C2 – Chemical bonds

Why is NaCl a solid at room temperature, but oxygen is a gas? NaCl = ionic, high MP due to strong **electrostatic** forces of attraction O_2 = small covalent, low MP due to weak **intermolecular** forces	What could you do to solid magnesium chloride to make it conduct electricity? Melt it or dissolve it (so **ions** are free to move)	Explain why the boiling point increases as you go down group 7. The **diatomic** molecules get bigger, so there are stronger **intermolecular** forces which require more energy to break.
Titanium chloride is a liquid at room temperature. Explain why you would **not** expect titanium chloride to be a liquid at room temperature. Titanium chloride is **ionic**. Ionic compounds are usually **solid at room temperature** because they have **strong electrostatic forces between ions**, so they have high MP.	Explain why metals conduct electricity. Metals are **giant ionic lattices** that are made up of **positive metal ions** surrounded by **delocalised electrons,** so electrons are able to **move through the metal**.	Why is steel stronger than pure iron? Steel is an alloy made up of **different types of atoms**. As the atoms are **different sizes**, the layers are **distorted** and atoms are **not able to slide over each other**.

C2 - Bonding, structure and the properties of matter

C1 - Atomic structure and the periodic table

C2 - Bonding, structure and the properties of matter

C3 - Quantitative chemistry

C4 - Chemical changes

C5 - Energy changes

C6 - The rate and extent of chemical change

C7 - Organic chemistry

C8 - Chemical analysis

C9 - Chemistry of the atmosphere

C10 - Using resources

Types of bonding

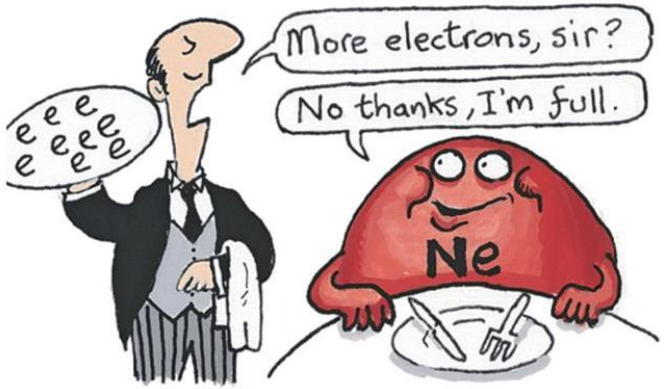
- Ionic bonding
- Covalent bonding
- Metallic bonding

Properties of bonding

- 3 states of matter
- Properties of ionic compounds
- Properties of covalent molecules (Small and Giant)
- Metals and alloys
- Graphene, fullerene and polymers
- Nanoparticles and orders of magnitude

TRIPLE **HIGHER**

To be stable, all atoms want **a full outer shell.**

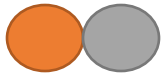


Atoms in **group 8/0** (like Neon) already have a full outer shell and therefore are **unreactive**.

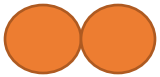
All other atoms in the periodic table are **unstable**, so they want to achieve a full outer shell.

To do this, they bond with other atoms by transferring or sharing electrons!

Ionic bonding Occurs between **metals** and **non-metals**



Covalent bonding Occurs between **non-metals** atoms



Metallic bonding Occurs between **metal** atoms

	Types of bonding		
	Ionic bonding	**Covalent bonding**	**Metallic bonding**
What atoms does this occur between?	Between metals and non metals	Between non-metals and non-metals	Between metal atoms
How are the electrons involved in bonding?	Electrons are **transferred** between atoms	Electrons are **shared** between atoms	Electrons are **delocalised** around atoms
What do these structures look like?	**Giant lattices** made up of **positive and negative ions** (attracted by **electrostatic** forces)	Can occur in **small covalent molecules** or **giant covalent structures**	**Giant structures** which can be **elements** (one type of metal) or **alloys** (mixture of metals)
Examples:	Sodium chloride Magnesium oxide	Carbon dioxide Water	Copper Steel

IONIC BONDING – TRANSFER

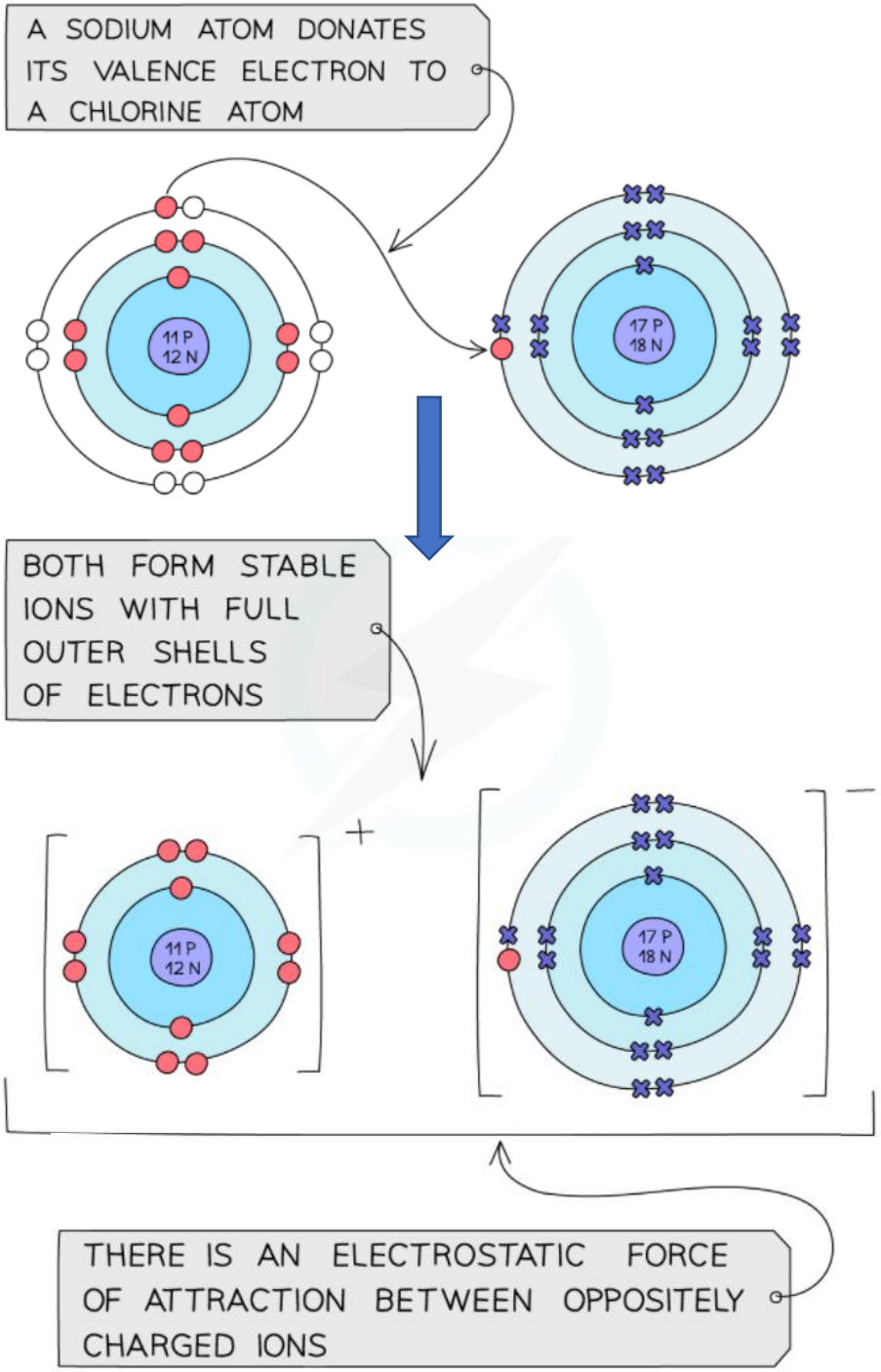
Ion = a particle that has a positive or negative charge due to the loss or gain of electrons.

Every atom in the same group will form an **ion** with the same charge:

+1 +2 ***LEARN THIS!!*** +3 -3 -2 -1

1 H Hydrogen 1																2 He Helium 4
2 Li Lithium 3	3 Be Beryllium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20
11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminum 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulfur 32	17 Cl Chlorine 35.5	18 H Argon 40
19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 64	30 Zn Zinc 65	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
37 Rb Rubidium 86	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Nb Niobium 96	43 Tc Technetium 98	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	48 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
55 Cs Cesium 133	56 Ba Barium 137	57 La Lanthanum 139	72 Hf Hafnium 179	73 Ta Tantalum 181	74 W Tungsten 184	75 Re Rhenium 186	76 Os Osmium 190	77 Ir Iridium 192	78 Pt Platinum 195	79 Au Gold 197	80 Hg Mercury 201	81 Ti Thallium 204	82 Pb Lead 207	83 Bi Bismuth 209	84 Po Polonium 210	85 At Astatine 210	86 Rn Radon 222
87 Fr Francium 223	88 Ra Radium 226	89 Ac Actinium 227	104 Unq Unilquadium 257	105 Unp Unilpentium 260	106 Unh Unilhexium 263	107 Uns Unilseptium 262	108 Uno Unilloctium 265	109 Une Unicenium 266									

2 He Helium 4 ← Proton number ← Symbol ← Name of element ← Relative atomic mass



Task: Draw the dot and cross diagrams for:

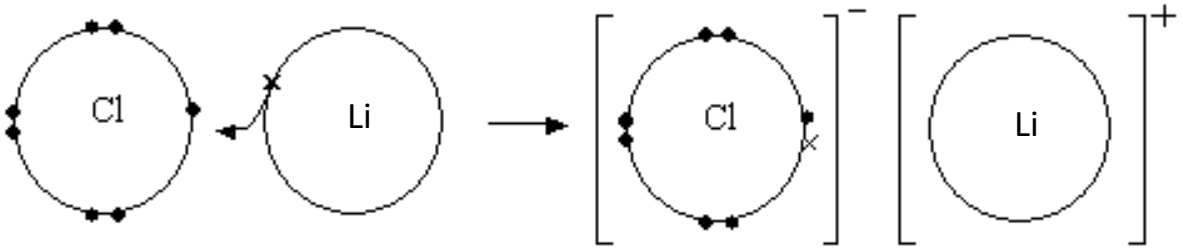
1. Li + Cl
2. K + F
3. Mg + O

Challenge:

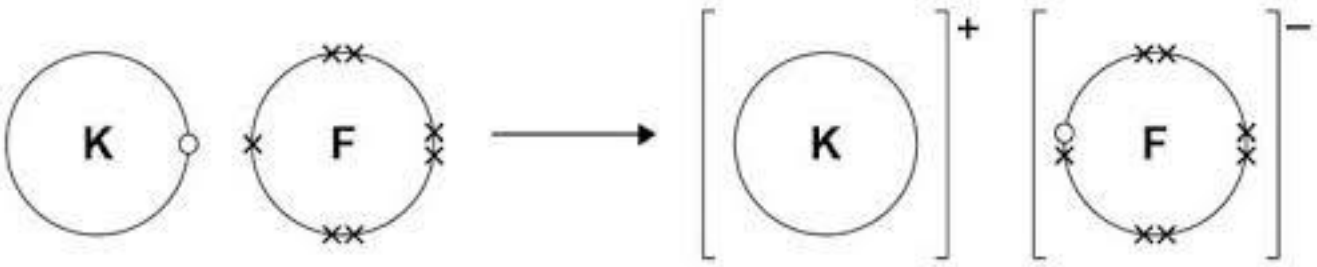
4. Mg + Cl
5. Na + O

You only need to draw the outer shell of electrons!

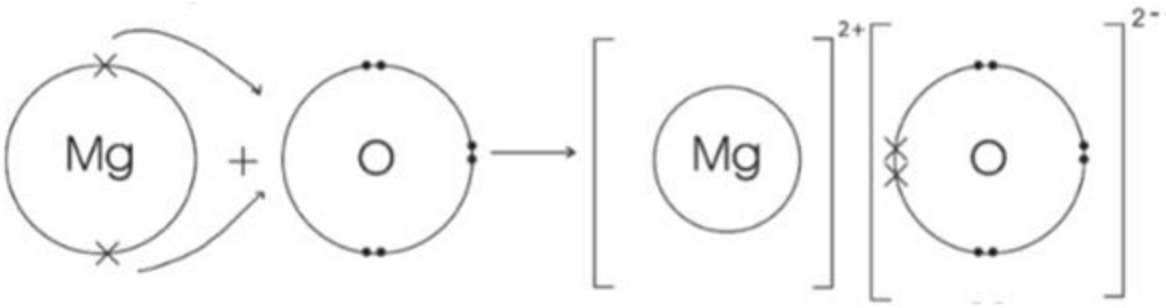
a) Li + Cl



b) K + F

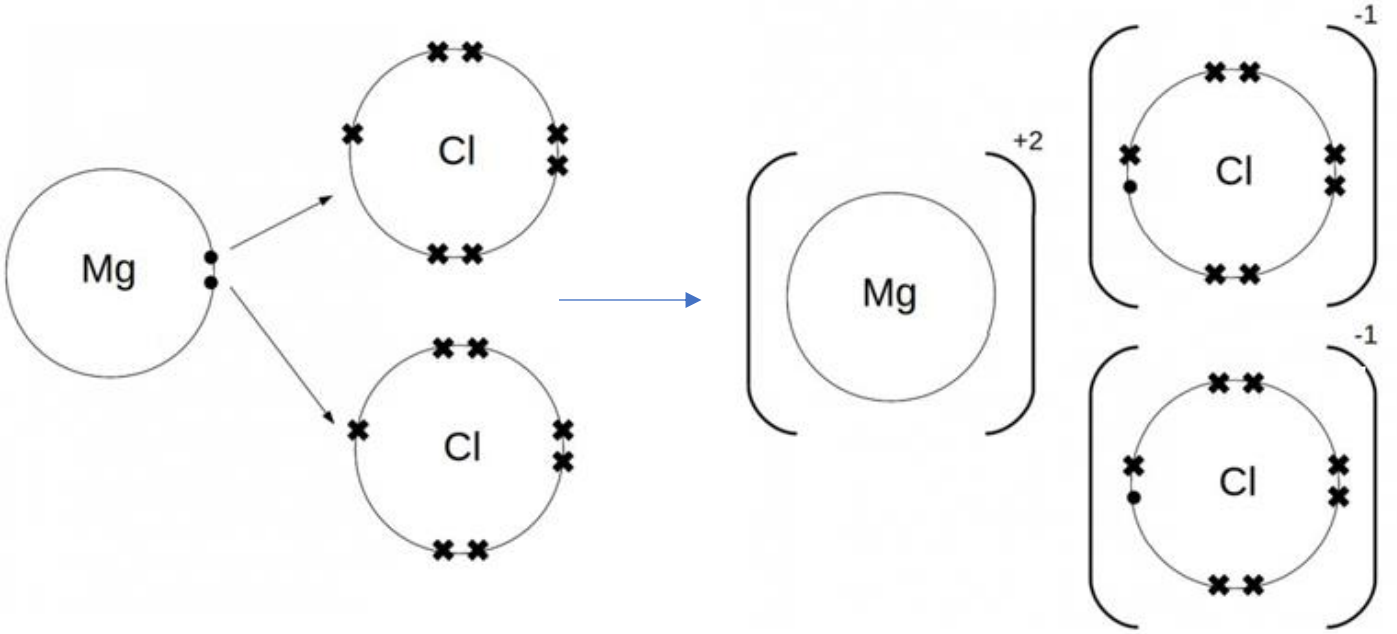


c) Mg + O

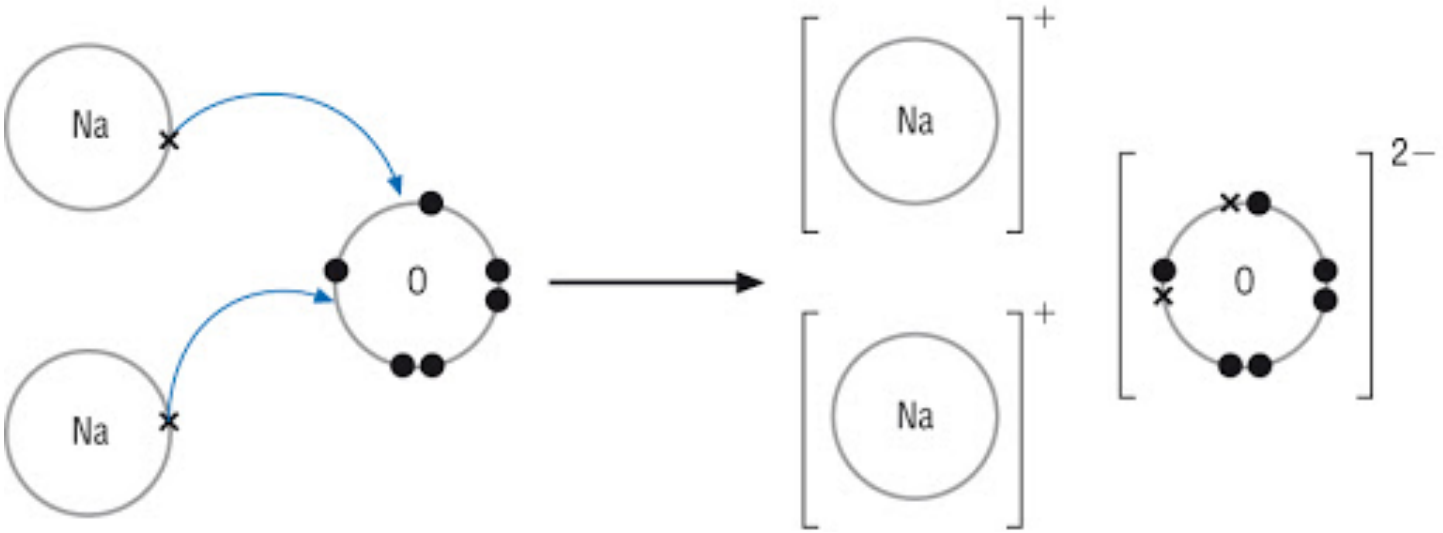


Challenge:

a) Mg + Cl



b) Na + O



Task: Predict the formula of each of the following compounds:

1. Na + N Na_3N *(sodium nitride)*
2. Ca + S CaS *(calcium sulphide)*
3. Al + Cl $AlCl_3$ *(aluminium chloride)*
4. Mg + N Mg_3N_2 *(magnesium nitride)*
5. Al + O Al_2O_3 *(aluminium oxide)*

Challenge – *Name the compounds! Remember:*

1. *The name of the metal comes first, the name of the non-metal comes second.*
2. *The ending of the non-metal changes to 'ide'.*

Empirical formula =
a chemical formula showing the simplest ratio of elements in a compound.

e.g. Sodium chloride has the empirical formula NaCl, which is one Na^+ ion and one Cl^- ion.

