CAIE Chemistry A-level

Topic 3 - Chemical Bonding

Flashcards

What is ionic bonding?

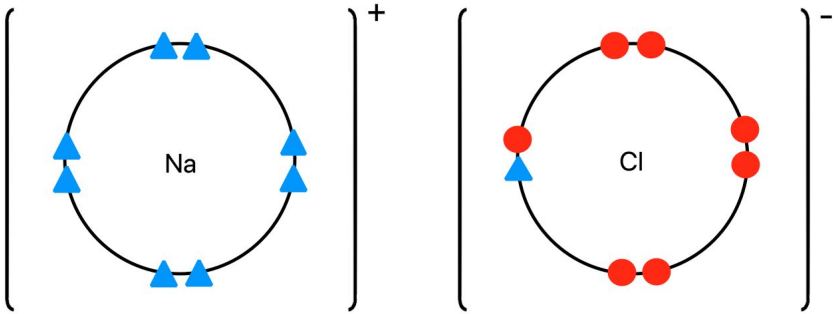
What is ionic bonding?

The strong electrostatic attraction between oppositely charged ions.

Draw a dot-and-cross diagram for sodium chloride

Draw a dot-and-cross diagram for sodium chloride

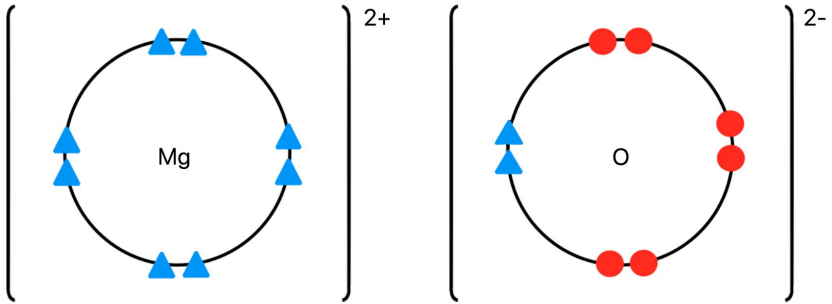
The sodium atom loses one electron to form an Na^+ ion.
The chlorine atom gains the electron from sodium, becoming a Cl^- ion. Both ions have a full outer shell of electrons.



Draw a dot-and-cross diagram for magnesium oxide

Draw a dot-and-cross diagram for magnesium oxide

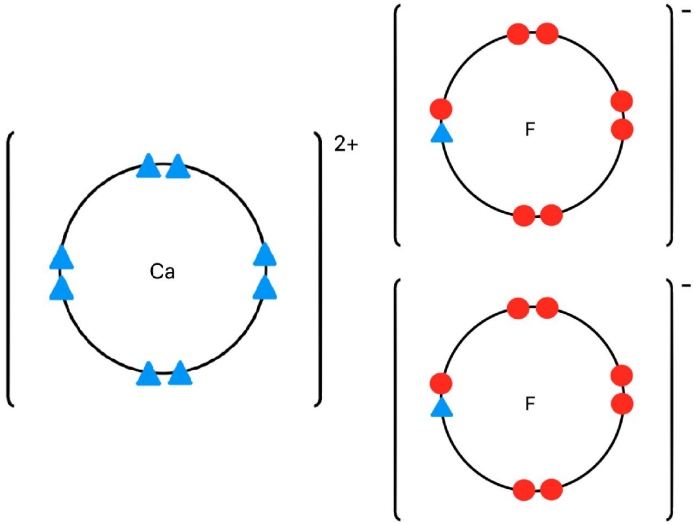
The magnesium atom loses two electrons to form a magnesium ion, Mg^{2+}. The oxygen atom gains these electrons to become an O^{2-} ion. Both ions have a full outer shell of electrons.



Draw a dot-and-cross diagram for calcium fluoride

Draw a dot-and-cross diagram for calcium fluoride

The calcium atom loses two electrons to form a Ca^{2+} ion.
Two fluorine atoms each gain an electron, forming two F^- ions.
All the ions have a full outer shell of electrons.



What is a covalent bond?

