GCSE (AQA) ADDITIONAL SCIENCE

Chemistry

Structure and Bonding Workbook

Section 1: Simple molecular substances

D – Explain what a simple molecular substance is and name some examples
C – State the properties of a simple molecular substance
B – Explain the properties of simple molecular substances
A – Link the properties to the substances uses

Section 2: Giant covalent substance

D – Give examples of giant covalent substances and explain structure
C – State the properties of a giant covalent substance
B – Explain the properties of giant covalent substances
A – Link the properties to the substances uses

Section 3: Giant ionic substances

D –Explain structure of an ionic lattice
C – State the properties of a giant ionic substance
B – Explain the properties of giant ionic substances
A – Link the properties to the substances uses

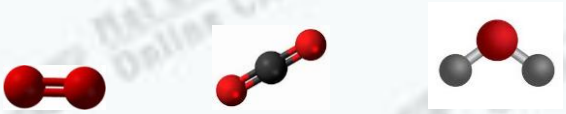
Section 4: Covalent bonding

D – State which substances contain covalent bonding
C – Explain what covalent bonding is, when it occurs and the difference between a single and a double bond.
B - Draw the bonding for a simple molecule containing 1 single bond (eg. F_2)
A - Draw the bonding for a simple molecule containing multiple single bonds (eg. H_20, NH_3) or a double bond (eg. O_2)
A* - Draw the bonding in molecules with multiple bonds including single and double bonds (eg. HNO)

Section 5: Ionic bonding

D – State which substance contain ionic bonding
C – Explain how ionic bonding works and between what types of atom
B – Draw a dot and cross diagram to show the bonding in NaCl
A – Describe the bonding in complex ionic compounds (eg. $MgCl_2$)
A* - Predict the chemical formula for ionic compounds

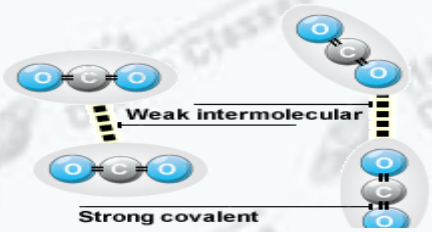
Simple Molecular Substances



Simple molecular substances are made up of molecules.

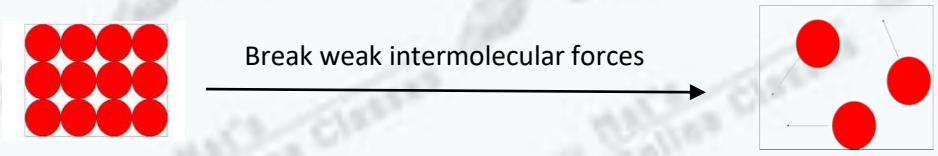
What's a molecule? A molecule is what we call a collection of atoms joined together by covalent bonds. Examples include: CO_2, H_2O and O_2

The molecules are held together by weak intermolecular forces.



Boiling and melting point

To melt and boil a simple molecular substance (turn from a solid to a gas) you have to break the weak intermolecular forces that hold the molecules together as a solid.



These forces are weak so simple molecule substances have low boiling and melting points.

Electrical conductivity

Simple molecular substances do not conduct electricity! This is because they **don't** have any free electron or ions to carry the electrical charge.

All molecules form simple molecular substances. Examples are water (H_2O), carbon dioxide (CO_2), Chlorine gas (Cl_2), Oxygen gas (O_2), methane (CH_4) and Hydrogen (H_2).

Note that all these are gases or liquids at room temperature because of low melting and boiling points

Key points (Need to know for a C)

- **Molecule held together by weak intermolecular forces**
- **Molecules made up of atoms covalently bonded together**
- **Substances have low boiling and melting points**
- **Substances have no electrical conductivity**

Tasks

1. Write down the definition of a molecule and look at the 3 pictures of molecules at the top of the previous page.

   .....
   .....

2. Covalent bonds are ..... (inside, between, outside) the molecules
   Weak intermolecular forces are ..... (inside, between, outside) the molecules.

