IONIC Bonding

Ions are charged particles which are formed when atoms lose or gain electrons.

Positive ions (cations) are usually formed by metallic elements by the **loss of electron(s)**. For example, sodium loses the electron in its outer shell to form a 1+ ion: $Na \rightarrow Na^+ + e^-$

Negative ions (anions) are usually formed by non-metallic elements by the **gain of electron(s)**. For example, chlorine gains an electron to fill up its outer shell $Cl + e^- \rightarrow Cl^-$

The atoms in the main part of the Periodic Table lose or gain electrons to have a full outer shell (noble gas electronic configuration).

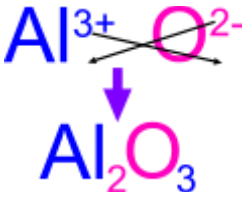
Group Number	Ion		Group Number	Ion
1	1+		7	1-
2	2+		6	2-
3	3+		5	3-

Other common ions: **NH_4^+ (ammonium), Ag^+, Cu^{2+}, Fe^{2+}[Iron(II)], Zn^{2+}, Fe^{3+} [Iron(III)], Pb^{2+} [lead(II)], OH^- (hydroxide), NO_3^-(nitrate), CO_3^{2-}(carbonate), SO_4^{2-}(sulfate), H^+.**

charges must be learnt

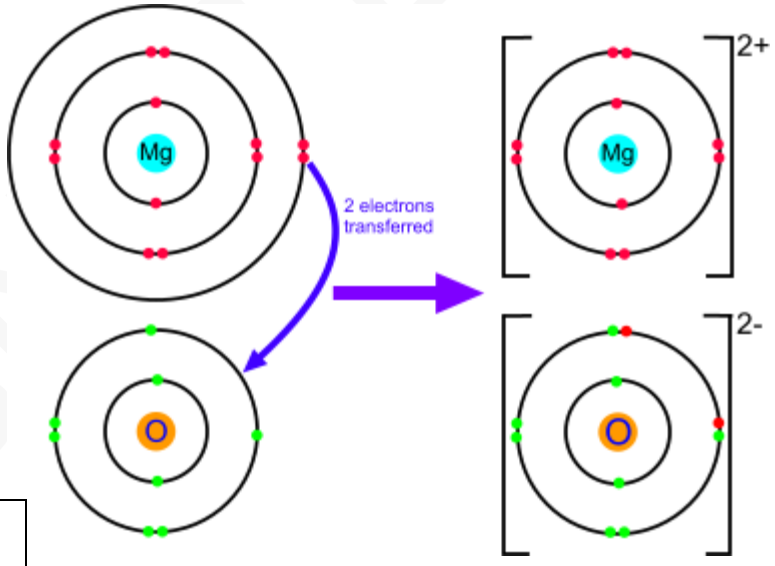
Note sulfide is S^{2-} but sulfate is SO_4^{2-}.

Ions with 'ate' in the name contain oxygen.



The formula of an ionic compound can be worked out by swapping over the charges:

Ionic bonding is the strong electrostatic attraction between oppositely-charged ions.

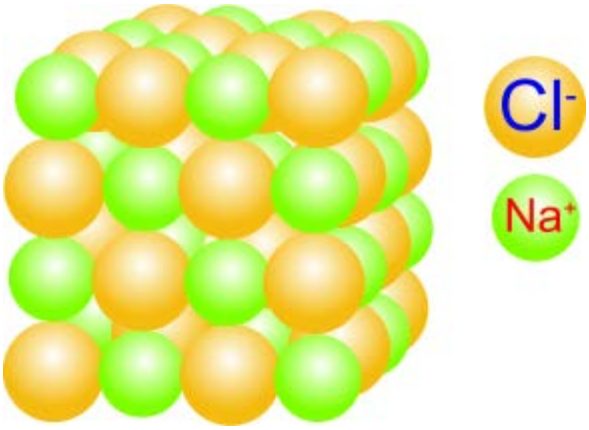


Ionic bonds are formed between metallic and non-metallic elements, e.g. MgO, NaCl are ionic compounds.

Electrons are transferred from the metal to the non-metal atom.

Common question:
When sodium oxide is formed two Na atoms must transfer 1 electron each to an O atom to form 2 Na^+ ions and 1 O^{2-} ion.
The formula of sodium oxide is Na_2O.