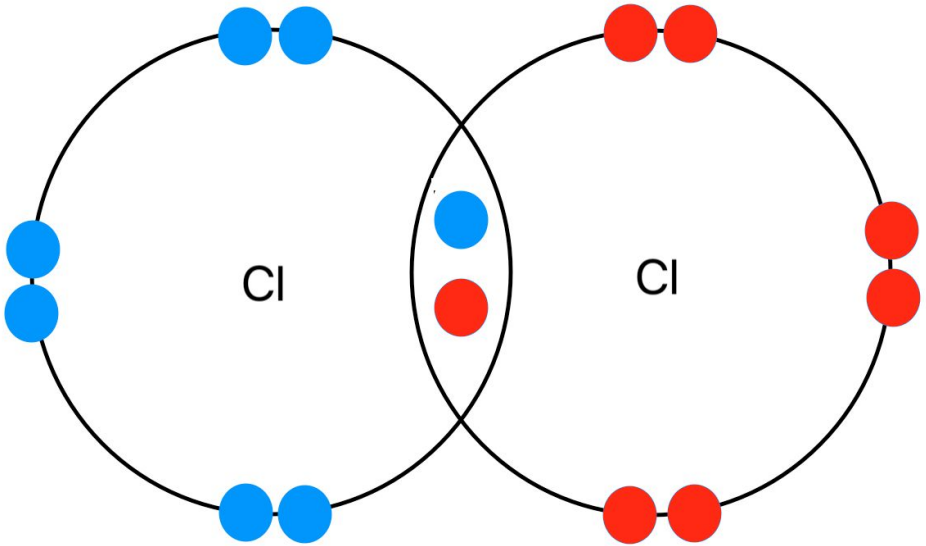
What is a covalent bond?

- A bond formed by a shared pair of electrons between two non-metals.
- Electrostatic attraction between the positive nuclei of the bonded atoms and the negative electrons between these nuclei holds the atoms together.

Draw a dot and cross diagram of Cl_2

Draw a dot-and-cross diagram of Cl_2

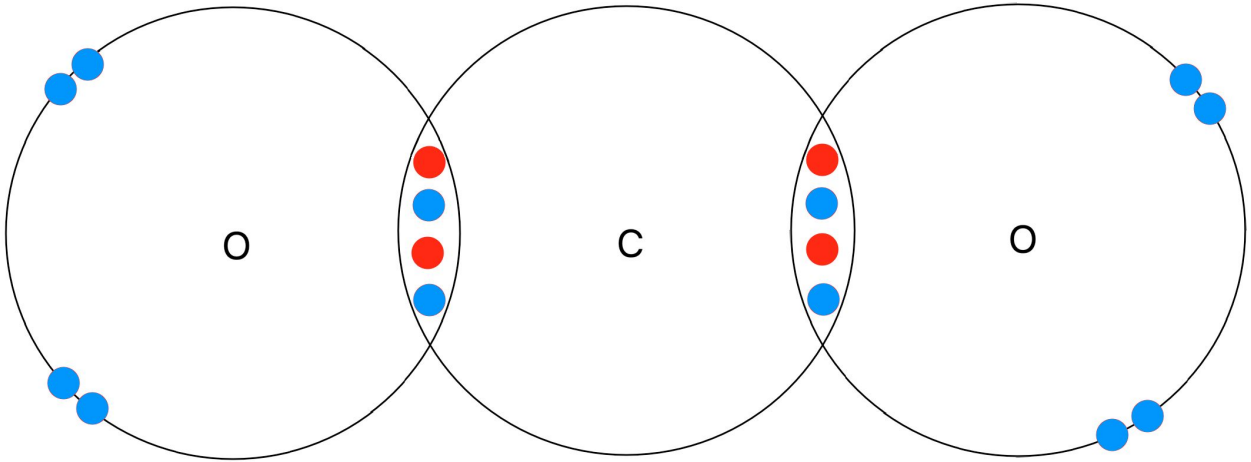
(Outer shell electrons only)



Draw a dot and cross diagram of CO_2

Draw a dot and cross diagram of CO_2

(Outer shell electrons only)



What is a dative covalent bond?