3. Write down 2 properties of all simple molecular substances

   a. ..... (low, intermediate, high) melting point and boiling point
   b. .....(no, poor, good) electrical conductivity

4. Write a short explanation for why simple molecular substances have a low boiling point. Include the words: weak intermolecular forces and molecules

   .....
   .....
   .....
   .....

5. Write a short explanation for why simple molecular substances have no electrical conductivity. Include the words: electrons and ions

   .....
   .....
   .....
   .....

If you can do all this you're ready to try the exam questions again!

Exam questions – Simple molecular substances

Spacecraft have been to the planets Venus and Mars. The spacecraft have sent back information about the atmosphere of each planet.

The main gas in the atmosphere of Mars is carbon dioxide.

a. Carbon dioxide has 1 carbon atom and 2 oxygen atoms. What is the chemical formula of carbon dioxide? ..... (1 mark)

b. Explain the electrical conductivity of simple molecular substances such as carbon dioxide.

.....

.....

.....(2 marks)

c. Explain, in terms of structure, why carbon dioxide is a gas, even at low temperatures.

.....

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.....

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..... (3 marks)

Total: /6

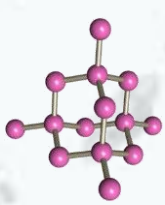
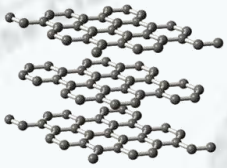
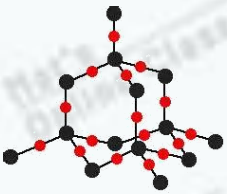
Now mark it using the mark scheme on the next page

Mark scheme – Simple molecular substances

Question	Answer	Notes	Marks	Grade
a	CO_2	0 if number not subscript	1	D
b	No electrical conductivity (1 mark) Electrons fixed in position/ not free to move (1 mark) *or* No ions or electrons free to move (1 mark)		2	B/A
c	Intermolecular forces between molecues (1 mark) Intermolecular forces are weak (1 mark) Only a small amount of energy (heat) needed to overcome (break, separate) forces/bonds (1 mark)		3	B/A

Giant Covalent Substances

Giant covalent substances are made up of millions and millions of atoms which are all bonded together with **a network** of **covalent bonds.**

These are 3 examples of giant covalent substances

Diamond **Graphite** **Silica**

Structure

Diamond – Made up of carbon atoms. All carbon atoms covalently bonded to 4 other carbon atoms. These strong covalent bonds make it extremely hard.

Graphite – Made up of layers of carbon atoms. These layers can slide over one another and rub off making graphite soft and good for use in pencils.

Silica – Made up of silicon and oxygen atoms all covalently bonded together. It is very hard.

Melting point and boiling point

All giant covalent molecules have a high melting point and boiling point.

- To boil or melt a giant molecular substance you would have to pull the atoms apart.
- The atoms are all connected with covalent bonds.
- Covalent bonds are strong so need a lot of energy (heat) to break.

Electrical conductivity

Diamond **doesn't** conduct electricity because there are no free electrons or ions to carry the charge.

Silica is a **poor** conductor of electricity.

Graphite is the odd on out. It **can** conduct electricity because electrons **can** move within the **layers** and carry the electrical charge.

Tasks

Complete the table

Property	**Explanation**
Diamond	
..... melting point and boiling point	
..... electrical conductivity	
Graphite	
..... melting point and boiling point	
..... electrical conductivity	
Silica	
..... melting point and boiling point	
..... electrical conductivity	LEAVE BLANK

Exam questions – Giant covalent substances

a. Diamond is a substance made up of carbon atoms. What type of substance is diamond?

..... (1 mark)

b. One property of diamond is that it doesn't conduct electricity. Another is that it has a

..... melting point and boiling point. (1 mark)

c. Explain why diamond has the melting point and boiling point it does with reference of the structure of diamond.

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..... (3 marks)

d. There is one giant covalent substance that **does** conduct electricity well. What is the name of this substance?