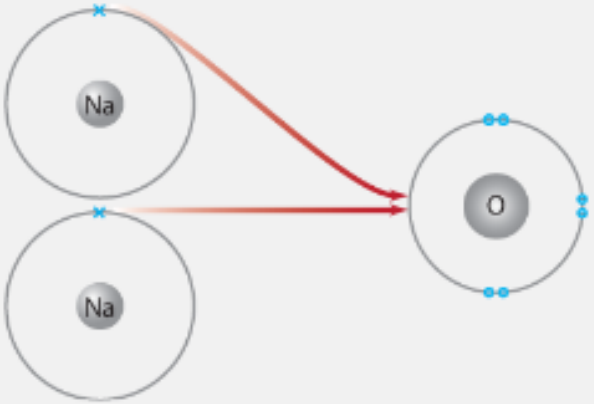
So, if you had 10 Na^+ ions and 10 Cl^- ions, the empirical formula would still be NaCl – this is the simplest ratio.

Challenge: What would the empirical formula if you had 10 Mg^{2+} ions and 20 Cl^- ions?

Empirical formula

Sodium only has one electron to lose, but oxygen needs to gain two electrons. Two sodium atoms are needed to bond with one oxygen atom.

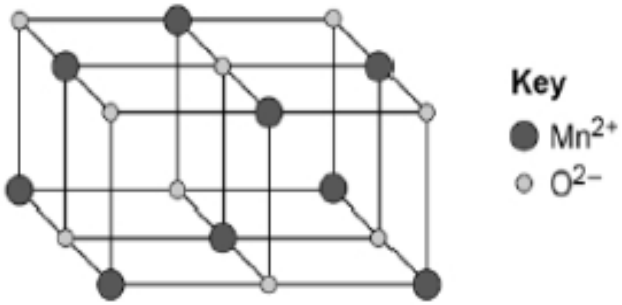
a. 2D electron transfer diagram of sodium oxide



Empirical formula = ? ***Na_2O***

Manganese oxide is an ionic compound.

Figure 3

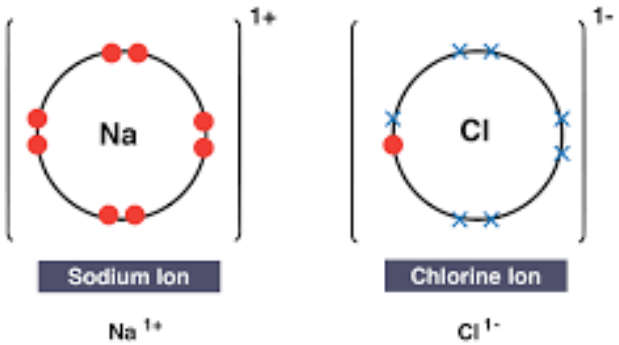


Determine the empirical formula of manganese oxide.

Empirical formula = ? ***MnO***

LO: Discuss the limitations of dot and cross diagrams.

Dot and cross

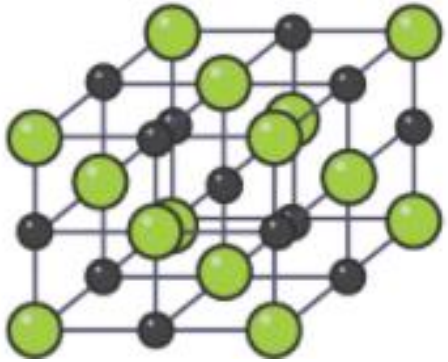


Shows how the bonds are formed.
Shows the **ratio** of atoms.

Not to scale.

Does not show the shape of the molecules.

3D structure

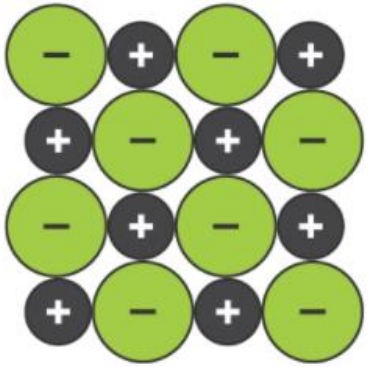


Shows the arrangement of the atoms in space.

Not to scale.

Does not show information about forces between atoms.

2D structure



Easiest to draw.
Shows the arrangement of atoms in one layer.

Not to scale.

Does not show how atoms in other layers are arranged.

Equations of ion formation (HT ONLY)

Ionic equations can be used to show whether atoms LOSE or GAIN electrons:

$Na \rightarrow Na^+ + e^-$ This shows that sodium has **lost** an electron to become **positive**

$Cl + e^- \rightarrow Cl^-$ This shows that chlorine has **gained** an electron to become **negative**.

Task: Write the equations for the ion formation in NaBr:

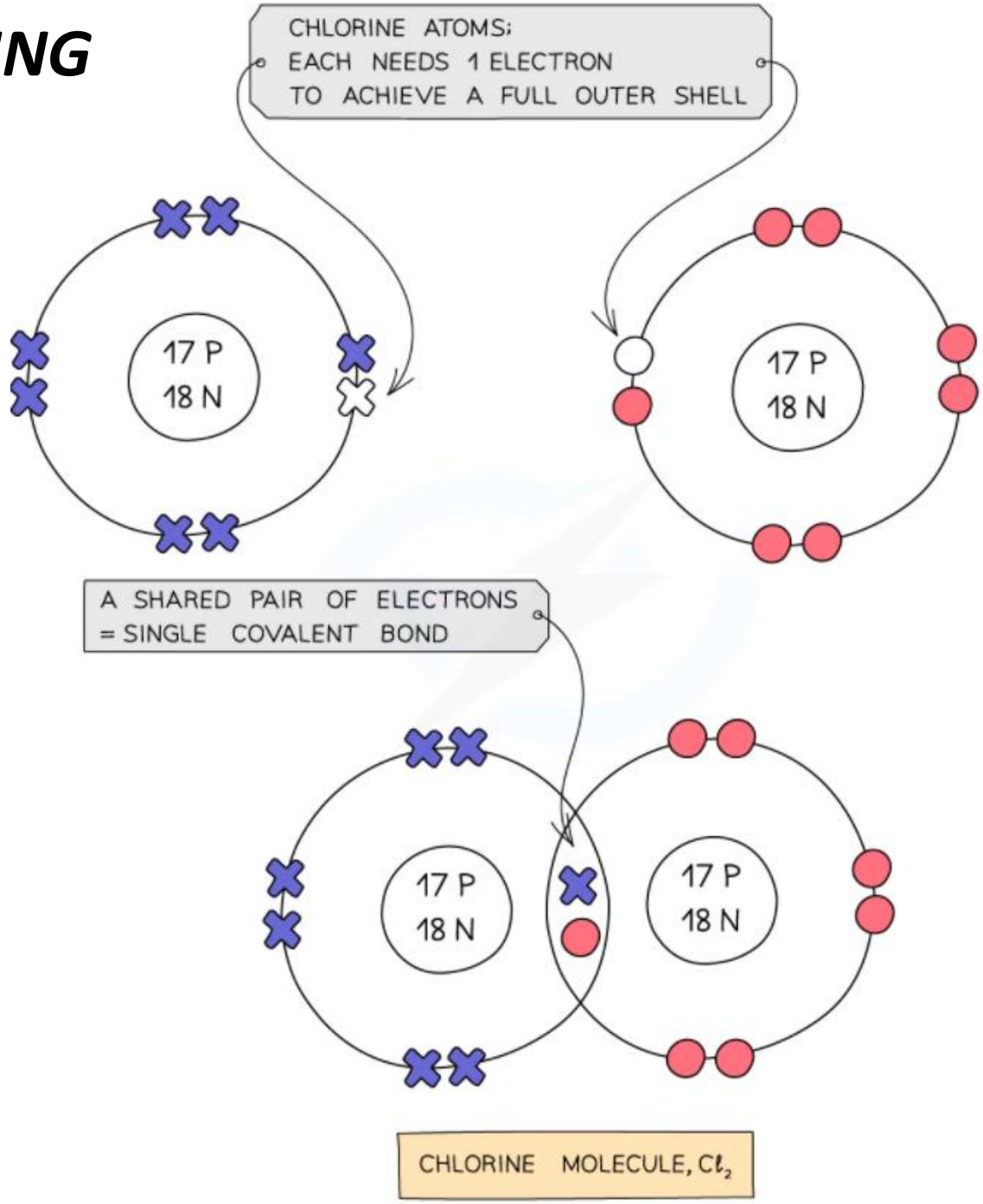
$Na \rightarrow Na^+ + e^-$

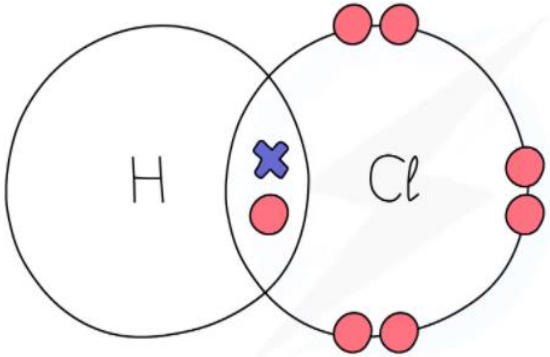
$Br + e^- \rightarrow Br^-$

The charges balance each other out to form NaBr

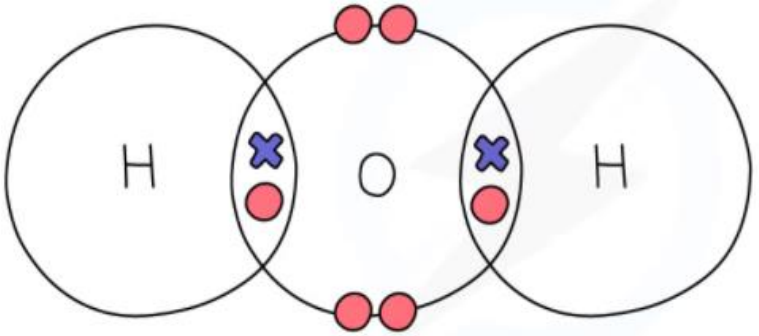
COVALENT BONDING

SHARING of electrons

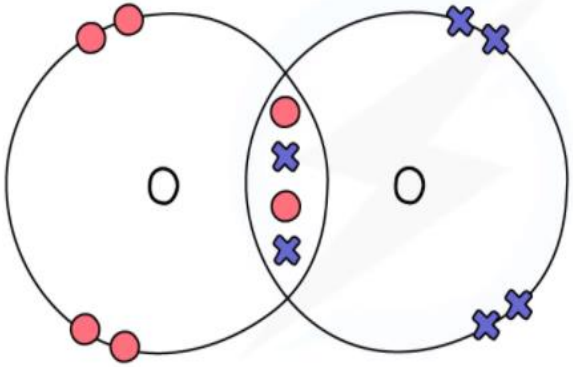




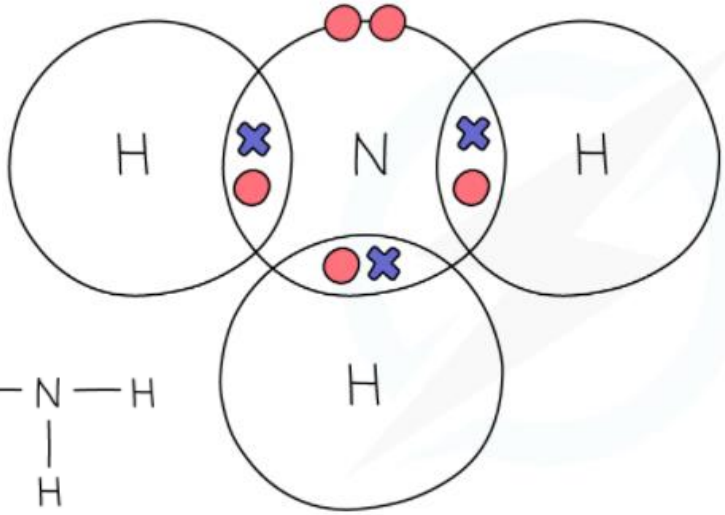
H — Cl

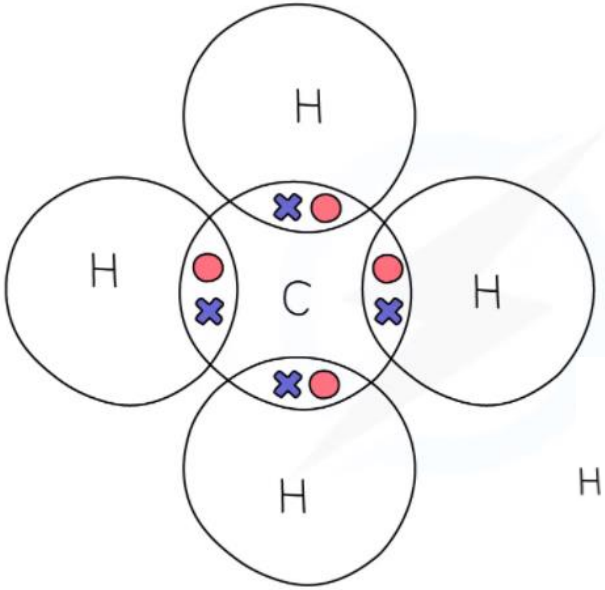


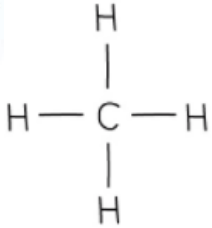
H — O — H

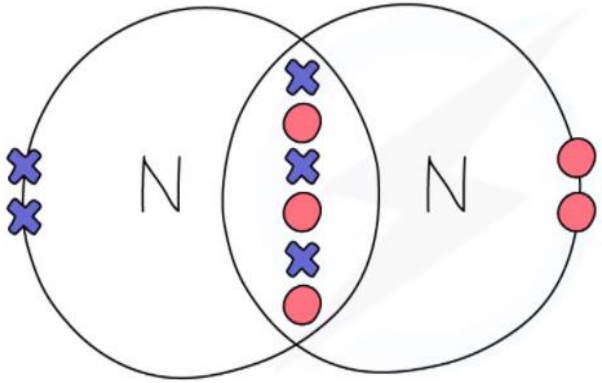


O ═ O







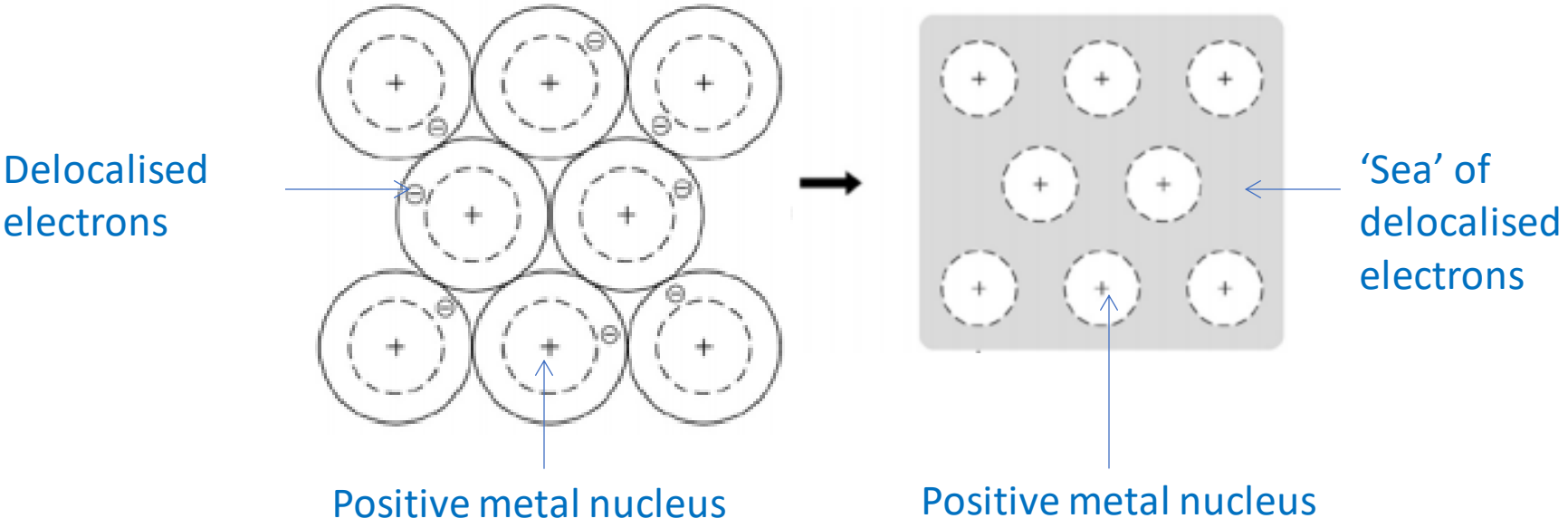


N ≡ N

METALLIC BONDING

DELOCALISED electrons

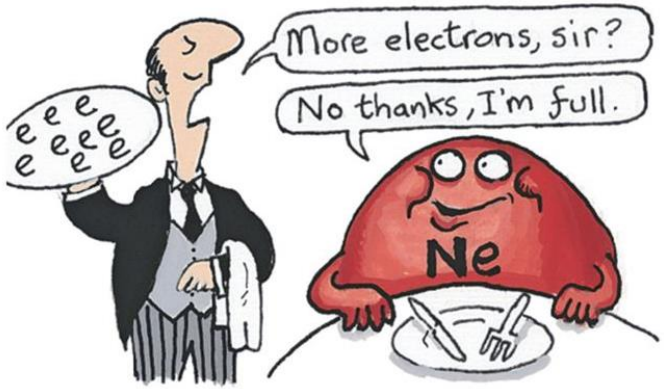
Metallic bonding occurs due to ***strong electrostatic forces of attraction*** *between the* ***positive metal nuclei*** *and the* ***negatively charged delocalised electrons.***



C2 – 4.2.1 – Chemical bonds

Why is NaCl a solid at room temperature, but oxygen is a gas?	What could you do to solid magnesium chloride to make it conduct electricity?	Explain why the boiling point increases as you go down group 7.
Titanium chloride is a liquid at room temperature. Explain why you would **not** expect titanium chloride to be a liquid at room temperature.	Explain why metals conduct electricity.	Why is steel stronger than pure iron?

To be stable, all atoms want **a full outer shell.**

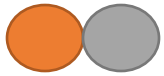


Atoms in **group 8/0** (like Neon) already have a full outer shell and therefore are **unreactive**.

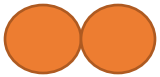
All other atoms in the periodic table are **unstable**, so they want to achieve a full outer shell.

To do this, they bond with other atoms by transferring or sharing electrons!

Ionic bonding Occurs between **metals** and **non-metals**



Covalent bonding Occurs between **non-metals** atoms



Metallic bonding Occurs between **metal** atoms

	Types of bonding		
	Ionic bonding	**Covalent bonding**	**Metallic bonding**
What atoms does this occur between?	Between metals and non metals	Between non-metals and non-metals	Between metal atoms
How are the electrons involved in bonding?	Electrons are **transferred** between atoms	Electrons are **shared** between atoms	Electrons are **delocalised** around atoms
What do these structures look like?	**Giant lattices** made up of **positive and negative ions** (attracted by **electrostatic** forces)	Can occur in **small covalent molecules** or **giant covalent structures**	**Giant structures** which can be **elements** (one type of metal) or **alloys** (mixture of metals)
Examples:	Sodium chloride Magnesium oxide	Carbon dioxide Water	Copper Steel

IONIC BONDING – TRANSFER

Ion = a particle that has a positive or negative charge due to the loss or gain of electrons.

