Combined Science - Chemistry

CC5-7 Knowledge organiser

C5-7: Bonding

Sequence

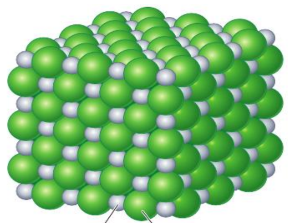
1. Ionic bonding
2. Ionic compounds
3. Properties of ionic compounds
4. Covalent bonding
5. Covalent structures
6. Allotropes of carbon
7. Metallic bonding
8. Classifying materials

1. Ionic bonding

Bond	An attraction between two atoms that holds them together.
Ion	An atom or group of atoms that has gained a charge by gaining or losing electrons.
Charge	Whether an ion is positive or negative.
Cation	Positive ion formed by losing electrons. Formed by metal atoms.
Anion	Negative ion formed by gaining electrons. Formed by non-metal atoms.
Size of charge	The number of electrons transferred affects the size of charge: losing two electrons makes a 2+ charge, gaining three electrons makes a 3- charge.
How many electrons are given away or stolen?	**Metals:** give away however many electrons are in the outer shell **Non-metals:** steal however many electrons are needed to fill the outer shell.
Electrostatic force	A force of attraction between a positive and negative particle.
Ionic bond	When two oppositely charged ions are held together by an electrostatic force.
Forming ionic bonds	Electrons are transferred from a metal atom to a non-metal atom to form a positive metal cation and a negative metal anion. The oppositely charged ions are attracted to each other.

2. Ionic compounds

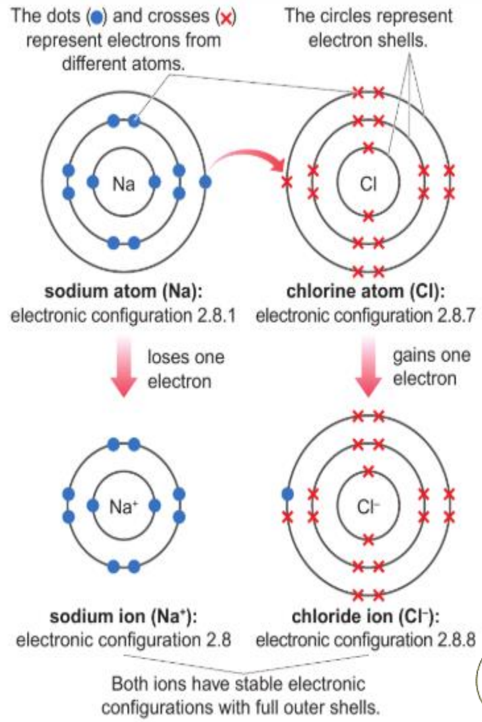
Chemical formula	Shows the number of atoms of each element present in one 'unit' of a compound.
Writing formulae	- Each chemical symbol starts with a capital letter. - The number of each atom present is shown with a subscript number after the symbol. E.g. H_2SO_4.
Determining ionic formulae	- Ensure the total number of positive and negative charges balance. - Change the number of each ion present by changing the subscript numbers.
Compound ions	An ion made from two or more atoms that share a charge.
Common compound ions	Hydroxide: OH^- Nitrate: NO_3^- Sulfate: SO_4^{2-} Sulfite: SO_3^{2-} Carbonate: CO_3^{2-} Ammonium: NH_4^+
Including compound ions in formulae	If you need more than one, put brackets around it. E.g. $Mg(OH)_2$
Ionic lattice	The structure of ionic compounds: a repeating 3D pattern of alternating positive and negative ions.



Na^+ (a sodium ion) Cl^- (a chloride ion)

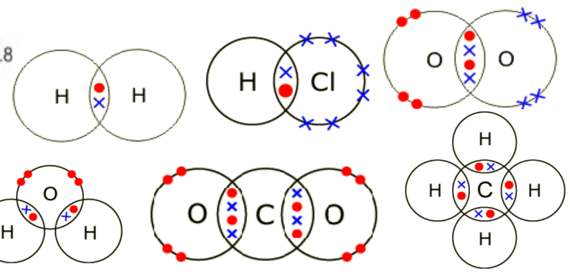
3. Properties of ionic compounds

Melting point of ionic compounds	High because melting needs a lot of energy to break strong ionic bonds.
Solubility of ionic compounds	Many ionic compounds dissolve in water.
Electrical conductivity of ionic compounds	Solid: Do not conduct because ions can't move. Liquid (molten or solution): Do conduct because ions can move.
How ionic compounds conduct electricity	When they are in a liquid form, the positive cations move to the negative electrode (cathode) and the negative anions move the positive electrode (anode).



4. Covalent bonding

Covalent bond	An electrostatic attraction between two atoms formed from a shared pair of electrons.
Double bond	A covalent bond involving two shared pairs of electrons.
Dot and cross diagram	A bonding diagram showing the electrons in the outer shell of each atom, with electrons drawn as dots or crosses.
Hydrogen, H_2	Two overlapping circles both labelled H. One pair in the overlap.
Hydrogen chloride, HCl	Two overlapping circles labelled H and Cl. One pair in the overlap, 6 electrons around Cl.
Oxygen, O_2	Two overlapping circles both labelled O. Two pairs in the overlap, 4 electrons around each O.
Water, H_2O	Three overlapping circles in a line labelled H, O, H. A pair in each overlap, 4 electrons around O.
Carbon dioxide, CO_2	Three overlapping circles in a line labelled O, C, O. Two pairs in each overlap, 4 electrons around each O.
Methane, CH_4	Five circles with one in the centre labelled C and 4 labelled H around it. A pair in each overlap.
Valency	The number of covalent bonds an atom can form.
Valency and groups	Group 4 = 4 (4 electrons needed) Group 5 = 3 (3 electrons needed) Group 6 = 2 (2 electrons needed) Group 7 = 1 (1 electron needed)
Working out molecular formulae	Find the lowest common multiple of the valency of each atom. Use the number of an atom required to reach the LCM.