..... (1 mark)

e. Give one other property of this substance. ..... (1 mark)

f. Explain why this substance can conduct electricity referring to its structure.

.....

.....

.....

..... (2 marks)

Total: /9

Now mark it using the mark scheme on the next page

Mark scheme – Simple molecular substances

Question	Answer	Notes	Marks	Grade
a	Giant covalent substance	Accept giant covalent	1	C
b	High	Accept very high	1	C
c	Giant covalent (substance) so lots of (strong) covalent bonds (1 mark) To boil or melt covalent bonds need to be broken (1 mark) High energy (high temperatures) required to break bonds (1 mark)		3	B
d	Graphite	Do not accept silica	1	C
e	Free electrons or Electrons free to move (1 mark) Within layers (1 mark)		2	B

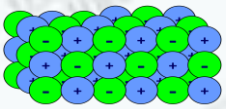
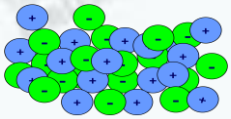
Giant Ionic Substances

Giant ionic substances are made up of millions and millions of **ions** all held together by **electrostatic attraction.**

What's an ion? An atom with a charge (positive or negative) due to the loss or gain of electrons.

What's electrostatic attraction? The attraction between a positively charged ion and a negatively charged ion

These ions all come together to form a giant ionic lattice. Shown below on the left

Solid  Molten 

Boiling and melting point

To melt or boil a giant ionic substance you have to pull apart the **ions** and therefore, break the electrostatic attractions.

Electrostatic attraction is very strong and so giant ionic substances have high boiling points and melting points.

Electrical conductivity

When the ions are held in place (the substance is a solid, shown above) the ions cannot move and so it **cannot** conduct electricity. If a giant ionic substance is molten (melted) then the ions are free to move and so it **can** conduct electricity.

Giant ionic substances dissolve in water. If we dissolve a giant ionic substance in water the ions all move apart and spread out in the water. This means they can move and giant ionic substances **can** conduct electricity when dissolved.

Examples include sodium chloride (table salt) and any other ionic compound. All ionic compounds form giant ionic substances. Always contains metals and non metals.

Key points (must know for a C)

- **Giant ionic lattice formed from positive and negative ions held together by electrostatic interactions**
- **Substance have high boiling points and melting points**
- **Substances don't conduct electricity when solid but do when molten or dissolved.**

Tasks

1 What is an ion?

.....

2 What is electrostatic interaction?

.....

3 Draw a 3 x 3 ionic lattice and state what holds the ions together

4 Why do giant ionic substances have high melting points and boiling points?

.....
.....
.....

5 The electrical conductivity of a giant ionic substance depends on its state

Does it conduct electricity as a solid? .....

Why? .....
.....

Does it conduct electricity when molten? .....

Why? .....
.....

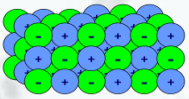
Does it conduct electricity when dissolved? .....

Why? .....
.....

Exam questions – Giant ionic substances

a. In giant ionic substances ions arrange themselves in giant ionic lattices, as shown below. What is the force that holds these ions together?

.....(1 mark)



b. Sodium chloride (table salt) is an example of a giant ionic substance. Explain as fully as you can the electrical conductivity of sodium chloride.

Include in your answer the electrical conductivity or sodium chloride in solid, molten and dissolved forms and an explanation to support your answer.

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.....(4 marks)

c. The bonding in an ionic compound such as sodium chloride is ionic. How could we know this only from knowing the atoms or ions that the compound contains?

.....