Every atom in the same group will form an **ion** with the same charge:

+1 +2 ***LEARN THIS!!*** +3 -3 -2 -1

1 H Hydrogen 1																2 He Helium 4
2 Li Lithium 3	3 Be Beryllium 9											5 B Boron 11	6 C Carbon 12	7 N Nitrogen 14	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20
11 Na Sodium 23	12 Mg Magnesium 24											13 Al Aluminum 27	14 Si Silicon 28	15 P Phosphorus 31	16 S Sulfur 32	17 Cl Chlorine 35.5	18 H Argon 40
19 K Potassium 39	20 Ca Calcium 40	21 Sc Scandium 45	22 Ti Titanium 48	23 V Vanadium 51	24 Cr Chromium 52	25 Mn Manganese 55	26 Fe Iron 56	27 Co Cobalt 59	28 Ni Nickel 59	29 Cu Copper 64	30 Zn Zinc 65	31 Ga Gallium 70	32 Ge Germanium 73	33 As Arsenic 75	34 Se Selenium 79	35 Br Bromine 80	36 Kr Krypton 84
37 Rb Rubidium 86	38 Sr Strontium 88	39 Y Yttrium 89	40 Zr Zirconium 91	41 Nb Niobium 93	42 Nb Niobium 96	43 Tc Technetium 98	44 Ru Ruthenium 101	45 Rh Rhodium 103	46 Pd Palladium 106	47 Ag Silver 108	48 Cd Cadmium 112	48 In Indium 115	50 Sn Tin 119	51 Sb Antimony 122	52 Te Tellurium 128	53 I Iodine 127	54 Xe Xenon 131
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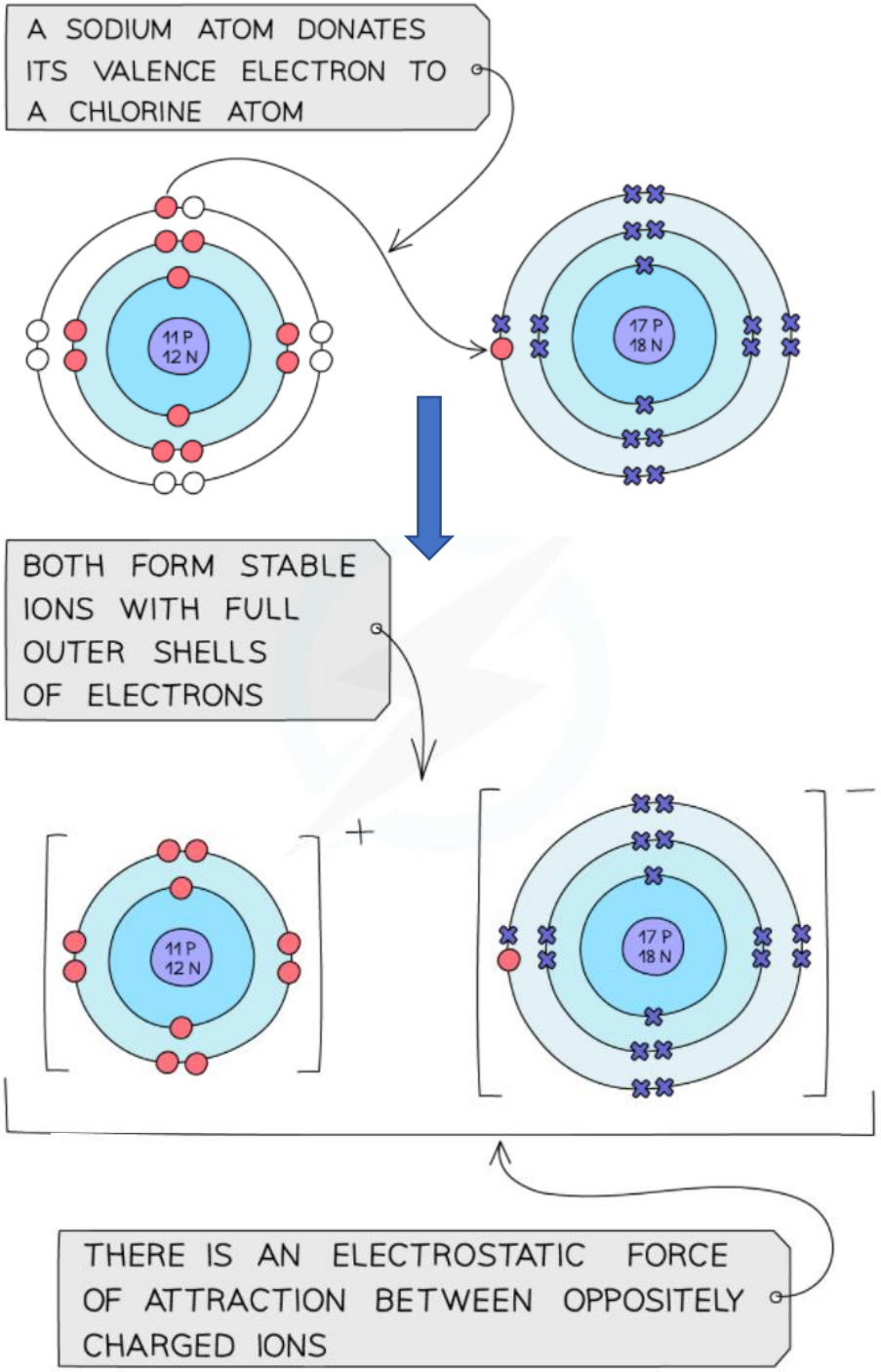
2 He Helium 4 ← Proton number ← Symbol ← Name of element ← Relative atomic mass



Task: Draw the dot and cross diagrams for:

1. Li + Cl
2. K + F
3. Mg + O

Challenge:

4. Mg + Cl
5. Na + O

You only need to draw the outer shell of electrons!

a) Li + Cl

b) K + F

c) Mg + O

Challenge:

a) Mg + Cl

b) Na + O

Task: Predict the formula of each of the following compounds:

1. Na + N
2. Ca + S
3. Al + Cl
4. Mg + N
5. Al + O

Challenge – *Name the compounds! Remember:*

1. *The name of the metal comes first, the name of the non-metal comes second.*
2. *The ending of the non-metal changes to 'ide'.*

Empirical formula =
a chemical formula showing the simplest ratio of elements in a compound.

e.g. Sodium chloride has the empirical formula NaCl, which is one Na^+ ion and one Cl^- ion.

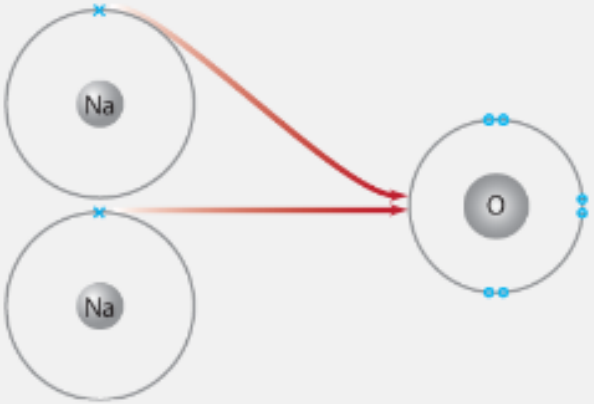
So, if you had 10 Na^+ ions and 10 Cl^- ions, the empirical formula would still be NaCl – this is the simplest ratio.

Challenge: What would the empirical formula if you had 10 Mg^{2+} ions and 20 Cl^- ions?

Empirical formula

Sodium only has one electron to lose, but oxygen needs to gain two electrons. Two sodium atoms are needed to bond with one oxygen atom.

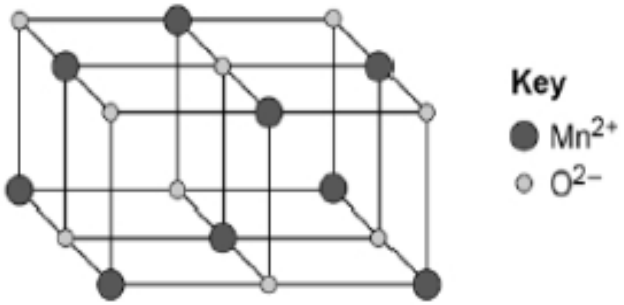
a. 2D electron transfer diagram of sodium oxide



Empirical formula =

Manganese oxide is an ionic compound.

Figure 3

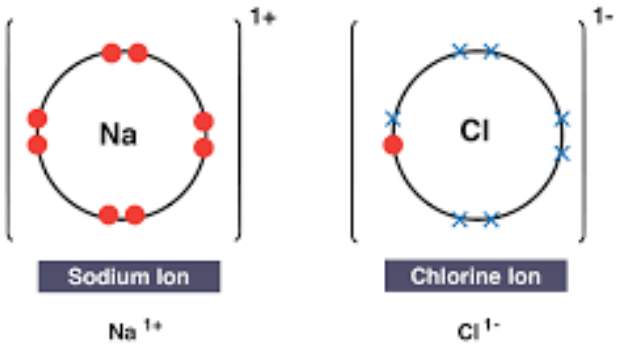


Determine the empirical formula of manganese oxide.

Empirical formula =

LO: Discuss the limitations of dot and cross diagrams.

Dot and cross

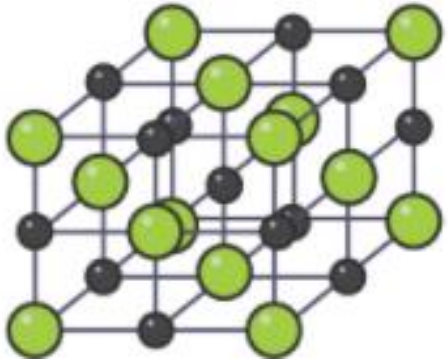


Shows how the bonds are formed.
Shows the **ratio** of atoms.

Not to scale.

Does not show the shape of the molecules.

3D structure

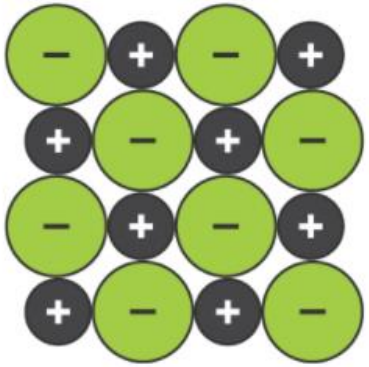


Shows the arrangement of the atoms in space.

Not to scale.

Does not show information about forces between atoms.

2D structure



Easiest to draw.
Shows the arrangement of atoms in one layer.

Not to scale.

Does not show how atoms in other layers are arranged.

Equations of ion formation (HT ONLY)

Ionic equations can be used to show whether atoms LOSE or GAIN electrons:

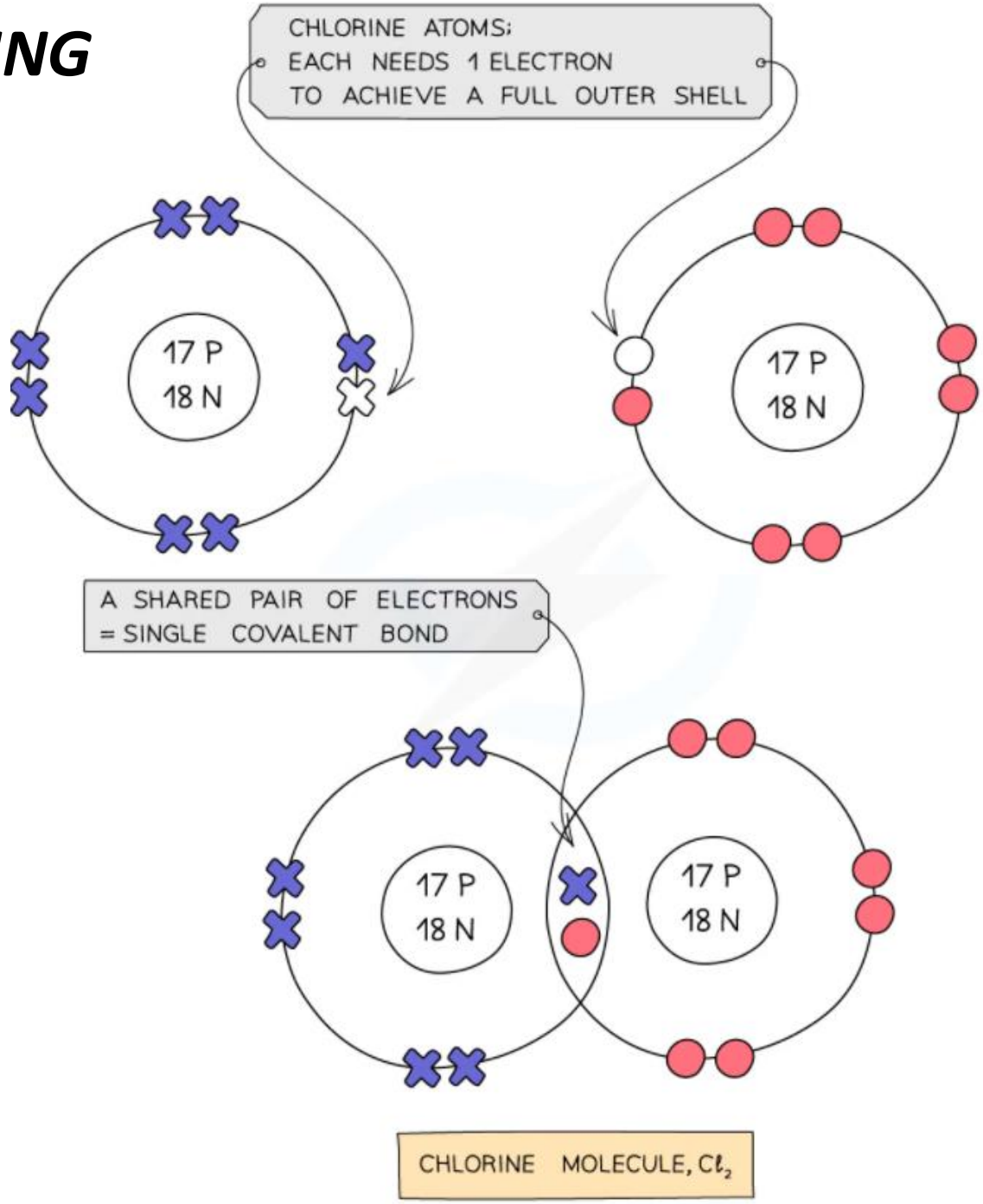
$Na \rightarrow Na^+ + e^-$ This shows that sodium has **lost** an electron to become **positive**

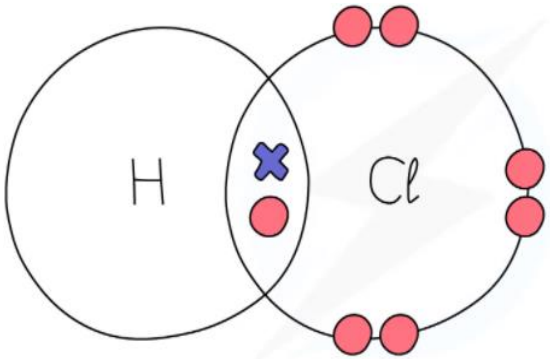
$Cl + e^- \rightarrow Cl^-$ This shows that chlorine has **gained** an electron to become **negative**.

Task: Write the equations for the ion formation in NaBr:

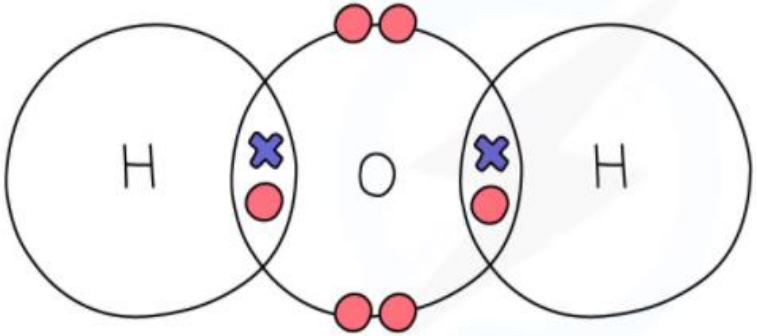
COVALENT BONDING

SHARING of electrons

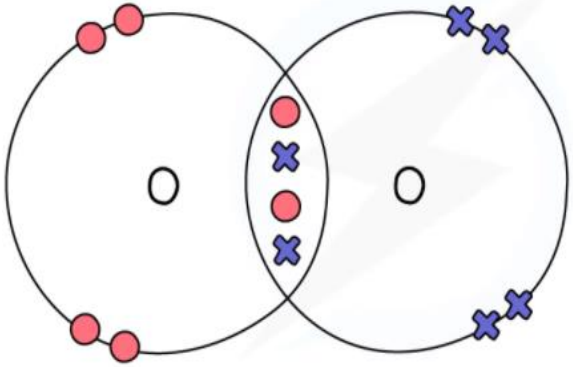




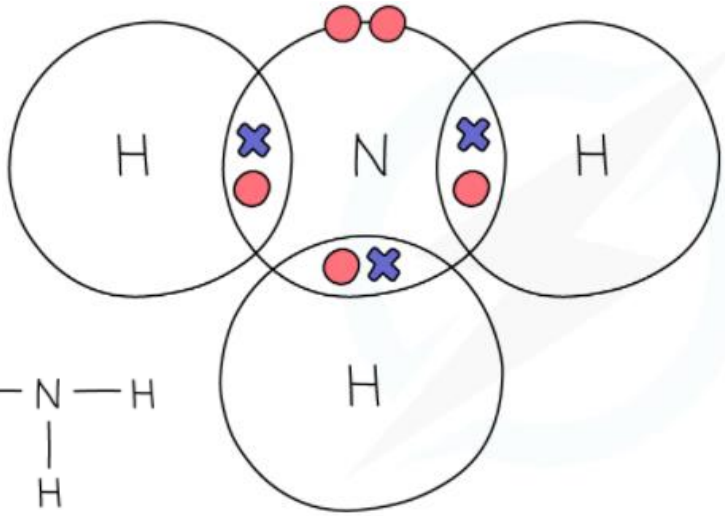
H — Cl

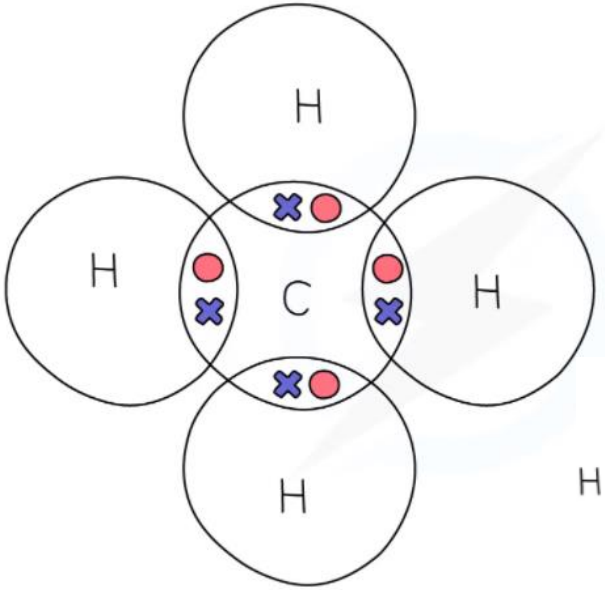


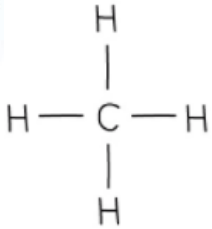
H — O — H

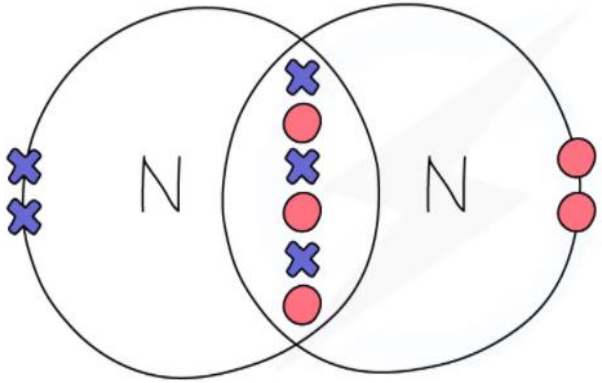


O ═ O







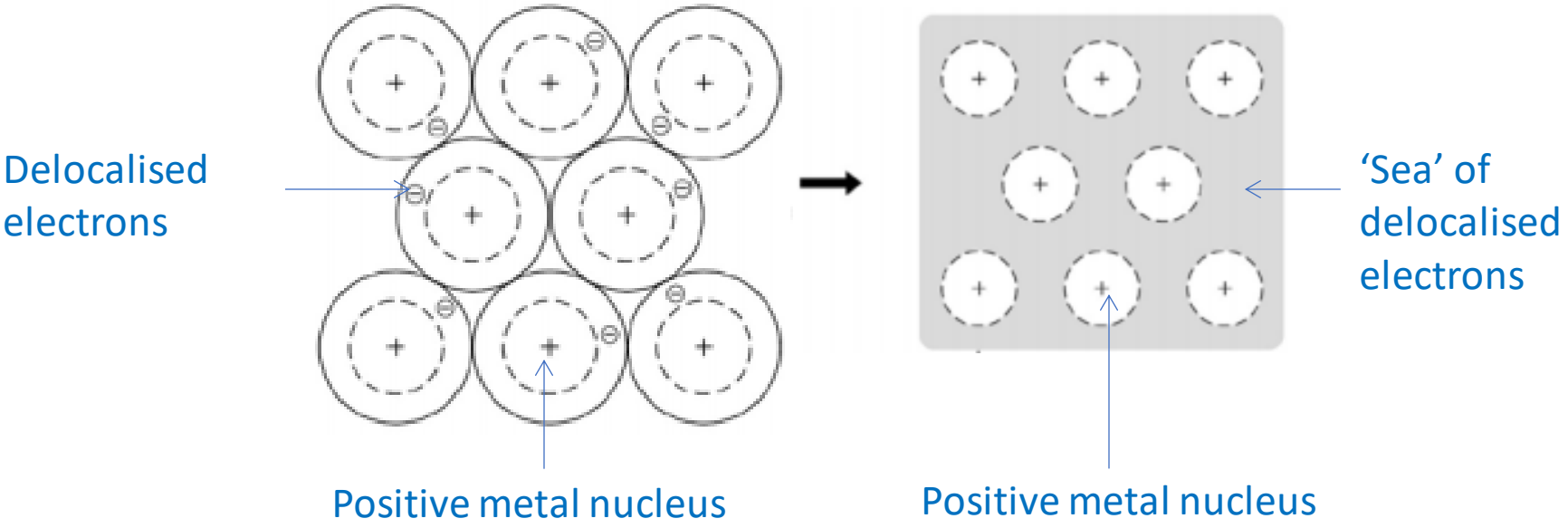


N ≡ N

METALLIC BONDING

DELOCALISED electrons

Metallic bonding occurs due to ***strong electrostatic forces of attraction*** *between the* ***positive metal nuclei*** *and the* ***negatively charged delocalised electrons.***



Title – C2 – Properties of substances

Monday, 25 September 2023

State two properties of metals. Shiny, hard, malleable, ductile, high melting point, good conductors.	Why did Mendeleev leave gaps in his periodic table? For undiscovered elements (that were later discovered)	Describe and explain the reactivity of noble gases. They are unreactive, because they have a full outer shell of electrons.
What would the charge be on a sodium ion? Explain why. Na +1, because sodium would lose one electron.	Describe the reactivity as you go down group 1 metals. Alkali metals get more reactive as you go down the group.	Complete the word equation and explain why the reaction has taken place: *sodium bromide + chlorine ->* *sodium bromide + chlorine -> sodium chloride + bromine* Chlorine is more reactive so has displaced bromine.

One electron is transferred from sodium to chlorine. This forms a positive sodium ion and a negative chloride ion.

C2 - Bonding, structure and the properties of matter

C1 - Atomic structure and the periodic table

C2 - Bonding, structure and the properties of matter

C3 - Quantitative chemistry

C4 - Chemical changes

C5 - Energy changes

C6 - The rate and extent of chemical change

C7 - Organic chemistry

C8 - Chemical analysis

C9 - Chemistry of the atmosphere

C10 - Using resources

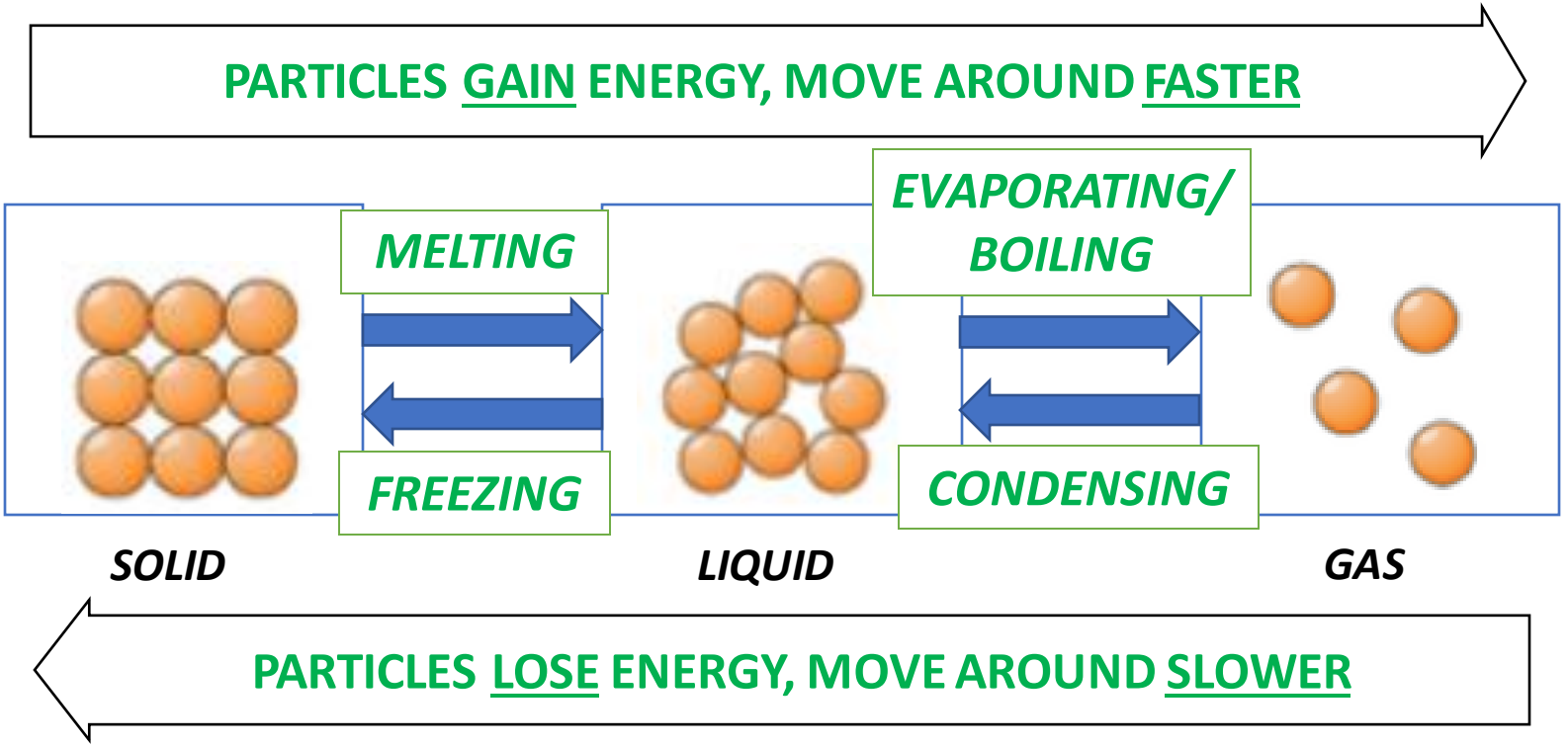
Types of bonding

- Ionic bonding
- Covalent bonding
- Metallic bonding

Properties of bonding

- 3 states of matter
- Properties of ionic compounds
- Properties of covalent molecules (Small and Giant)
- Metals and alloys
- Graphene, fullerene and polymers
- Nanoparticles and orders of magnitude

TRIPLE **HIGHER**



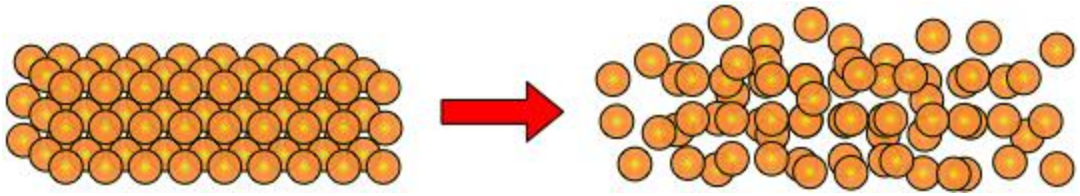
1. Complete the diagram below to show particle diagrams for each state of matter and the name of each process happening at A, B, C and D.
2. Describe what happens to the particles in terms of energy and movement when a solid turns into a liquid.

- In a **solid**, particles can only **vibrate** and are held in **fixed positions**.
- When heated, the particles gain **thermal energy**.
- The thermal energy is converted to **kinetic energy**, so particles **move faster**.
- Particles eventually gain enough energy to **break free from their fixed positions**. They start to **move past each other** and become **a liquid**.

LET'S RECAP...

Particle theory

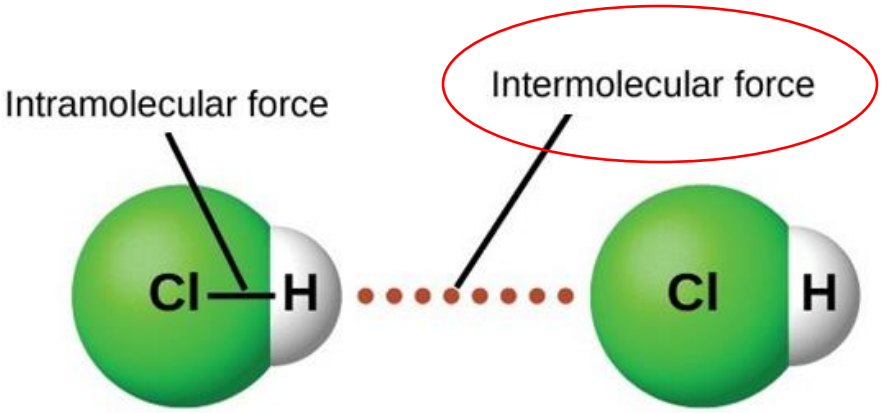
When a substance melts, the particles **gain kinetic energy** and they **break free from the regular arrangement** of atoms (solid) and move further apart (liquid):



SOLID ***LIQUID***

When this happens, the ***intermolecular*** forces are broken.

The stronger the forces the higher the melting point and boiling point.



Strong intermolecular forces

↓

Lots of energy needed to separate molecules

↓

High boiling points and melting points

e.g.

Weak intermolecular forces

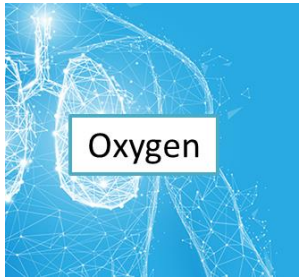
↓

Not a lot of energy needed to separate molecules

↓

Low boiling points and melting points

e.g.



Challenge: *Explain why gold is a solid at room temperature, but water is a liquid.*

Hint: Think about the melting points of both substances.

Extra challenge: *Explain why gold is a solid at room temperature, but water is a liquid.*
Hint: Think about the melting points of both substances.

- Gold has **strong** intermolecular forces, so it has a **high** melting point (1064°C).
- The melting point is **much higher** than room temperature (~25°C).
- At room temperature, there is **not enough thermal energy** to melt the gold by breaking the strong intermolecular forces.

- Water has **weak** intermolecular forces, so it has a **low** melting point (0°C).
- The melting point is **lower than** room temperature (~25°C).
- At room temperature, there **is enough thermal energy** to melt ice by breaking the strong intermolecular forces.
- **Solid ice turns into liquid water.**

These are known as '***state symbols***'. They are only used in symbol equations, not word equations!

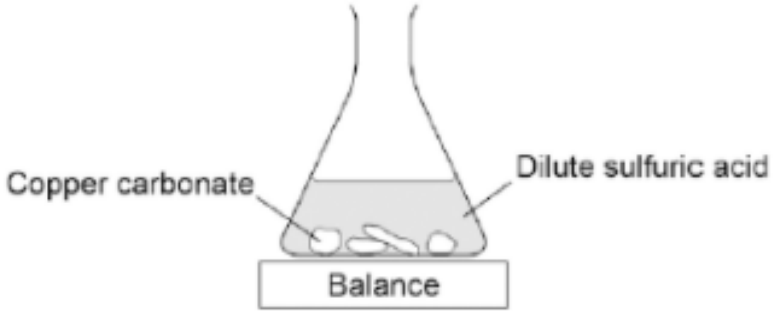
(s) ***(l)*** ***(aq)*** ***(g)***

The only substance that will ever be a pure liquid is water!

*All acids and alkalis will **always** be aqueous e.g. HCl (aq)*

A student investigated the reaction of copper carbonate with dilute sulfuric acid.

The student used the apparatus shown in the figure below.



Complete the state symbols in the equation.

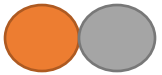
$CuCO_3$ (***(s)***) + H_2SO_4 (aq) → $CuSO_4$ (aq) + H_2O (***(l)***) + CO_2 (g)

Challenge – *Why did the mass of the balance decrease?*

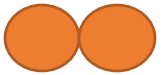
There are ***three types of bonding*** that occurs between atoms in compounds.

The type of bonding depends on what atoms are involved…

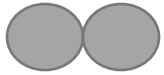
Ionic bonding Occurs between **metals** and **non-metals**



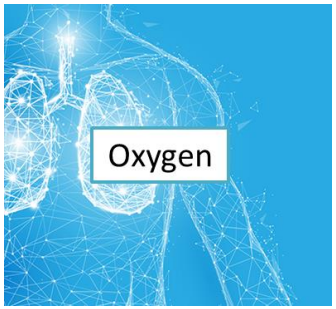
Covalent bonding Occurs between **non-metals** atoms



Metallic bonding Occurs between **metal** atoms



LOWEST MELTING POINT → HIGHEST MELTING POINT



-218.8 °C	0 °C	660.3 °C	801 °C	1,064 °C

What atoms are in each of these substances?

O_2	H_2O	Al	NaCl	Au
2 oxygen atoms	2 hydrogen atoms and 1 oxygen atom	1 aluminium atom	1 sodium atom and 1 chlorine atom	1 gold atom

So, what type of bonding occurs in these substances?

Covalent (non-metals)	*Covalent (non-metals)*	*Metallic (metals)*	*Ionic (metal and non metal)*	*Metallic (metals)*

DECODE IT NOW

Word:

Property (tier 2)

Define it:

A quality or characteristic of an object.

Write a sentence of your own that uses the word **property.**

Write your own definition of the word **property.**

Which subjects or topics will this word be relevant to?

Digging Deeper:

In science, a 'property' of a material refers to the whole object, not the individual atoms!

Link it (similar words):

Quality, attribute, feature, trait, mark, hallmark

Deconstruct it (Root word):

The word **property** is derived from an Anglo-Norman French variant of the Latin proprietas, meaning 'one's own, particular'.

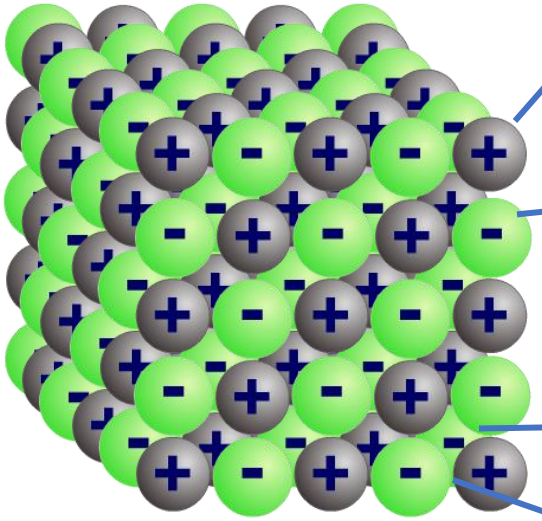
Use it:

The properties of a solid are that they are rigid, have a fixed shape and a fixed volume.

Ionic compounds

Key definition:

Ionic compounds are **GIANT IONIC LATTICES** made up of millions of **POSITIVE AND NEGATIVE IONS.** These oppositely charged ions are joined by **STRONG ELECTROSTATIC FORCES OF ATTRACTION** (ionic bonds).



Positive ion

Negative ion

Strong ionic bonds
(electrostatic attraction between oppositely charged ions)

How does this structure affect the properties of ionic compounds?

DECODE IT NOW

Word:
Electrostatic (tier 3)

Define it:
Relating to positive or negative electric charges (on ions).

Write a sentence of your own that uses the word **electrostatic.**

Write your own definition of the word **electrostatic.**

Which subjects or topics will this word be relevant to?

Link it (similar words):

Charged, positive, negative

Digging Deeper:

Ionic bonds are formed through electrostatic attraction between positive and negative ions.

Use it

Ionic bonds are very strong due to strong electrostatic forces of attraction.

Deconstruct it (Root word):

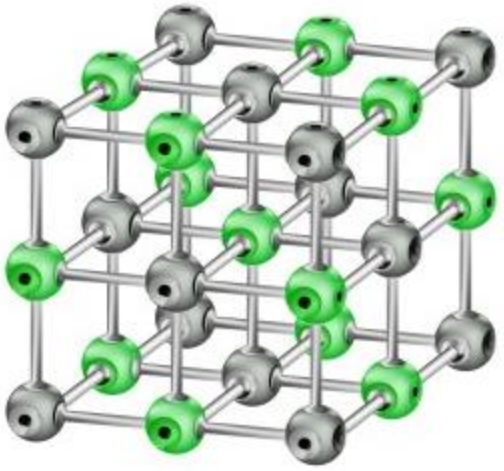
From '**electro-**' meaning *relating to electricity* and '**static**' meaning *not moving.*

Physical Properties of Ionic Compounds

1. Solid at room temperature, so they have **high melting points and boiling points.**

Why?