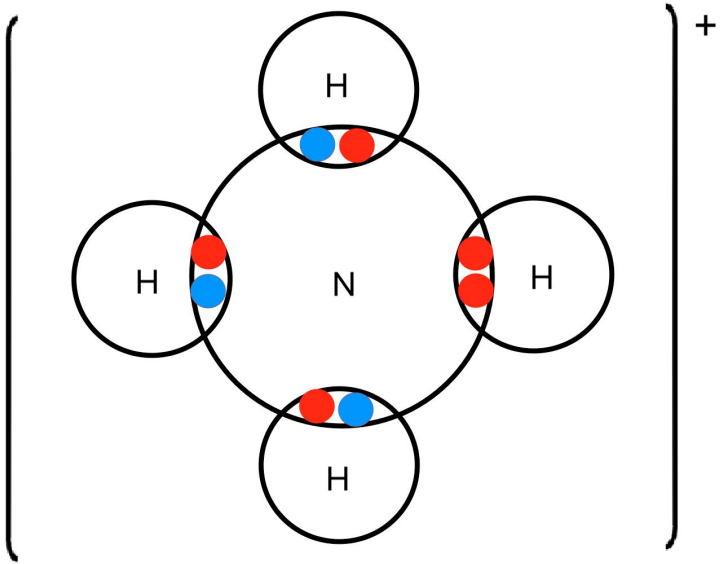
What is a dative covalent bond?

A covalent bond whereby both electrons in the shared pair are donated by one of the bonding atoms.

Draw a dot-and-cross diagram of NH_4^+

Draw a dot-and-cross diagram of NH_4^+

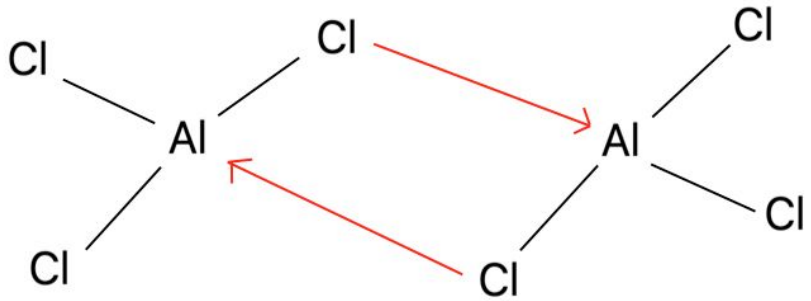
Each hydrogen atom is covalently bonded to the nitrogen. There is one dative covalent bond.



Describe the bonding in Al_2Cl_6

Describe the bonding in Al_2Cl_6

- Al_2Cl_6 is made from two $AlCl_3$ molecules.
- The Al from one molecule forms a dative covalent bond with a Cl from the other molecule. The same happens with the Al on other molecule.
- There are covalent bonds between the Al atom and the 3 Cl atoms in each $AlCl_3$ molecule.



What is a σ bond?

What is a σ bond?

- The **strongest** type of covalent bond.
- Formed from the **head-on** overlap of orbitals.

What is a π bond?

What is a π bond?

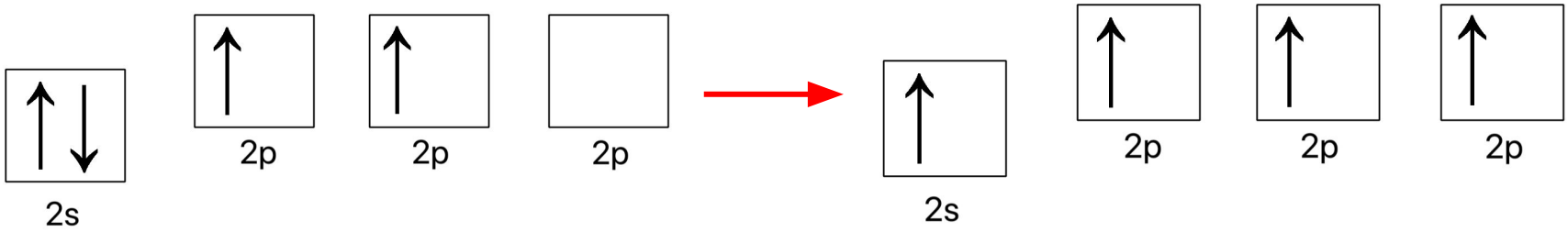
- Weaker than a σ bond.
- Formed from the **sideways** overlap of orbitals.
- A carbon-carbon π bond is formed from the sideways overlap of **p-orbitals** above and below the plane of the carbon atoms.

How does hybridisation to form sp^3 orbitals occur?

How does hybridisation to form sp^3 orbitals occur?