.....(1 mark)

d. Tick 2 boxes to indicate which 2 are properties of giant ionic substances (2 marks)

Property	Tick (✓)
Do not dissolve in water	
High melting points	
Low boiling points	
Strong bonds	

Total: /8

Mark scheme – Simple molecular substances

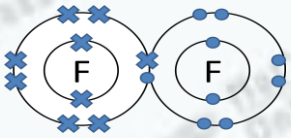
Queston	Answer	Notes	Marks	Grade
a	Electrostactic interaction/attraction/forces		1	C
b	Solid has no conductivity (1 mark) Ions held in place (1 mark) Molten or dissolves conduct (1 mark) Ions free to move (1 mark)	Lose 1 mark if solid molten or aqueous form not mentioned	4	A
c	Metal and non metal atoms	One from left and one from right side of periodic table accepted	1	B
d	High melting points (1 mark) Strong bonds (1 mark)		2	C

Covalent bonding

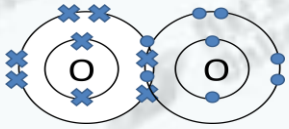
Covalent bonding is the **sharing of electrons**. This is between 2 non-metal atoms and forms a full outer shell of electrons. We draw this using dot and cross diagrams with overlapping electron shells.

You must be able to draw dot and cross diagrams for molecule containing single and multiple bonds

Single bond (2 electrons shared; 1 from each atom)



Double bond (4 electrons shared; 2 from each atom)



Rules

- If one atoms shares one electron with the atom next to it that atom must share the same back
- After counting up all the original electrons and the extra electrons from the sharing all atoms must have a full outer shell.
- The hard bit is working out how many electrons to share and to which atoms.

Tasks – Covalent bonding

Draw a chlorine atom only drawing the outer shell of electrons

How many electrons does it need to fill its outer shell? .....

Next draw 2 chlorine atoms with the outer shells overlapping. Draw one atom with electrons drawn as crosses and the other with electrons drawn as dots. In the overlapping section draw put one electron from one atom and one from the other.

Including shared electrons, how many electrons does each atom have on its outer shell

now? .....

Do the same for 2 oxygen atoms but this time it will be slightly different. Oxygen have 6 electrons on their outer shell so need to gain 2. To get 2 they will need to share 2 into the overlapping section each.

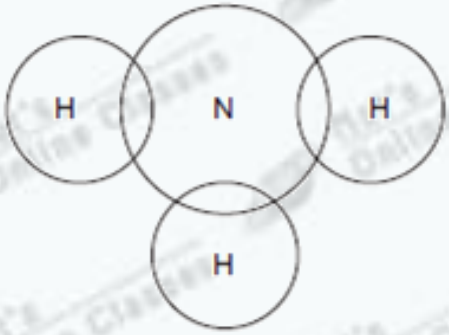
On a piece of paper try water (H_2O) and carbon dioxide (CO_2). **Remember the rules and if you can't do them ask a teacher to help you!!!!!**

Exam questions – Covalent bonding

a. Name the type of bonding present in molecules such as ammonia (NH_3)

..... (1 marks)

b. Complete the diagram to show the arrangement of the outer shell electrons of the nitrogen and hydrogen atoms in ammonia. (2 marks)



c. Draw a second dot and cross diagram to show the bonding in a molecule of oxygen (O_2) (2 marks)

Total: /5

Now mark it using the mark scheme on the next page

Mark scheme – Covalent bonding

Question	Answer	Note	Marks	Grade
a	Covalent		1	C
b	Nitrogen with 5 electrons, 1 overlapping with each hydrogen (1 mark) Hydrogen with 1 electron each overlapping with nitrogen	1 Mark deducted if not using dot and cross	2	B
c	1 mark for each oxygen drawn with 6 electrons and 2 in overlap region	1 mark deducted it dots and crosses not used	2	A

Ionic bonding

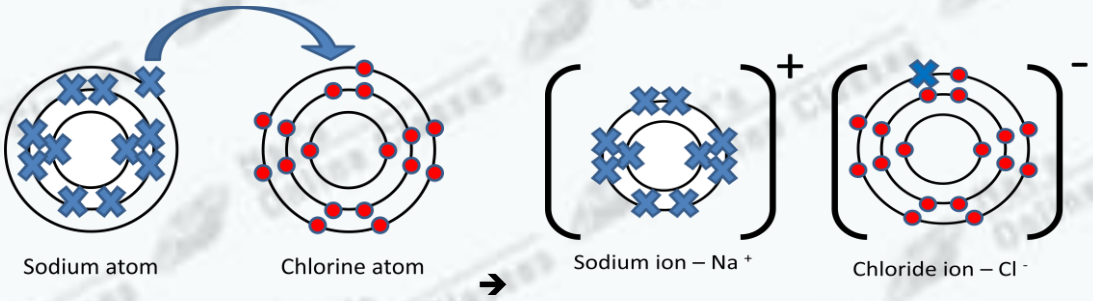
Ionic bonding is between ions. One is a metal ion which has lost an electron / electrons, the other is a non-metal ion that has gained an electron / electrons.