Strong electrostatic forces of attraction between oppositely charged ions
(ionic bonding)

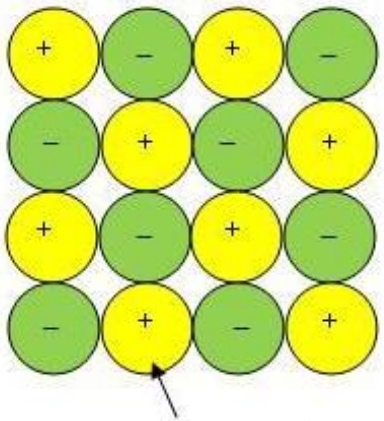


Physical Properties of Ionic Compounds

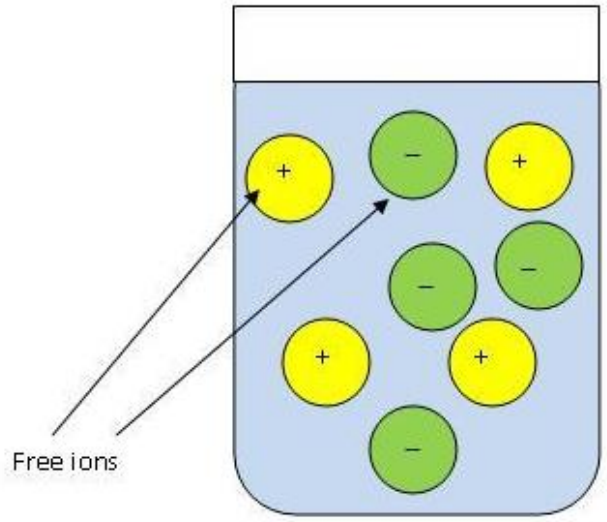
2. **Conduct electricity when molten or dissolved**
(NOT WHEN SOLID)

Why?

When molten or dissolved, ions are ***free to move and carry electrical charge***



X



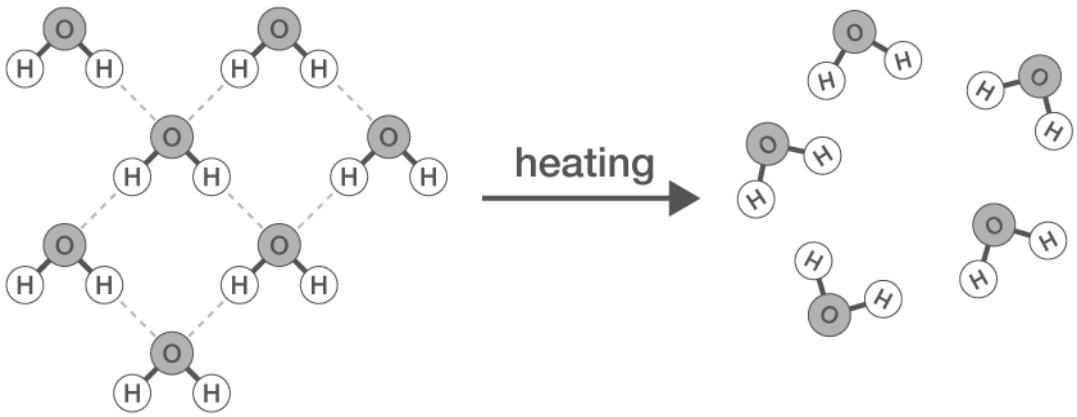
✓

Properties of simple covalent compounds

1. Gases at room temperature, so they have **low melting points and boiling points.**

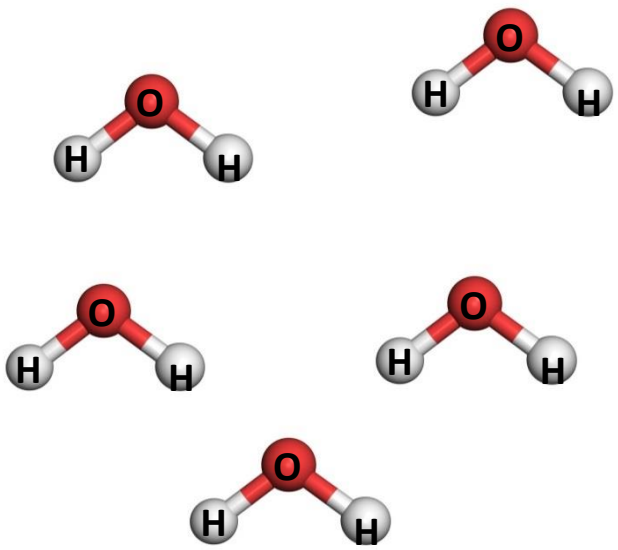
Why?

Weak intermolecular forces between molecules, do not require a lot of energy to break *(NOT weak covalent bonds!)*



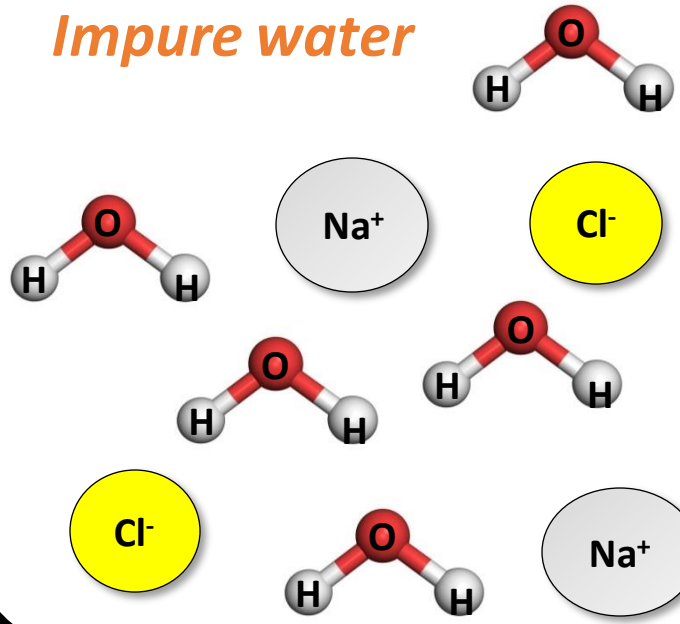
Can water compounds conduct electricity?

Pure water



No free moving charged particles.

Impure water



Free moving ions, which can carry electrical charge.

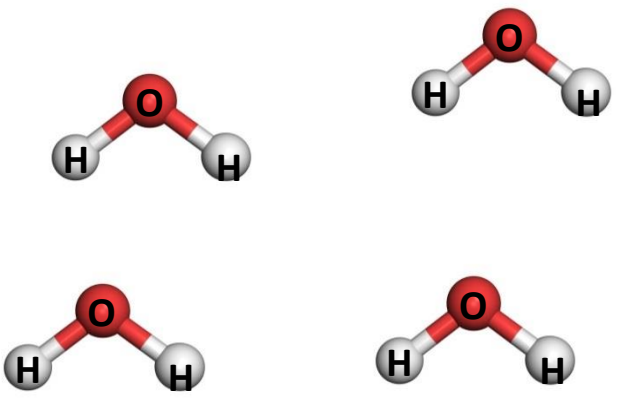
Properties of simple covalent compounds

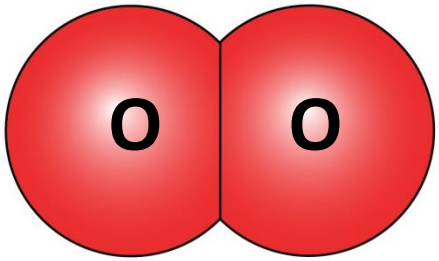
2. **Cannot conduct electricity**

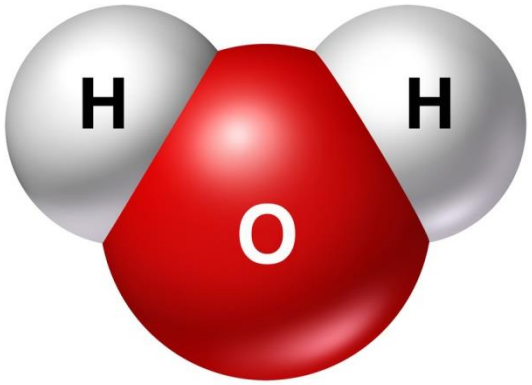
Why?

No free moving ions to carry electrical charge.

Pure water







Gas (g)

Smaller molecule

Weaker intermolecular forces

Lower MP/BP

Liquid (l)

Bigger molecule

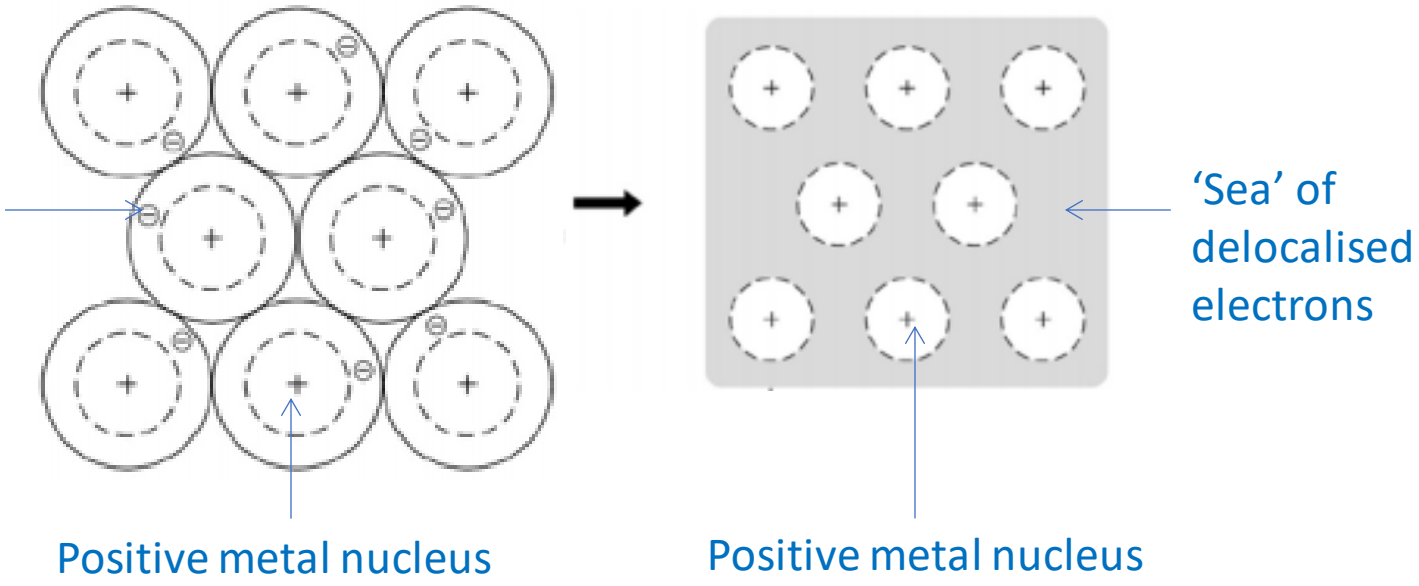
Stronger intermolecular forces

Higher MP/BP

Metallic structures

Key definition:

Metallic bonding occurs due to ***strong electrostatic forces of attraction*** *between the* ***positive metal nuclei*** *and the* ***negatively charged delocalised electrons.***



DECODE IT NOW

Word:
Delocalised
(tier 3)

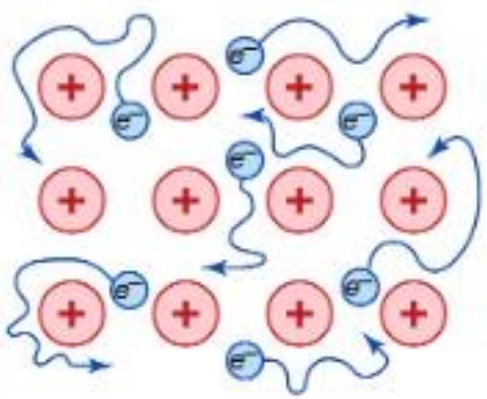
Define it:
When an electric charge is spread among several atoms that are bonded together.

Write a sentence of your own that uses the word **delocalised.**

Write your own definition of the word **delocalised.**

Which subjects or topics will this word be relevant to?

Digging Deeper:
Local means '*relating or restricted to a particular area*' . In everyday life, **delocalise** means to detach or remove something from it's particular location (the opposite of local!). In metals, this means that the electrons that are usually attached to one atom, can move between all of the atoms.



Link it (similar words):

Shared, spread, between

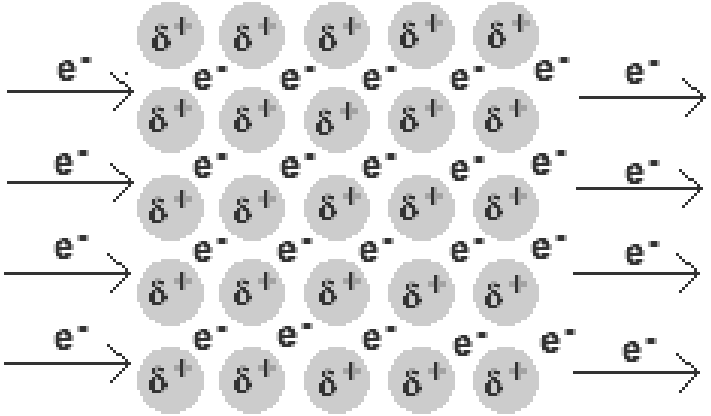
Use it
Delocalised electrons are able to move in between atoms in metals.

Properties of metals

1. They are ***good conductors of heat and electricity***

WHY?

Delocalised electrons allow the heat energy/ electrical charge to be transferred through the structure.

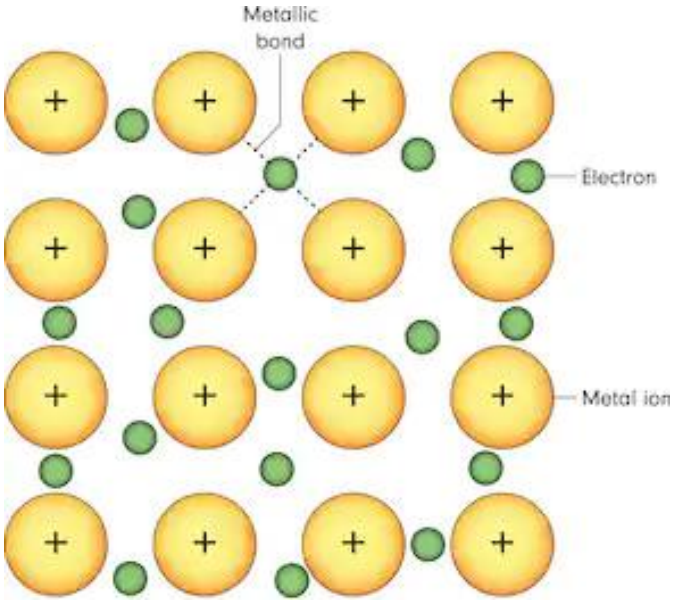


Properties of metals

3. They have ***high melting points and boiling points***

WHY?

Strong electrostatic forces of attraction between positive nuclei and delocalised electrons



Properties of metals

*4. They are **malleable** and **ductile***

Can be easily hammered into shape without breaking

Gold is a very malleable metal!

Can be drawn out into wires

Copper Metal

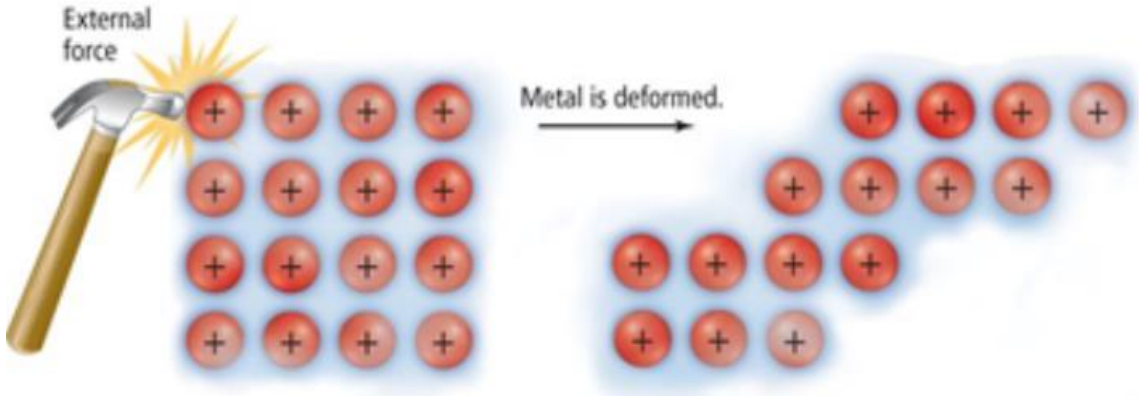
Copper Wire

Copper is a very ductile metal!

Properties of metals

*4. They are **malleable** and **ductile***

WHY?



Metals consist of **layers of atoms** that can **slide over one another** when the metal is bent, hammered or pressed.

DECODE IT NOW

Word:
Alloy (tier 3)

Define it:
Mixtures of metals that have been designed to make **useful materials**.

Write a sentence of your own that uses the word **alloy.**

Write your own definition of the word **alloy.**

Which subjects or topics will this word be relevant to?

Digging Deeper:

In the automotive industry, alloy wheels are wheels that are made from an alloy of aluminium or magnesium.

Link it (similar words):

Mixture, blend, combination

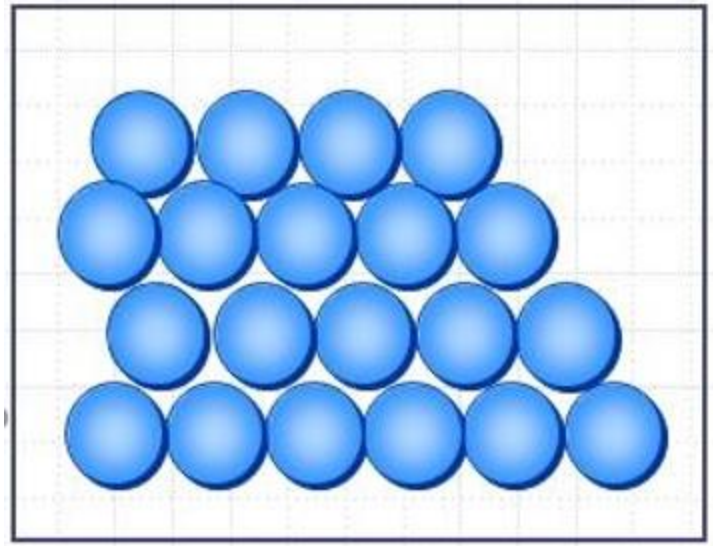
Use it

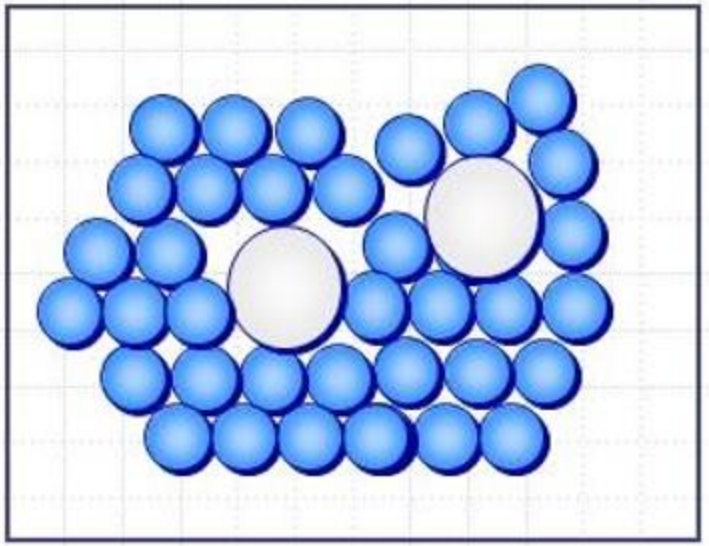
Steel is an alloy of carbon and iron, which makes the metal very hard.