Ionic crystals have a giant three dimensional lattice structure held together by the attraction between oppositely-charged ions



Ionic compounds have high melting and boiling points because a lot of energy is required to overcome the strong electrostatic forces between oppositely charged ions

Do not conduct electricity in the solid state (***ions*** held tightly in place- not free to move)

Conduct electricity when molten or in aqueous solution – ***ions*** free to move around.

Ionic compounds **have no molecules** in them, only positive and negative ions!

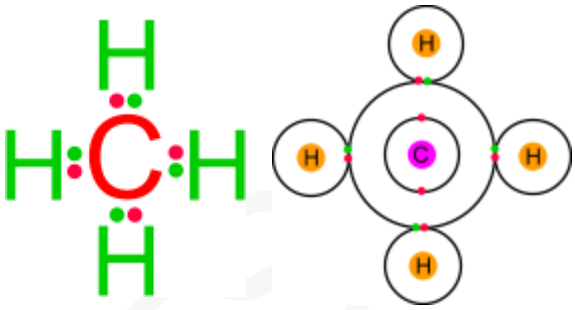
COVALENT Bonding

Molecule – 2 or more atoms covalently bonded.

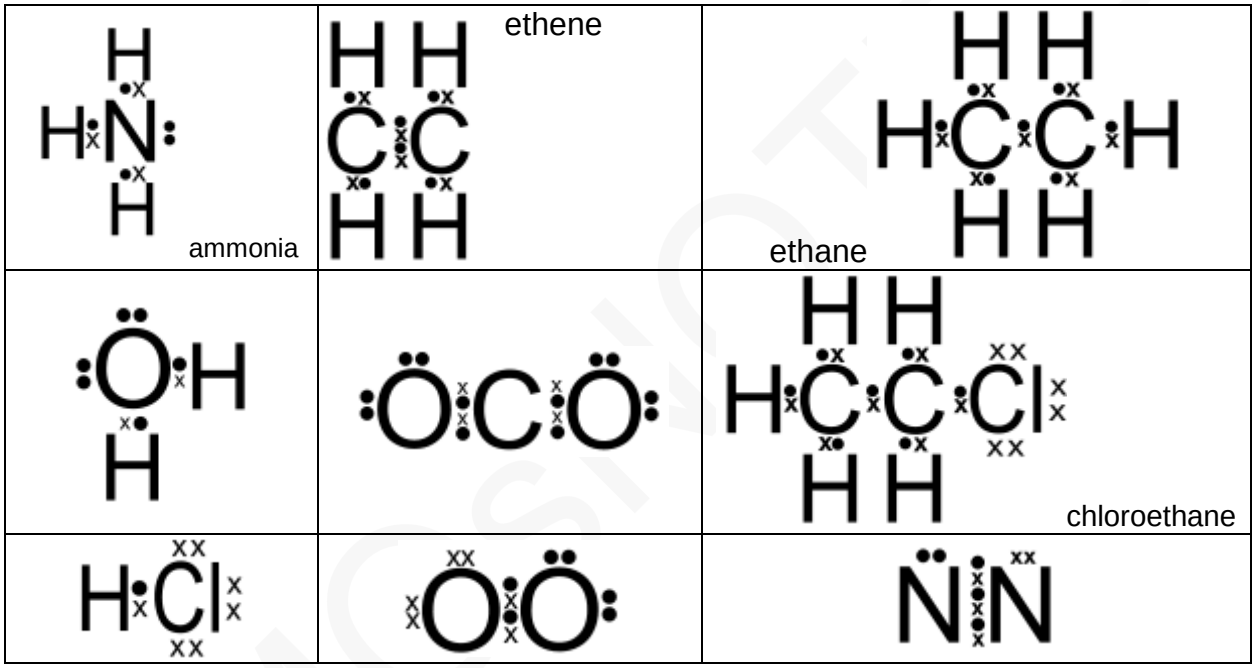
A covalent bonds is formed when two atoms share a **pair** of electrons. The atoms share pairs of electrons to give each atom a noble gas electronic configuration.

Covalent bonding is the strong electrostatic attraction between the shared pair of electrons and the nuclei of both the atoms involved in the bond.

Dot and cross diagrams for covalent molecules:
number of shared pairs of electrons = number of electrons that need to be gained for the atom to achieve a noble gas electronic configuration.
e.g. CH_4 (C needs to gain 4 electrons and H needs to gain 1 electron each)



Hydrogen:



Substances with molecular structures are gases or liquids or solids with low melting points and boiling points.

Low melting/boiling points because ***not much energy has to be supplied to break the weak intermolecular forces of attraction***.