Ionic bonding is the **transfer of electron(s)** to form ions which are held together by electrostatic interaction.

Method

1. Work out how many electrons need to be gained or lost in order to get a full outer shell
2. Work out the charge that the ion will form
3. Draw one type of ion with crosses and draw the other with dots (don't forget the square brackets and charges)

Sodium Chloride example:



What is happening?

Sodium atom needs to lose 1 electron to give it a full outer shell. This will form a sodium ion with a charge of +1.

Chlorine atom has 7 electrons in its outer shell so need to gain 1 to form a chloride ion. This ion will have a charge of -1

In the reaction between sodium and chlorine one electron is transferred from sodium to chorine to form a sodium ion and a chlorine ion.

These ions have opposite charges (positive and negative) and so the ions are held together via electrostatic attraction

Tasks

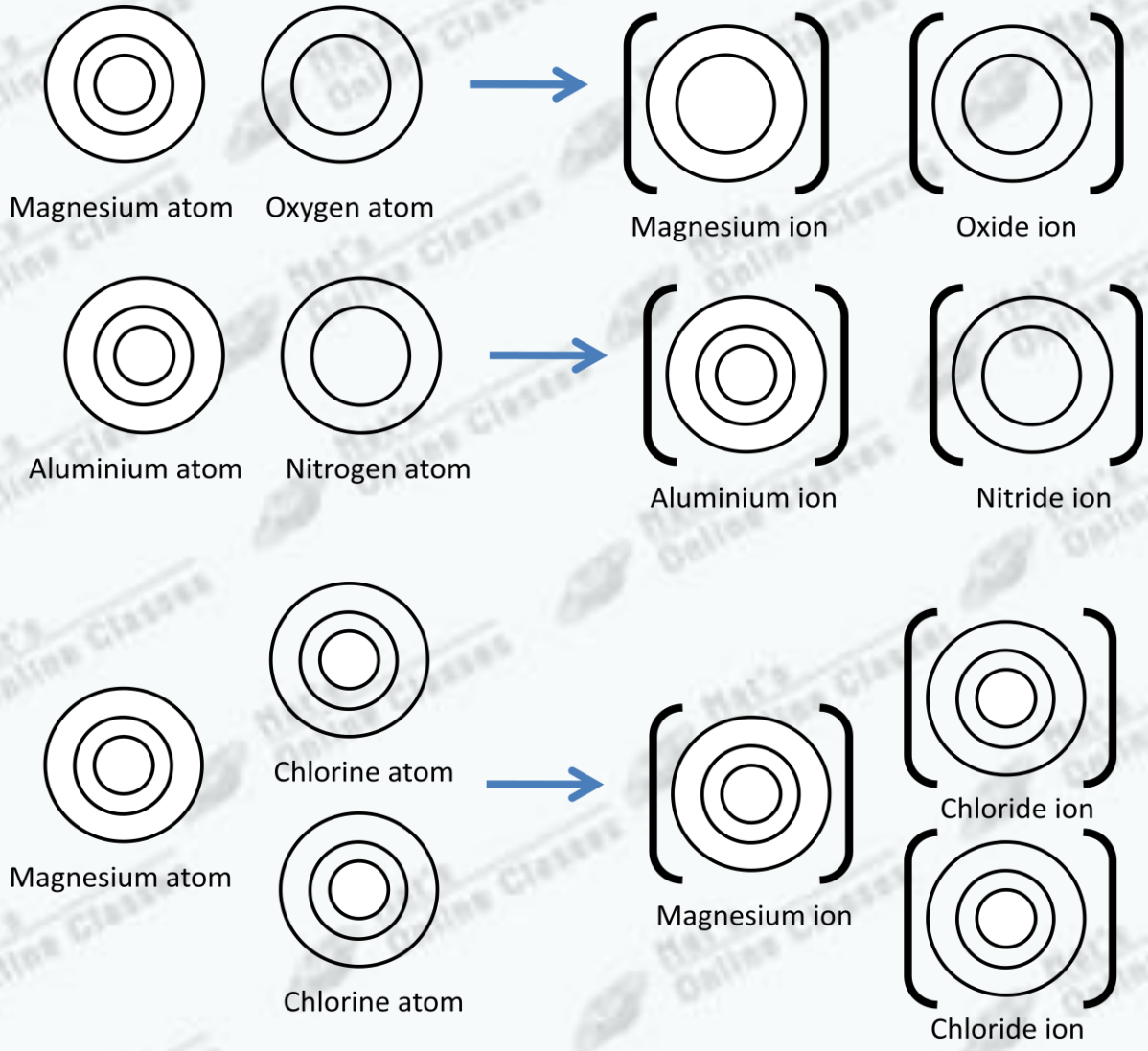
Ionic bonding occurs between _____ and ___ _____ atoms.