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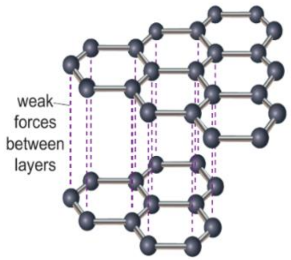
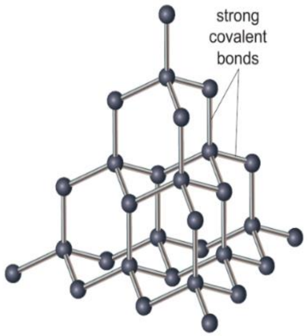
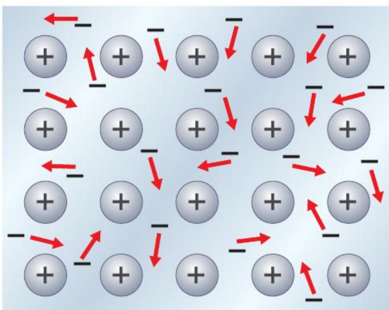
5. Covalent structures	
Molecule	A particle made from two or more atoms bonded together.
Simple molecular structure	A structure made of small molecules in which a few atoms join together to form a small particle.
Structure of molecular substances	Atoms in a molecule are held together by strong covalent bonds. Neighbouring molecules are held close by weak intermolecular forces.
Intermolecular force	A weak electrostatic force that holds two neighbouring molecules together.
Melting point of simple molecular compounds	Low because melting only needs a little energy to break weak intermolecular forces.
Electrical conductivity of simple molecular compounds	Do not conduct because there are no electrons that are free to move.
Examples of simple molecular substances	Hydrogen gas, oxygen gas, water, carbon dioxide, methane.
Giant molecular structure	A structure made of a repeating pattern of atoms covalently bonded together.
Melting point of giant molecular compounds	High because melting requires breaking strong covalent bonds.
Electrical conductivity of simple molecular compounds	Do not conduct (except graphite) because there are no electrons free to move.
Examples of simple molecular substances	Silicon dioxide (silica), diamond, graphite.
Polymer	A large molecule made of a small unit repeated many times.
Monomer	A small molecule that can be joined together many times to form a polymer.

6. Allotropes of carbon	
Allotrope	A different structural form of an element made of the same atoms just bonded together differently.
Carbon's allotropes	Graphite, diamond, graphene, fullerenes
Graphite	**Structure:** stacked sheets of carbon in a honeycomb pattern with delocalised electrons between them. **Properties:** sheets slide apart easily, excellent conductor **Uses:** lubricants
Diamond	**Structure:** Repeating pattern of 4 atoms bonded to 4 others. **Properties:** Extremely hard. **Uses:** Cutting tools and drills
Graphene	**Structure:** A single layer of atoms in a honeycomb pattern. **Properties:** Very strong, excellent conductor. **Uses:** None yet, but potentially many.
Buckminster fullerene	**Structure:** Ball-shaped molecules of C_{60}. **Properties:** Low melting point **Uses:** None
Carbon nanotubes	**Structure:** Cylinders made of carbons bonded in a honeycomb pattern. **Properties:** Very strong, excellent conductors **Uses:** Strong and flexible materials, electronics.





7. Metallic bonding	
Structure of metals	A lattice of positive metal ions surrounded by a cloud of delocalised electrons.
Delocalised electrons	Electrons that are not bound to a single atom but move freely around many.
Metallic bonding	The electrostatic attraction between the lattice of positive metal ions and the cloud of delocalised electrons.
Electrical conductivity of metals	Metals are good conductors because the electrons are free to move.
Comparing the conductivity of metals	Metals with more electrons in the outer shell – such as Al – are better conductors than those with fewer – such as Li – because there are more delocalised electrons that are able to move.
Malleable	When a substance dents when it is hit instead of shattering.
Malleability of metals	Metals are malleable because the atoms are arranged in regular sheets and these sheets can easily slide over each other when hit.
Melting point of metals	High because melting them requires breaking the strong force of attraction between the lattice of metal ions and the cloud of delocalised electrons.



B Metals consist of stacked layers of ions in a 'sea' of delocalised ('free') electrons.

8. Bonding models	
Classifying materials	The properties of a material can be used to determine the type of bonding in it.
Properties of ionic compounds	High melting point, often soluble in water, solid does not conduct electricity, liquid/solution does.
Properties of simple molecular compounds	Low melting point, does not conduct electricity, sometimes soluble in water.
Properties of giant molecular compounds	High melting point, does not conduct electricity (except graphite), insoluble in water.
Properties of metallic compounds	High melting point, does conduct electricity, insoluble in water.
Bonding models	The ideas and drawings that we use to explain the bonding of atoms.
Problems with bonding models	- Dot and cross diagrams make electrons seem different, they are not - Atoms appear stationary but are actually vibrating - Atoms don't appear to be touching when they actually are.