Deconstruct it (Root word):

From French word ***'aloyer'*** which means '***combine'.***

Alloys are usually **stronger** than pure metals.



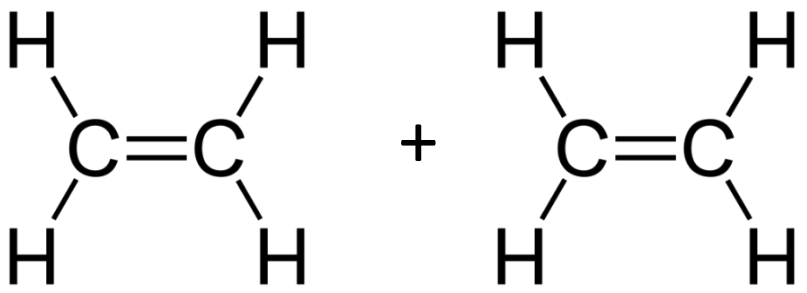


Pure metal:
Atoms all the same size in a regular arrangement, so atoms can easily slide over each other.

Alloys:
Different sized atoms disrupts the rows and means that the atoms **can not slide easily over each** other making it stronger.

Polymers

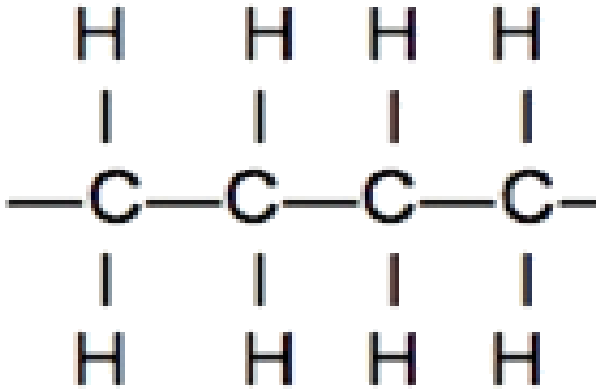
In polymerisation reactions many small molecules called **monomers** join together to form a very large molecules called **polymers**.



Monomers

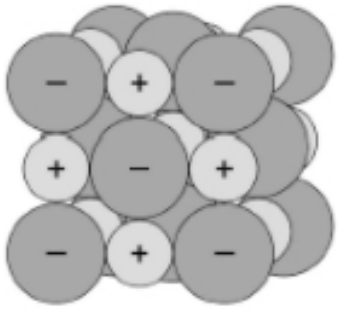
Polymers are **giant covalent compounds** made up of **HYDROCARBONS** (formed from hydrogen and carbon atoms only).

The covalent bonds are very **strong**, so polymers have very **high melting points**.



Polymers

The diagram below shows part of the structure of sodium chloride (NaCl).



Sodium chloride

(d) What holds the particles together in sodium chloride?

Use the diagram above.

Tick (✓) **one** box.

Electrostatic attractions ☐

Intermolecular forces ☐

Metallic bonds ☐

Exam practice (foundation)

(e) Solid sodium chloride does not conduct electricity.

Give **two** ways in which sodium chloride can be made to conduct electricity.

1. _____

_____

2. _____

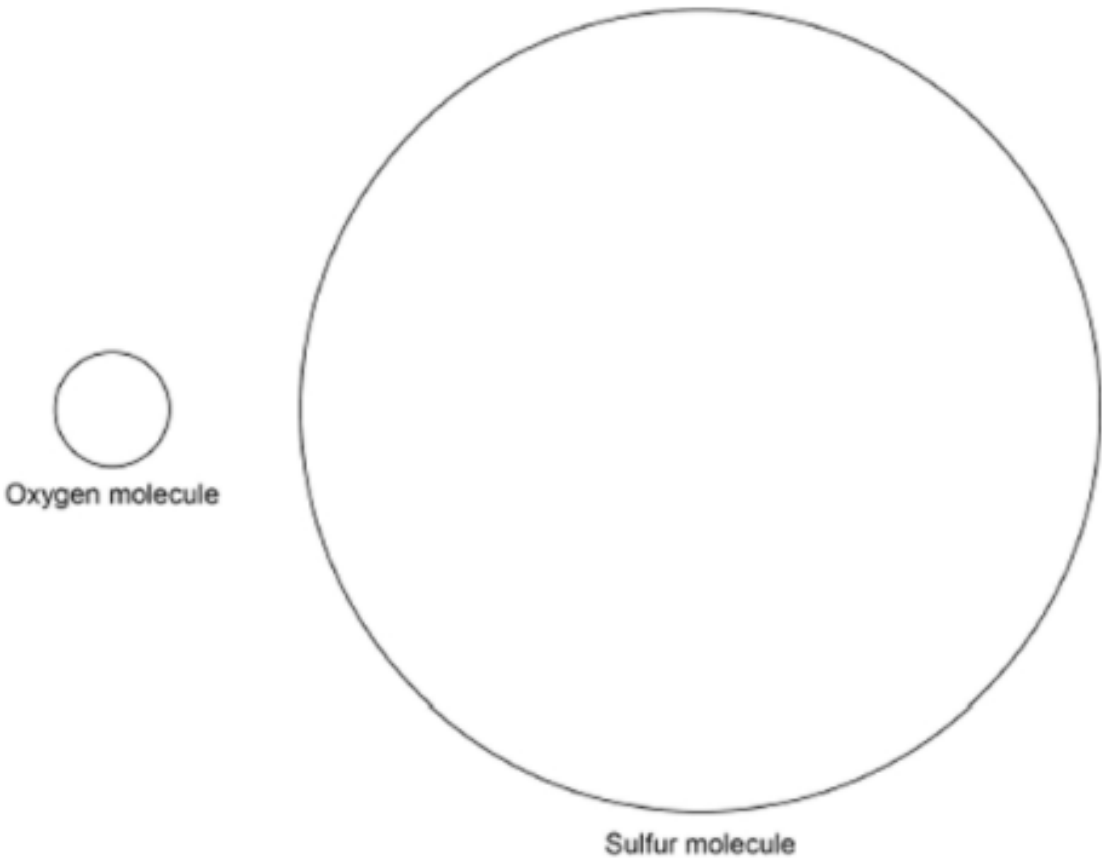
_____

(2)

Exam practice (foundation)

(f) **Figure 3** shows the relative sizes of an oxygen molecule and a sulfur molecule.

Figure 3



How does the boiling point of sulfur compare with the boiling point of oxygen?

Complete the sentences.

The boiling point of sulfur is _____ the boiling point of oxygen.

This is because in sulfur the intermolecular forces are _____

than the intermolecular forces in oxygen.

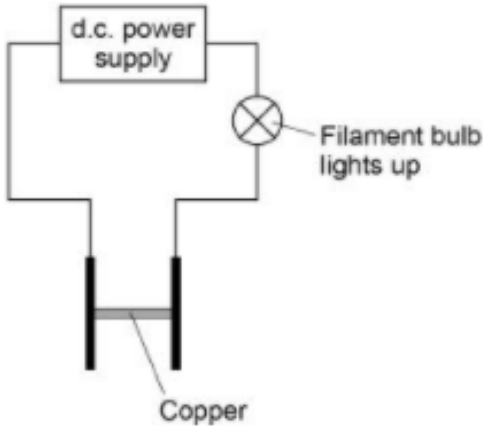
(2)

Exam practice (foundation)

An electric current is passed through copper.

Figure 5 shows the apparatus used.

Figure 5



(f) Complete the sentence.

Choose the answer from the box.

gas	liquid	solid	solution

Figure 5 shows that copper conducts electricity as a _____ .

(1)

(g) Complete the sentence.

Choose the answer from the box.

atoms	electrons	ions	molecules

Copper conducts electricity because of the movement of delocalised _____ .

(1)

Exam practice (foundation)

Give **two** physical properties of metals.

1. _____

_____

2. _____

_____

(2)

Complete the sentence.

Choose the answer from the box.

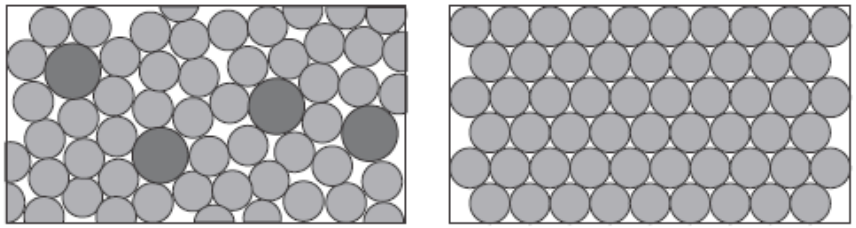
attract	bond	slide	vibrate

Metals can be stretched into wires

because the layers of atoms can _____ .

(1)

Alloy **Pure zinc**



Use **Figure 2** to explain why the alloy is harder than pure zinc.

_____

_____

_____

(2)

Potassium fluoride is an ionic compound.

Explain why ionic compounds have high melting points.

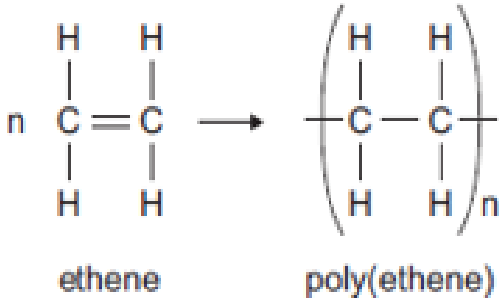
Use the following words in your answer:

- attraction
- energy
- ions.

Exam practice (foundation)

(4)

(ii) Poly(ethene) is produced from ethene in a polymerisation reaction. The equation for the reaction is:



Exam practice (foundation)

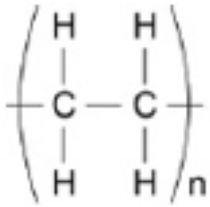
Which **two** statements about the polymerisation reaction to form poly(ethene) are correct? Tick (✔) **two** boxes.

	Tick (✔)
A polymer is a small molecule.	
Many ethene molecules join together.	✔
Poly(ethene) contains a double bond.	
The monomer is ethene.	✔

(2)

Figure 2 shows part of a large hydrocarbon molecule.

Figure 2



Exam practice (foundation)

(c) Which **two** elements are in all hydrocarbons?

1. __ Carbon _____

2. __ Hydrogen _____

(2)

(d) Complete the sentence. Choose the answer from the box.

an atom	**a metal**	**a polymer**	**a salt**

The large molecule represented in **Figure 2** is _____ A polymer _____

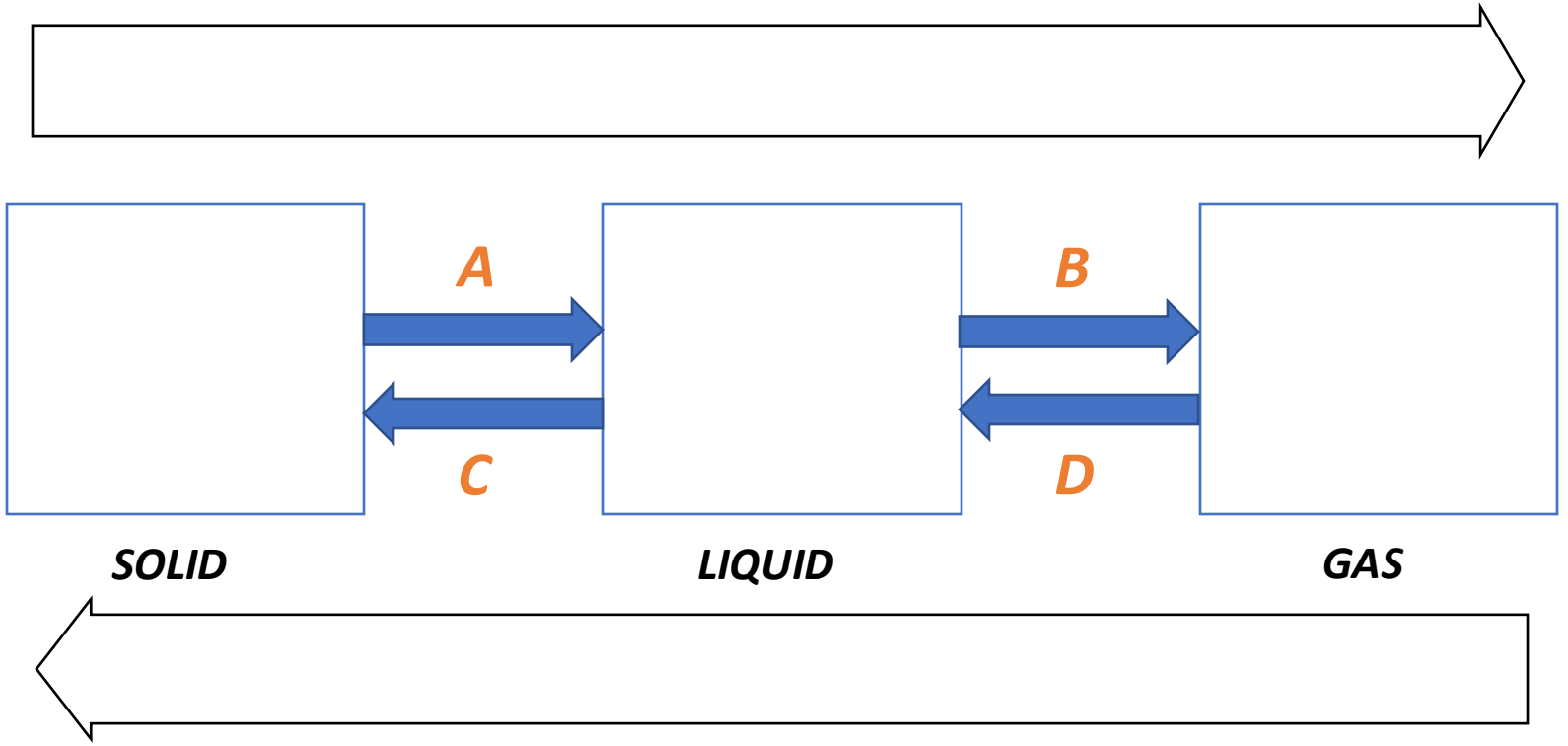
(1)

TO PRINT

Title – C2 – Properties of substances

State two properties of metals.	Why did Mendeleev leave gaps in his periodic table?	Describe and explain the reactivity of noble gases.
What would the charge be on a sodium ion? Explain why.	Describe the reactivity as you go down group 1 metals.	Complete the word equation and explain why the reaction has taken place: *sodium bromide + chlorine ->*

Challenge – *Describe the movement of electrons when sodium reacts with chlorine.*

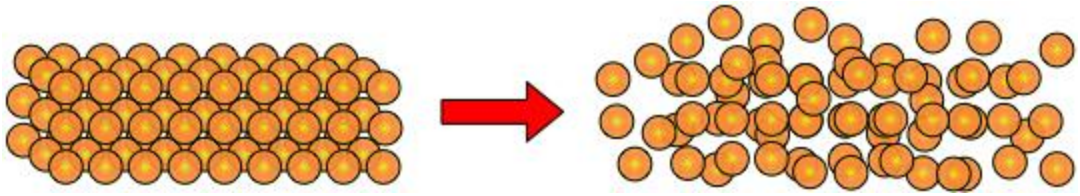


1. Complete the diagram below to show particle diagrams for each state of matter and the name of each process happening at A, B, C and D.
2. Describe what happens to the particles in terms of energy and movement when a solid turns into a liquid.

LET'S RECAP...

Particle theory

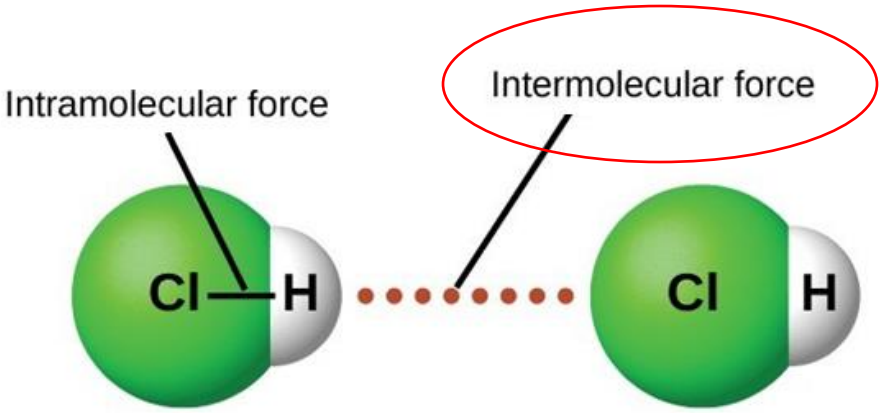
When a substance melts, the particles **gain kinetic energy** and they **break free from the regular arrangement** of atoms (solid) and move further apart (liquid):



SOLID ***LIQUID***

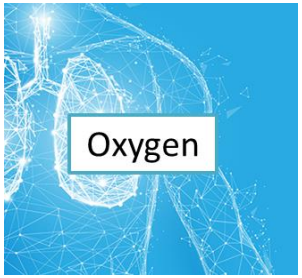
When this happens, the ***intermolecular*** forces are broken.

The stronger the forces the higher the melting point and boiling point.



e.g.

e.g.



Challenge: *Explain why gold is a solid at room temperature, but water is a liquid.*

These are known as '***state symbols***'. They are only used in symbol equations, not word equations!

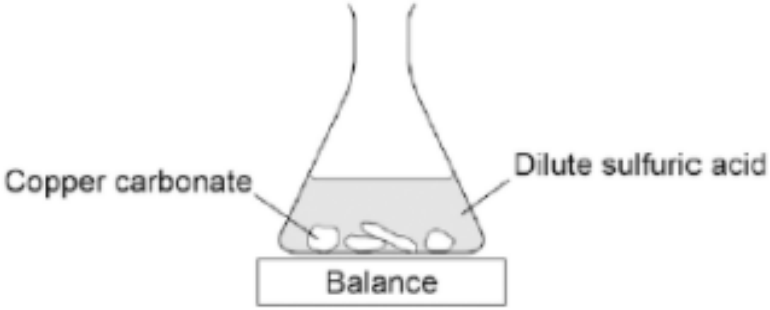
(s)	***(l)***	***(aq)***	***(g)***
			

The only substance that will ever be a pure liquid is water!

= dissolved in water

A student investigated the reaction of copper carbonate with dilute sulfuric acid.

The student used the apparatus shown in the figure below.



Complete the state symbols in the equation.

$CuCO_3$ (____) + H_2SO_4 (aq) → $CuSO_4$ (aq) + H_2O (____) + CO_2 (g)

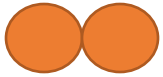
Challenge – *Why did the mass of the balance decrease?*

There are ***three types of bonding*** that occurs between atoms in compounds.

The type of bonding depends on what atoms are involved…

Ionic bonding Occurs between **metals** and **non-metals**

Covalent bonding Occurs between **non-metals** atoms

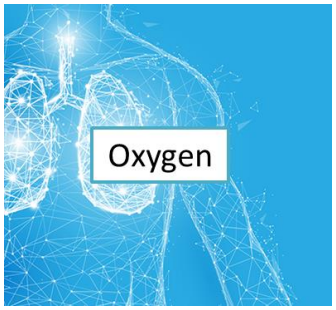


Metallic bonding Occurs between **metal** atoms

Remember: METALS are on the LEFT of the periodic table, NON-METALS are on the RIGHT of the periodic table

LOWEST MELTING POINT

HIGHEST MELTING POINT



-218.8 °C **0 °C** **660.3 °C** **801 °C** **1,064 °C**

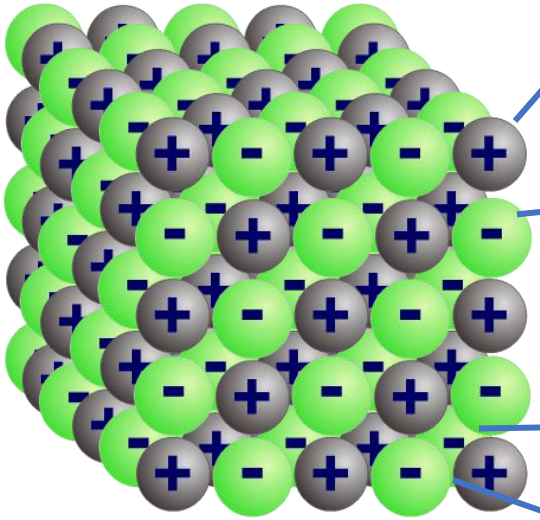
What atoms are in each of these substances?

So, what type of bonding occurs in these substances?

Ionic compounds

Key definition:

Ionic compounds are **GIANT IONIC LATTICES** made up of millions of **POSITIVE AND NEGATIVE IONS.** These oppositely charged ions are joined by **STRONG ELECTROSTATIC FORCES OF ATTRACTION** (ionic bonds).

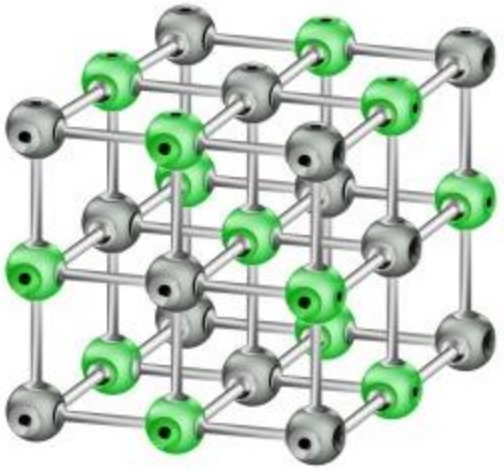


How does this structure affect the properties of ionic compounds?

Physical Properties of Ionic Compounds

1.

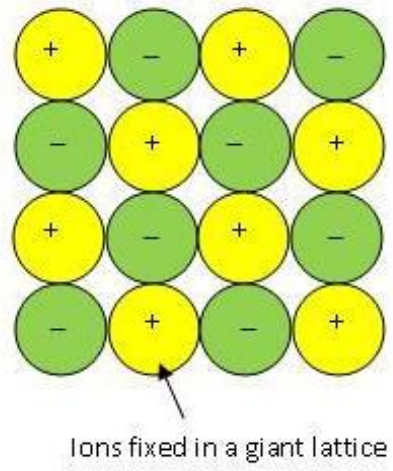
Why?



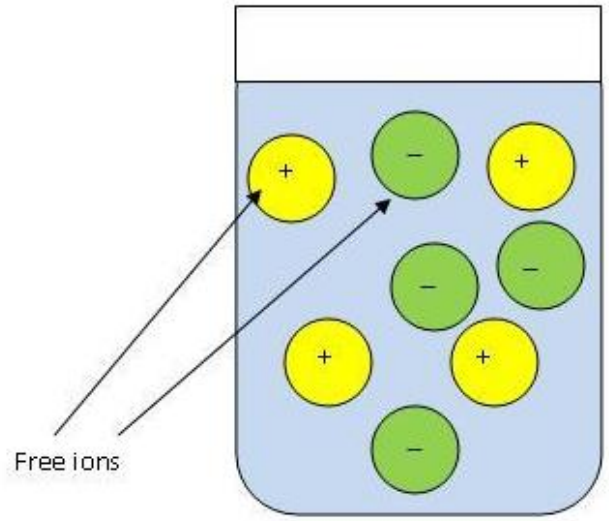
Physical Properties of Ionic Compounds

2.

Why?



X

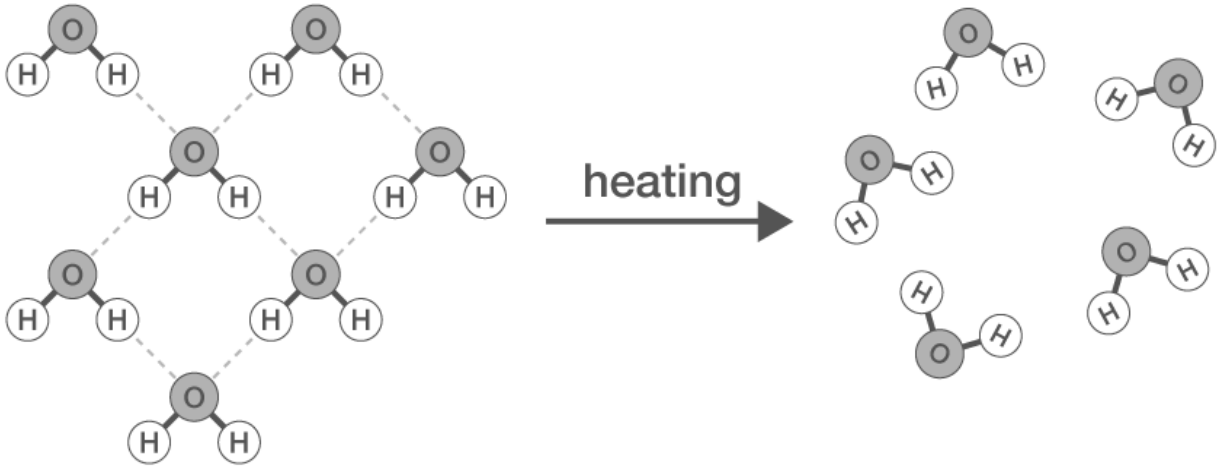


✓

Properties of simple covalent compounds

1.

Why?

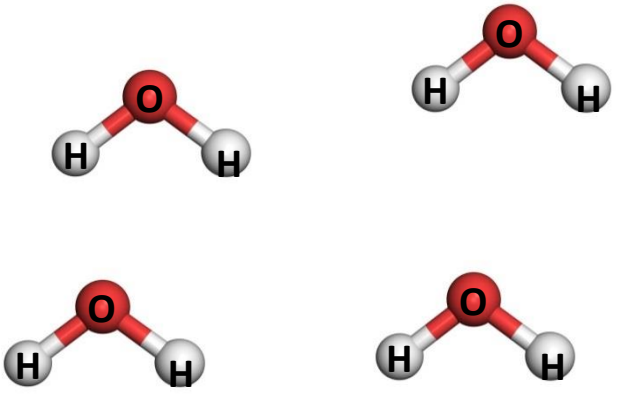


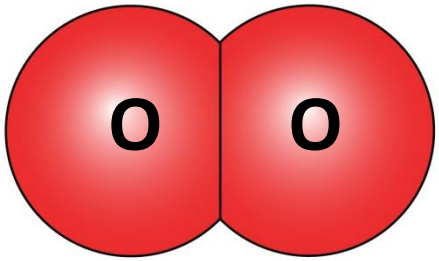
Properties of simple covalent compounds

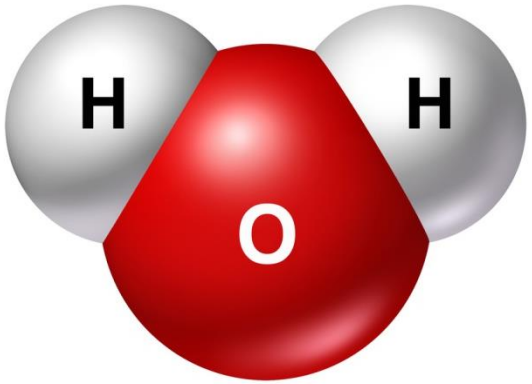
2.

Why?

Pure water







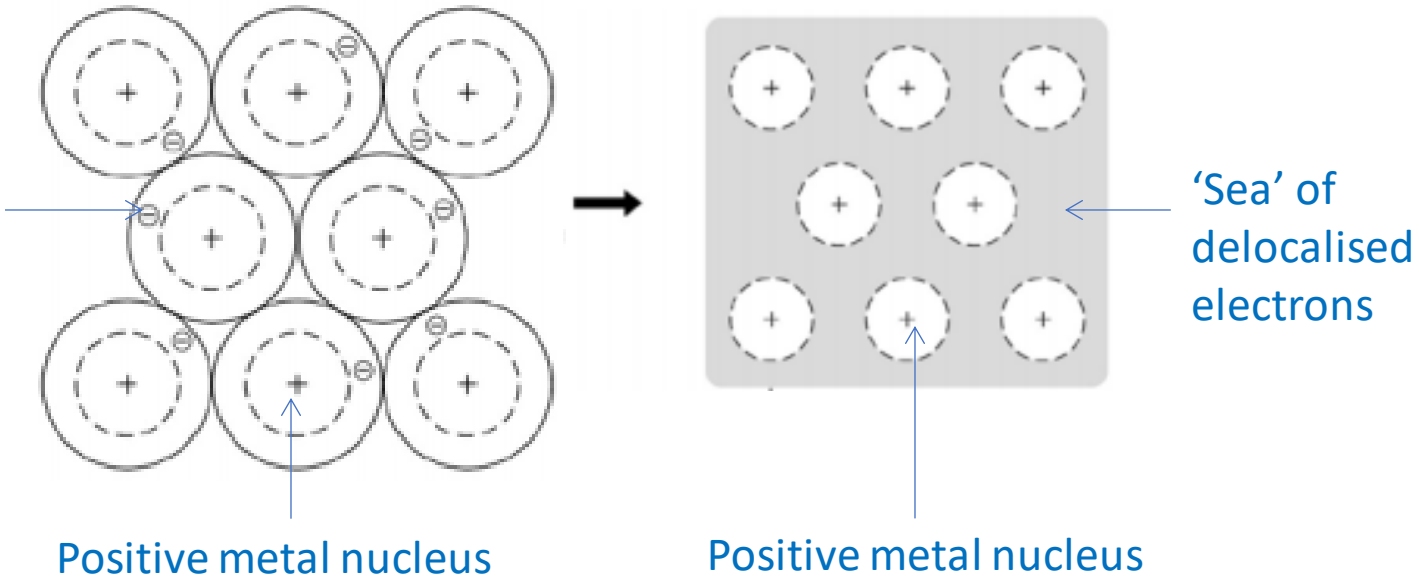
Gas (g)

Liquid (l)

Metallic structures

Key definition:

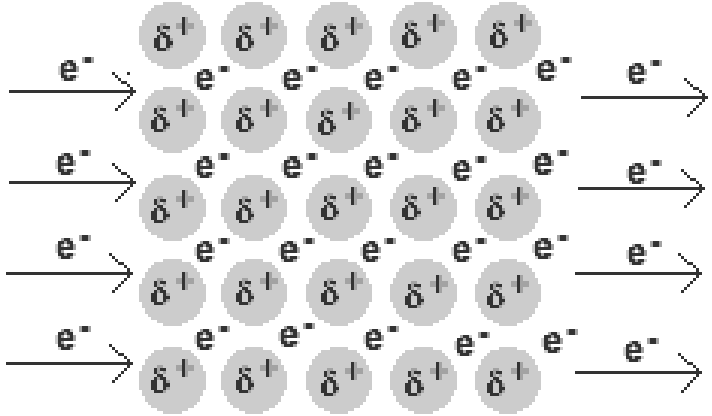
Metallic bonding occurs due to ***strong electrostatic forces of attraction*** *between the* ***positive metal nuclei*** *and the* ***negatively charged delocalised electrons.***



Properties of metals

1.

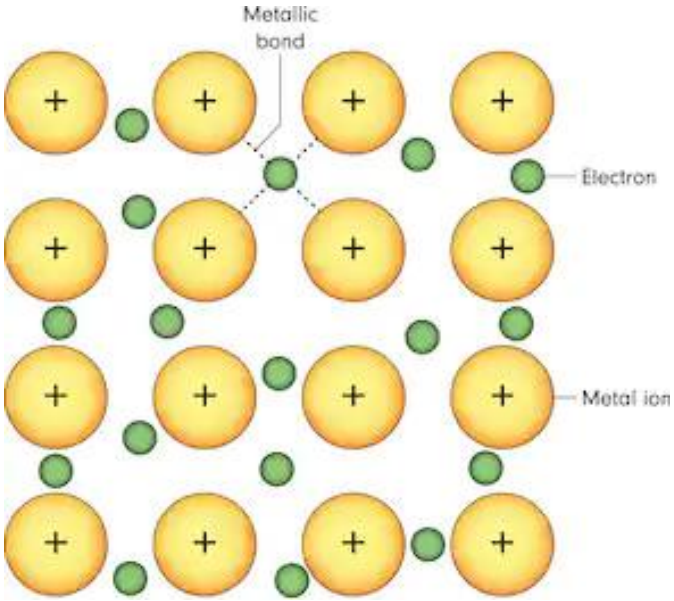
WHY?



Properties of metals

2.

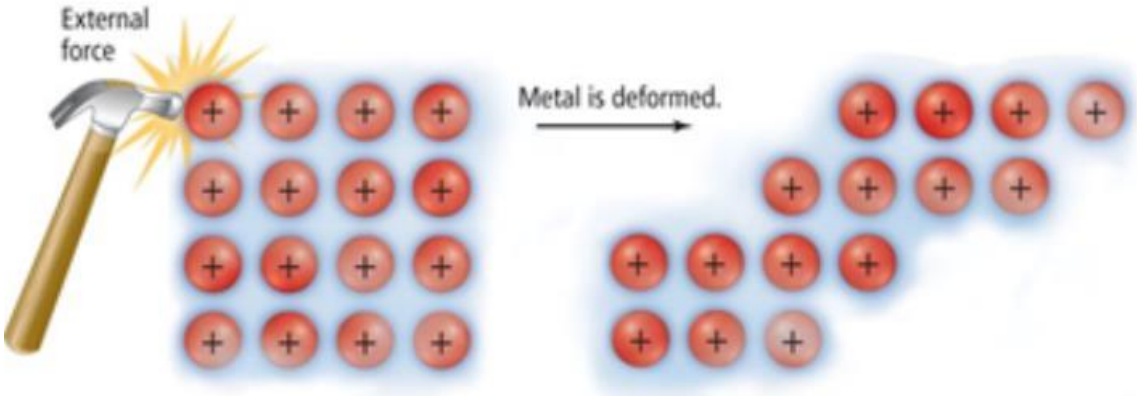
WHY?



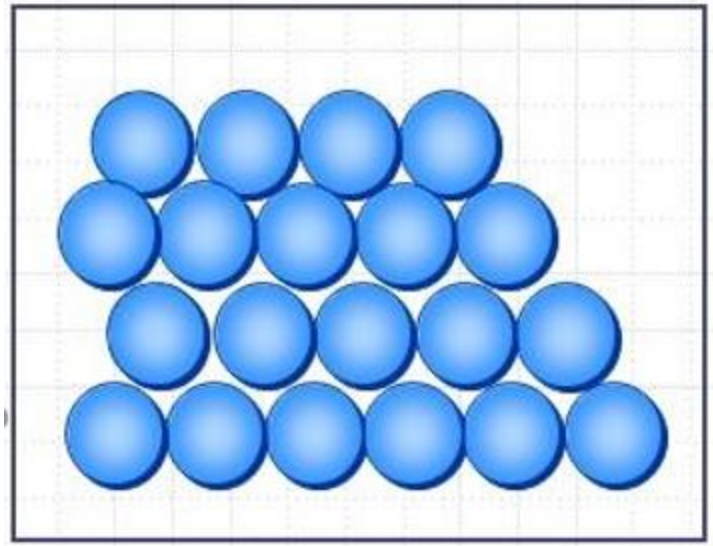
Properties of metals

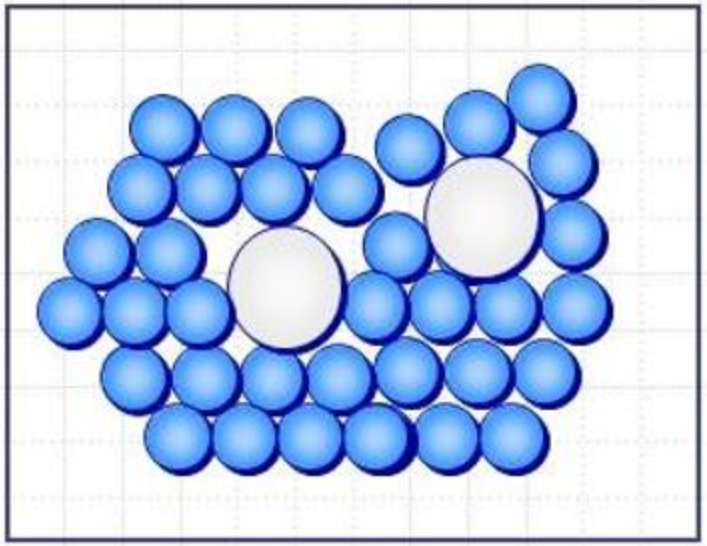
*3. They are **malleable** and **ductile***

WHY?



Alloys are usually **stronger** than pure metals.



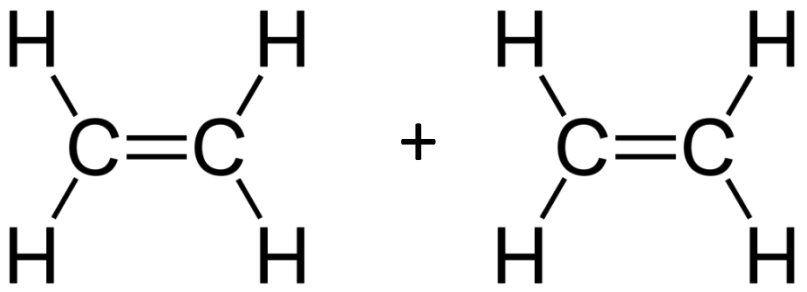


Pure metal:

Alloys:

Polymers

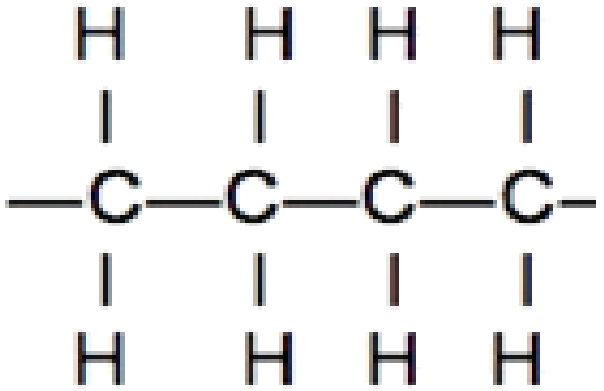
In polymerisation reactions many small molecules called **monomers** join together to form a very large molecules called **polymers**.