Electrons are _____ from the metal to the non metal forming

_____ and _____ ions. These ions are held together due to

_____ _____.

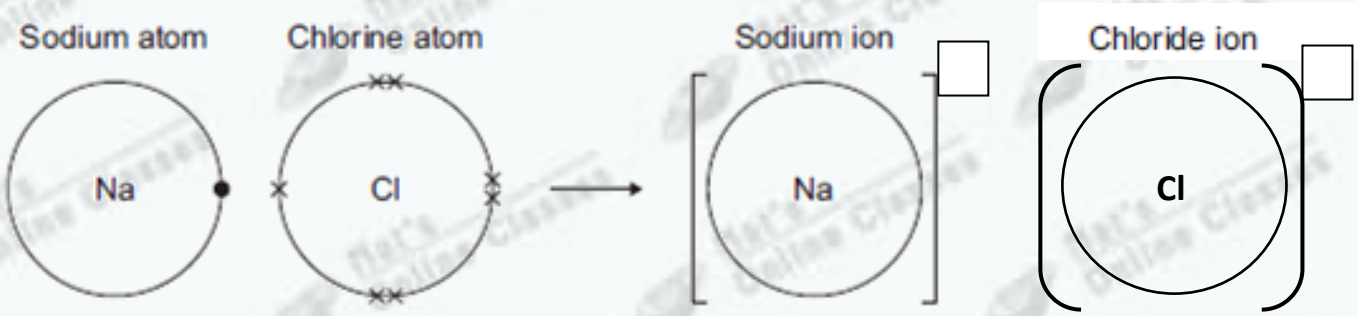
Complete the diagrams by adding electrons and charges



Exam questions – Ionic bonding

a. Complete the diagram below to show the bonding in sodium chloride. (3 marks)

Only the outer shells are shown and you need to add on electrons and charges.