NO COVALENT BONDS ARE BROKEN

Melting/boiling points increase as relative molecular mass increases because the intermolecular forces of attraction get stronger so more energy must be supplied to break them.

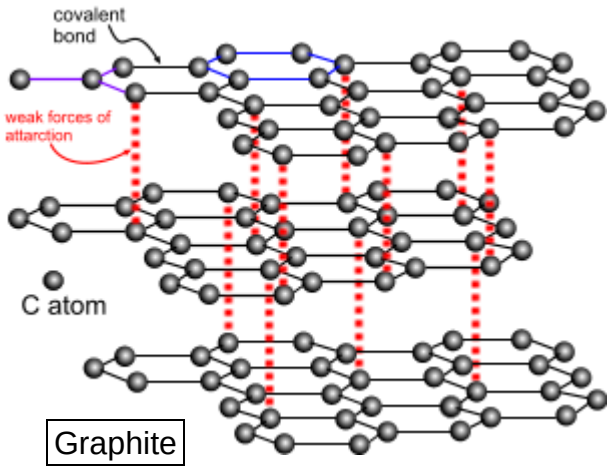
Covalent compounds do not usually conduct electricity – no charged particles that are free to move – electrons are held tightly in covalent bonds and molecules have no charge overall.

IONIC	COVALENT MOLECULAR
high melting point solids	solid, liquid or gas with low melting points
Strong electrostatic forces between oppositely-charged ions in the giant lattice structure must be broken – requires a lot of energy	Only ***weak intermolecular forces of attraction*** broken when the substances are melted or boiled – does not require much energy
Often soluble in water and usually insoluble in organic solvents	Not usually soluble in water but soluble in organic solvents.
Do not conduct electricity in the solid state (ions held tightly in place) but do conduct when molten or in aqueous solution – ions free to move	Do not conduct electricity in any state - no free ions/electrons. Acids and ammonia dissociate in water to produce ions e.g. $HCl_{(aq)}$ conducts electricity.

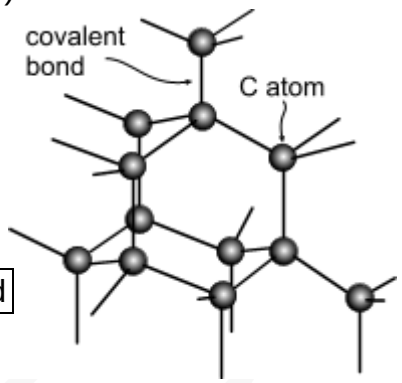
Giant covalent structures

Substances with giant covalent structures are solids with high melting and boiling points - strong **covalent bonds must be broken** when they are melted or boiled – this requires a lot of energy.

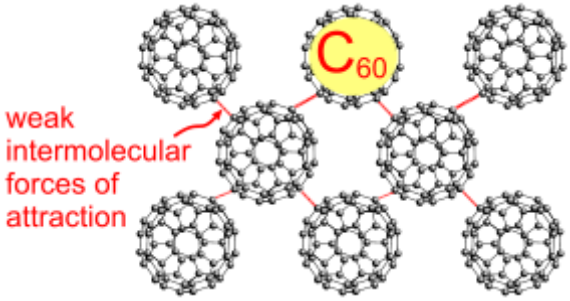
Diamond and graphite have giant covalent structures (no molecules).



Graphite



Diamond



C_{60} fullerene – simple molecular structure

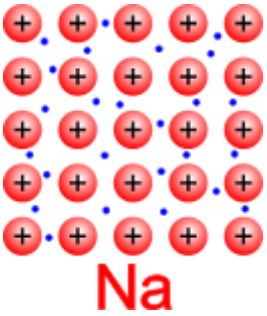
Diamond is very hard (only strong covalent bonds present). Graphite has weak forces of attraction between layers between layers that are easily broken so that the layers slide over each other easily - Graphite is soft. C_{60} will also be soft.

Diamond and graphite have high melting points – a lot of energy must be supplied to break strong covalent bonds.
Fullerene has a lower melting point – not as much energy must be supplied to break the weaker intermolecular forces of attraction.

Graphite conducts electricity – C only forms 3 bonds - delocalised electrons free to move.
Diamond does not conduct electricity – no charged particles free to move
C_{60} does not conduct electricity – molecules have no charge.

METALLIC Bonding

Metal have a giant lattice structure of positive ions surrounded by a sea of delocalised electrons.



Metals conduct electricity – *delocalized electrons* free to move

Metals are malleable because the *layers* of *metal ions* can slide over each other.