Monomers

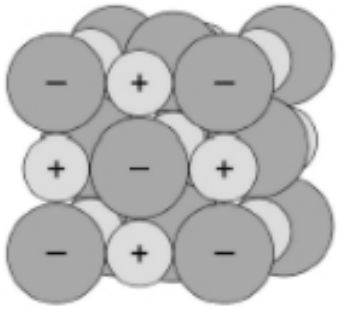
Polymers are **giant covalent compounds** made up of **HYDROCARBONS** (formed from _____ only).

The covalent bonds are very **strong**, so polymers have very _____.



Polymers

The diagram below shows part of the structure of sodium chloride (NaCl).



Sodium chloride

(d) What holds the particles together in sodium chloride?

Use the diagram above.

Tick (✓) **one** box.

Electrostatic attractions ☐

Intermolecular forces ☐

Metallic bonds ☐

Exam practice (foundation)

(e) Solid sodium chloride does not conduct electricity.

Give **two** ways in which sodium chloride can be made to conduct electricity.

1. _____

_____

2. _____

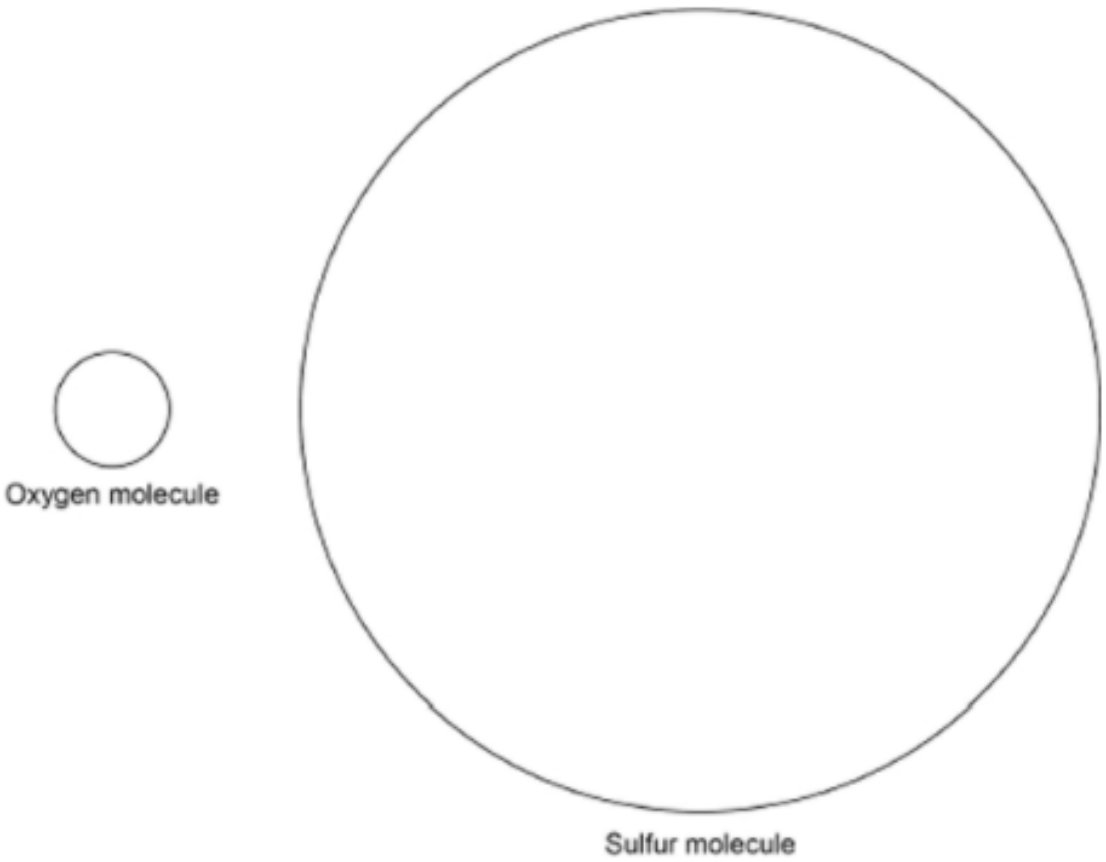
_____

(2)

Exam practice (foundation)

(f) **Figure 3** shows the relative sizes of an oxygen molecule and a sulfur molecule.

Figure 3



How does the boiling point of sulfur compare with the boiling point of oxygen?

Complete the sentences.

The boiling point of sulfur is _____ the boiling point of oxygen.

This is because in sulfur the intermolecular forces are _____

than the intermolecular forces in oxygen.

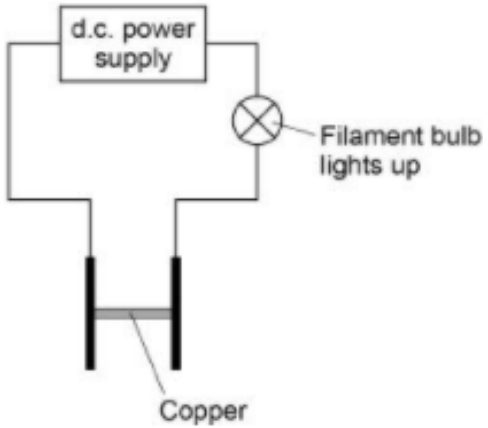
(2)

Exam practice (foundation)

An electric current is passed through copper.

Figure 5 shows the apparatus used.

Figure 5



(f) Complete the sentence.

Choose the answer from the box.

gas	liquid	solid	solution

Figure 5 shows that copper conducts electricity as a _____ .

(1)

(g) Complete the sentence.

Choose the answer from the box.

atoms	electrons	ions	molecules

Copper conducts electricity because of the movement of delocalised _____ .

(1)

Exam practice (foundation)

Give **two** physical properties of metals.

1. _____

_____

2. _____

_____

(2)

Complete the sentence.

Choose the answer from the box.

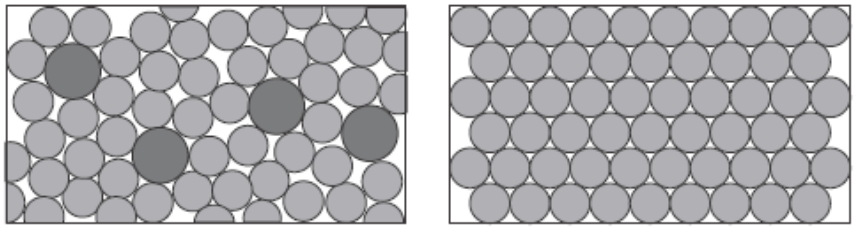
attract	bond	slide	vibrate

Metals can be stretched into wires

because the layers of atoms can _____ .

(1)

Alloy **Pure zinc**



Use **Figure 2** to explain why the alloy is harder than pure zinc.

_____

_____

_____

(2)

Potassium fluoride is an ionic compound.

Explain why ionic compounds have high melting points.

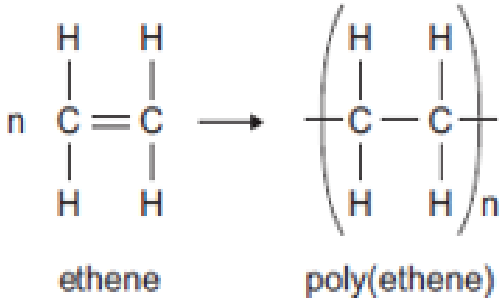
Use the following words in your answer:

- attraction
- energy
- ions.

Exam practice (foundation)

(4)

(ii) Poly(ethene) is produced from ethene in a polymerisation reaction. The equation for the reaction is:



Exam practice (foundation)

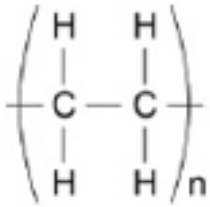
Which **two** statements about the polymerisation reaction to form poly(ethene) are correct? Tick (✔) **two** boxes.

	Tick (✔)
A polymer is a small molecule.	
Many ethene molecules join together.	
Poly(ethene) contains a double bond.	
The monomer is ethene.	

(2)

Figure 2 shows part of a large hydrocarbon molecule.

Figure 2



Exam practice (foundation)

(c) Which **two** elements are in all hydrocarbons?

1. _____

2. _____

(2)

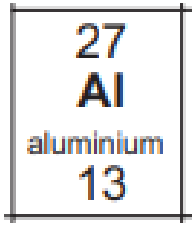
(d) Complete the sentence. Choose the answer from the box.

an atom	**a metal**	**a polymer**	**a salt**

The large molecule represented in **Figure 2** is _____

(1)

C2 – Giant covalent molecules

What type of bonding occurs in sodium chloride? Why Ionic, it is a metal and a non-metal.	Explain why oxygen (O_2) is a gas at room temperature. Oxygen (covalent) has a low boiling point due to weak intermolecular forces	Why are alloys stronger than pure metals? Different sized atoms means the layers are disrupted, so atoms can't slide over each other.
Why do polymers have high melting points? The atoms are bonded with strong covalent bonds that need a lot of energy to break.	What is the mass number of aluminium? 27  	How many of each atom are in the following compounds? H_2SO_4 = 2 H, 1 S, 4 O $CaCO_3$= 1 Ca, 1 A, 3 O 2 CaOH = 2 Ca, 2 O, 2 H 3 $MgCl_2$= 3Mg, 6 Cl

Independent *= concentration of acid*

Dependent *= temperature change*

Control variables *= VOLUME of acid, VOLUME of alkali, concentration of alkali, starting temperature*

C2 - Bonding, structure and the properties of matter

C1 - Atomic structure and the periodic table

C2 - Bonding, structure and the properties of matter

C3 - Quantitative chemistry

C4 - Chemical changes

C5 - Energy changes

C6 - The rate and extent of chemical change

C7 - Organic chemistry

C8 - Chemical analysis

C9 - Chemistry of the atmosphere

C10 - Using resources

Types of bonding

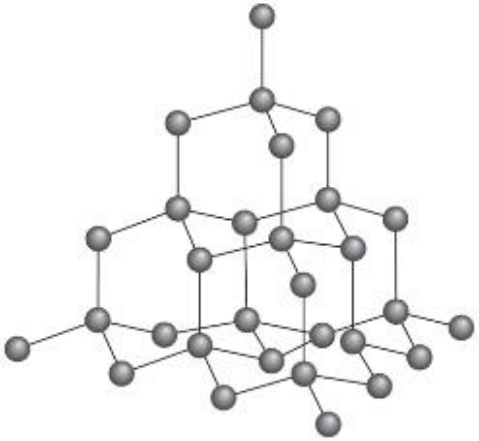
- Ionic bonding
- Covalent bonding
- Metallic bonding

Properties of bonding

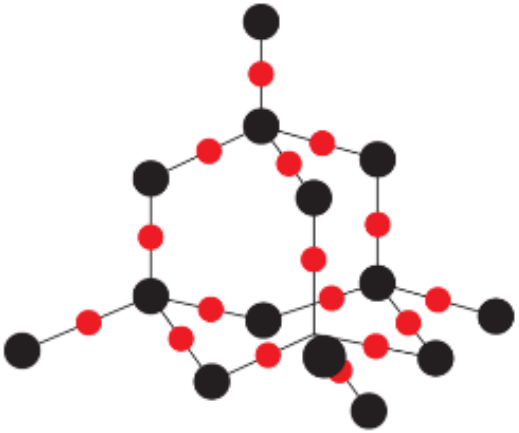
- 3 states of matter
- Properties of ionic compounds
- Properties of covalent molecules (Small and Giant)
- Metals and alloys
- Graphene, fullerene and polymers
- Nanoparticles and orders of magnitude

TRIPLE **HIGHER**

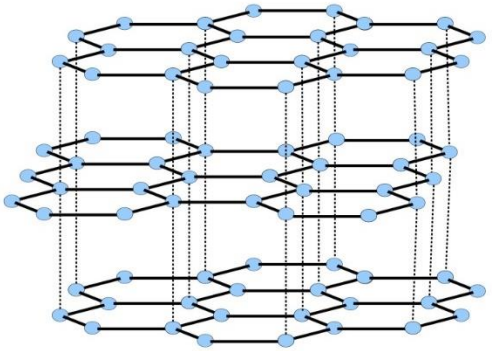
Examples of giant covalent structures



Diamond



Silicon dioxide



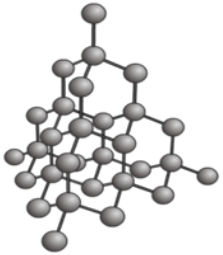
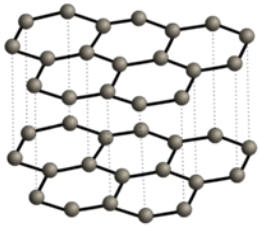
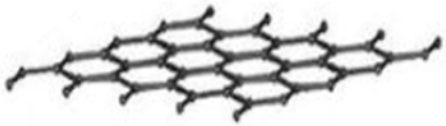
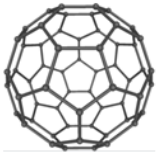
Graphite

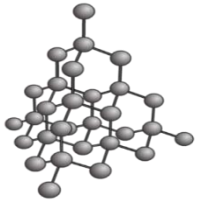
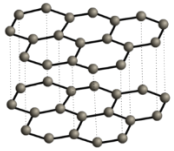
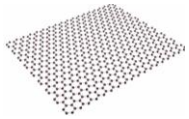
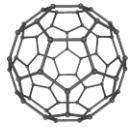
Giant structures
Potentially made from billions of atoms
Strong covalent bonds acting between the atoms.

*You need to be able to **describe** and **explain** the **properties** of four types of giant covalent compounds…*

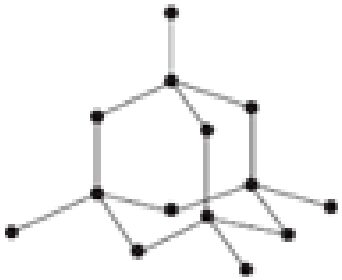
1. *Diamond*
2. *Graphite*
3. *Graphene*
4. *Fullerenes*

These are all made from CARBON, so all contain STRONG COVALENT BONDS that require a LOT OF ENERGY TO BREAK

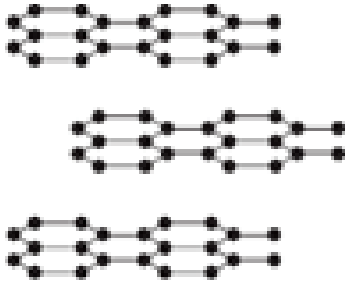
Diamond	Graphite	Graphene	Fullerenes
Bonding & Structure 	**Bonding & Structure** 	**Bonding & Structure** 	**Bonding & Structure**  
Properties	**Properties**	**Properties**	**Properties**
Uses	**Uses**	**Uses**	**Uses**

Diamond	Graphite	Graphene	Nanotubes/fullerenes
Bonding & Structure - Each carbon bonded to 4 other carbon atoms - No delocalised electrons. 	Bonding & Structure - Each carbon bonded with 3 other carbon atoms - Delocalised electrons that can carry charge. - Arranged in layers with weak forces between layers. 	Bonding & Structure - Each carbon bonded to 3 other carbon atoms. - Delocalised electrons that can carry charge. - Only one layer thick. 	Bonding & Structure - Each carbon bonded to 3 other carbon atoms. - Delocalised electrons that can carry charge. - Arranged in tubes/spheres.  
Properties - High melting point and boiling point - Does not conduct electricity - Hard - Transparent - Shiny	Properties - High melting point and boiling point - Conducts electricity (due to delocalised electrons) - Soft and slippery because layers can slide over each other	Properties - High melting point and boiling point - Conducts electricity (due to delocalised electrons) - Transparent and lightweight	Properties - High melting point and boiling point - Conducts electricity (due to delocalised electrons) - Large surface area to volume ratio
Uses - Drill bits - Jewellery	Uses - Pencils - Electrodes - Lubricants	Uses - Solar cells and batteries - Electronics	Uses - Tennis rackets - Transporting drugs around the body

The diagrams show the structures of diamond and graphite.



Diamond



Graphite

(a) Diamond and graphite both contain the same element.

What is the name of this element? _____

(1)

(a) Use the diagrams above and your knowledge of structure and bonding to explain why:

(i) graphite is very soft

_____

(2)

(ii) diamond is very hard

_____

(2)

(iii) graphite conducts electricity.

_____

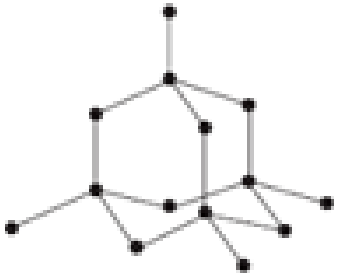
(2)

(Total 7 marks)

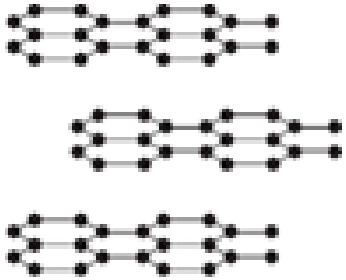
Challenge:

Both diamond and graphite have high melting points, but diamond's thermal conductivity is 10x higher than that of graphite. Suggest why.

The diagrams show the structures of diamond and graphite.



Diamond



Graphite

(a) Diamond and graphite both contain the same element.

What is the name of this element? Carbon

(1)

(a) Use the diagrams above and your knowledge of structure and bonding to explain why:

(i) graphite is very soft

Arranged in layers with weak intermolecular forces, can slide over each other.

(2)

(ii) diamond is very hard

Giant lattice, with strong covalent bonds between each carbon atom.

(2)

(iii) graphite conducts electricity.

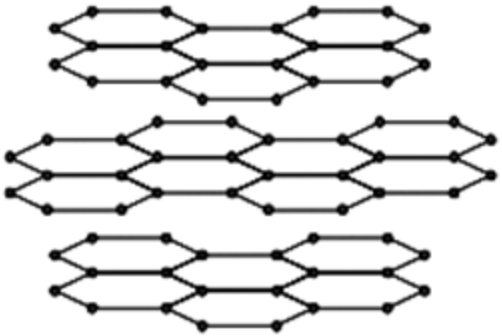
Each carbon has 1 delocalised electron, so can carry an electrical charge.

(2)

(Total 7 marks)

Graphite and diamond are different forms of the element carbon.
Graphite and diamond have different properties.

The structures of graphite and diamond are shown below.



Graphite

Diamond

(a) Graphite is softer than diamond.

Explain why.

(4

(b) Graphite conducts electricity, but diamond does not.

Explain why.

(3