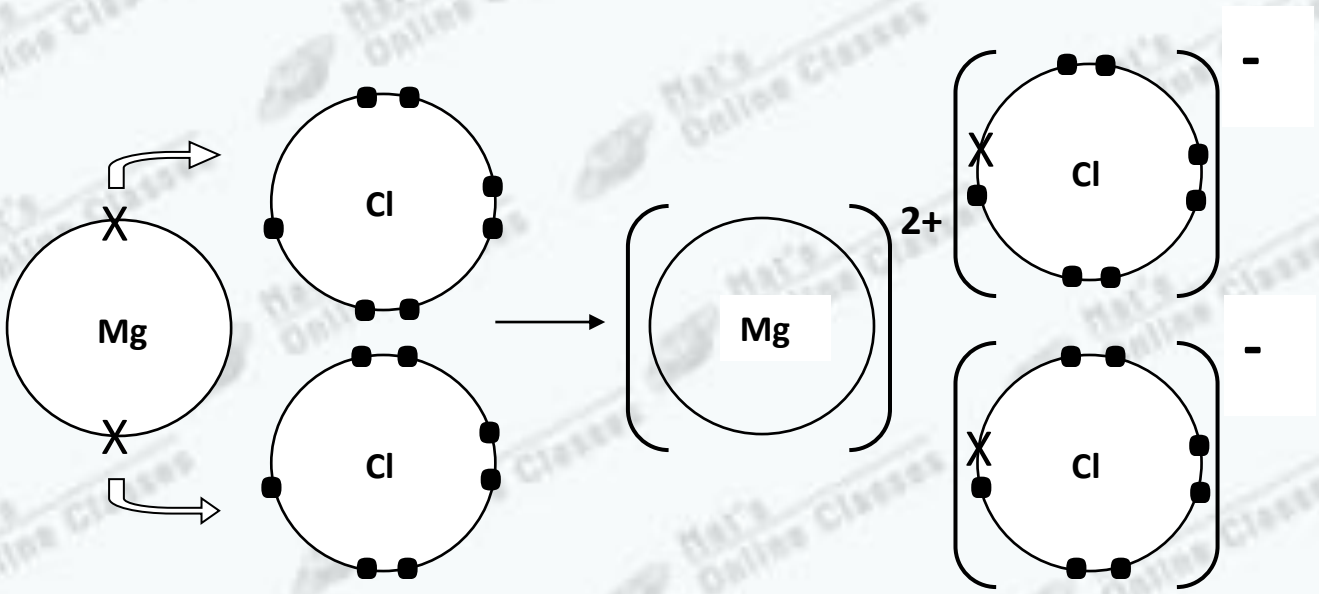
b. A sodium atom turns into a sodium ion by ..... (losing, gaining, sharing) an electron. (1 mark)

c. A sodium ion has ..... (a positive, a negative, no) charge. (1 mark)

d. Use the diagram below to help you answer the following question.

Describe as fully as you can what happens when magnesium reacts with chlorine to produce magnesium chloride. (4 marks)

To achieve top marks you should use the words atom, ion, electron and charge.



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.....(4 marks)

e. Explain as fully as you can what ion Calcium forms.

.....

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..... (2 marks)

f. Calcium chloride is an ion compound. What is the chemical formula for calcium chloride. ..... (1 mark)

g. Calcium nitride is an ionic compound that contains calcium and nitrogen ions. What is the chemical formula for calcium nitride?

..... (1 mark)

Total: /13

Mark scheme – Covalent bonding

Question	Answer	Notes	Marks	Grade
a	+ or 1+ in box above sodium and – or 1- in box about chlorine (1 mark) 0 electrons on sodium ion and 8 electrons on chlorine ion (1 mark) 7 crosses 1 dot on chlorine ion (1 mark)		3	A
b	Losing		1	C
c	Positive		1	C
d	Any 4 from: Mg atom loses 2 electrons Mg atom gains a 2+ charge Cl atoms gains 1 electron each Cl atom gains a 1– charge each Mg ion has a 2+ charge Mg ions has lost 2 electrons Cl ion has a 1- charge Cl ion has gained 1 electron Electrostatic attraction/interaction/force holds ions together	Max 3 marks if... • Atom or ion is omitted • Sharing, covalent or metallic used	4	A
e	Ca^{2+}/ 2+ charge / 2 positive charge (1 mark) 2 electrons lost from outer shell to form a full outer shell. (1 mark)	Or sensible answer	2	B
f	$CaCl_2$		1	A*
g	Ca_3N_2		1	A*

Exam Questions

Totals

Simple molecular substances: /6

Giant covalent substances: /9

Giant ionic substances: /8

Covalent bonding: /5

Ionic bonding: /13

Total: /41

Grade boundaries

E: 3 mark

D: 8 marks

C: 16 marks

B: 22 marks

A: 29 marks

A*: 35 marks

Grade: