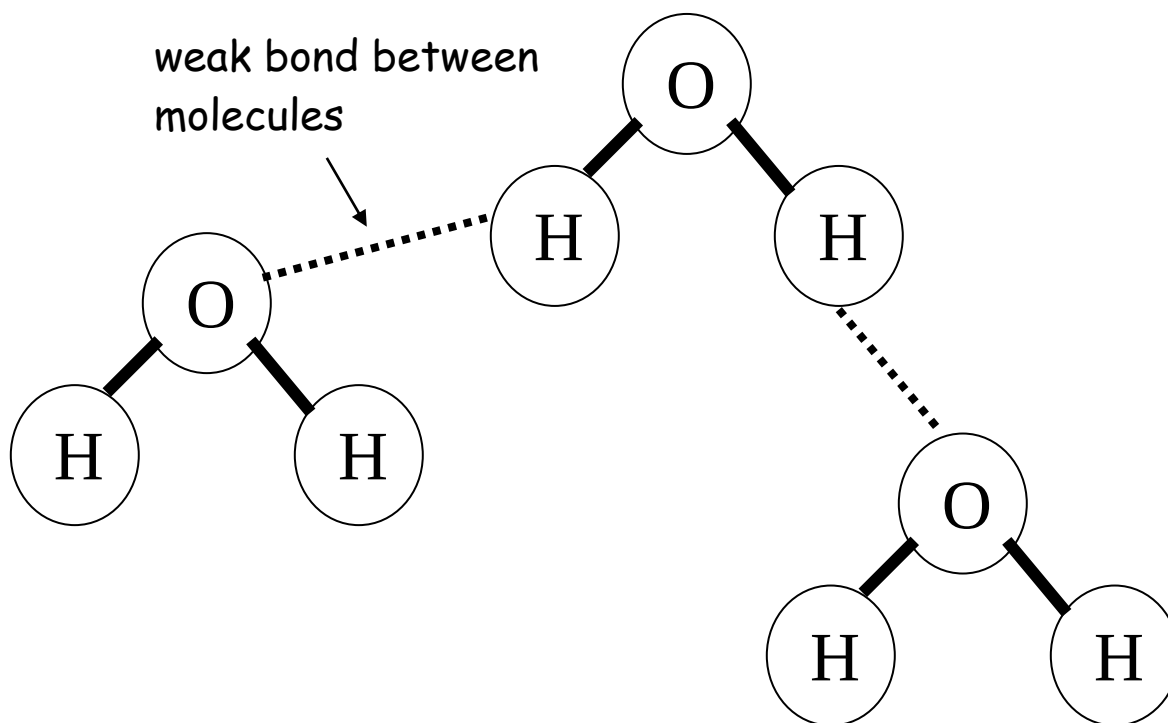
Why can covalent substances be any state?

Read

So we already know that ionic substances contain particles called ions and covalent substances contain particles called molecules.

Substances that are made from molecules can be solid (for example wax), liquid (for example water and alcohol) or gas (for example carbon dioxide, methane) at room temperature so they must be easier to melt or boil than ionic substances.

This is because bonds between ions are strong but bonds between molecules are only weak.



When a covalent molecule substance melts, it is only the weak bonds between molecules that break. This means that

covalent substances are easier to melt than ionic substances so they have **low melting points and boiling points** and so **they can be solid liquid or gas at room temperature.**

Write a heading and try the following work

1. List some examples of the names of covalent molecular substances that are solids, liquids and gases.
2. Copy the diagram of the water molecules.
3. Use the diagram to explain why covalent substances have low melting points and boiling points.
4. Titanium chloride is a compound that is a liquid at room temperature.
 - a) Using only the names of the elements in titanium chloride, what type of compound is it?
 - b) How do we know that this must be wrong?
 - c) Collect a copy of the ionic/covalent summary sheet and circle the correct words before you stick it into your jotter.

Public domain copyright free images from the collection at
<http://www.wpclipart.com/index.html>