E.g. For carbon in methane:

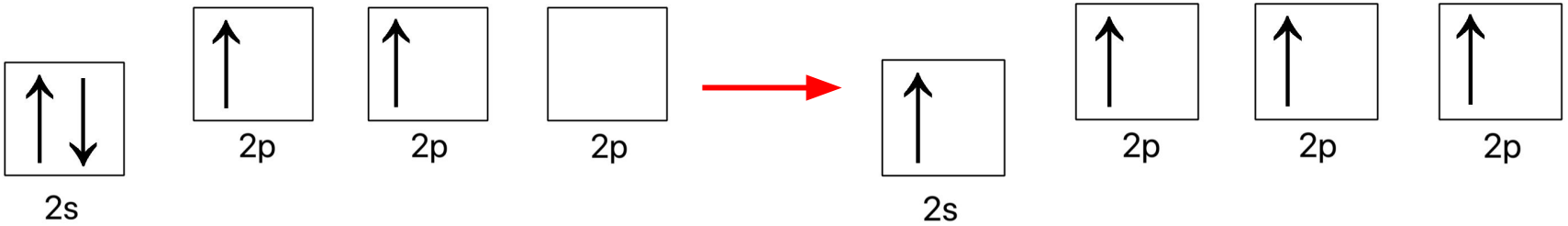
A 2s orbital electron has been promoted to a 2p orbital. Electrons then rearrange themselves via hybridisation into four identical orbitals called the sp^3 orbitals. These four orbitals can then take part in bonding with hydrogen to form methane, CH_4.



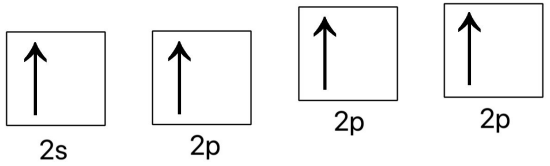
How does hybridisation to form sp orbitals occur?

How does hybridisation to form sp orbitals occur?

E.g. For carbon in ethyne (C_2H_2)



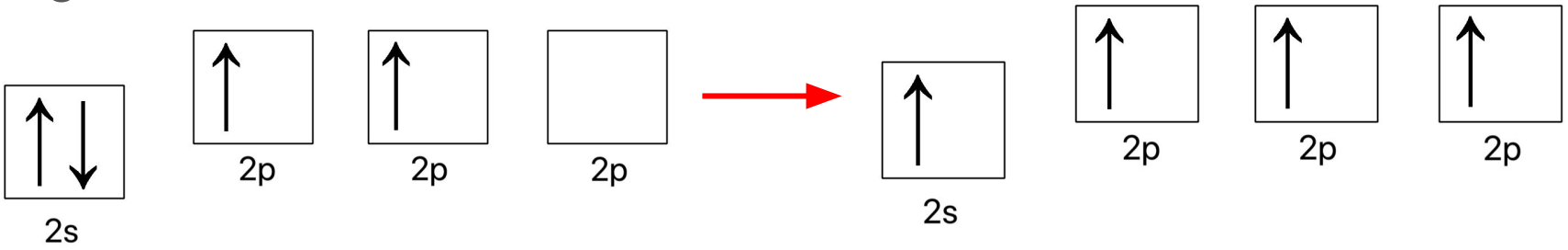
A 2s orbital electron has been promoted to a 2p orbital. Hybridisation occurs for 2 out of the four orbitals (with a 2s and a 2p orbital). These two orbitals, sp hybrids, are now identical.



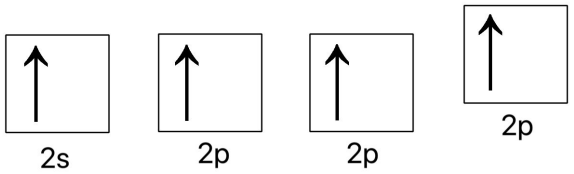
How does hybridisation to form sp^2 orbitals occur?

How does hybridisation to form sp^2 orbitals occur?

E.g. For carbon in ethene:



A 2s orbital electron has been promoted to a 2p orbital. Hybridisation occurs for three out of the four orbitals (one 2s and two 2p). These three orbitals, sp^2 hybrids, are now identical.



What is electron repulsion theory?

What is electron repulsion theory?

- Electron pairs repel each other meaning they position themselves as far apart as possible.
- All bonding electron pairs repel each other equally.
- Lone pairs offer more repulsion than bonded pairs.

What is the shape and bond angle of a molecule with 2 bonding pairs?

What is the shape and bond angle of a molecule with 2 bonding pairs?

Linear, 180°

E.g. Carbon dioxide, CO_2

What is the shape and bond angle of a molecule with 3 bonding pairs?

What is the shape and bond angle of a molecule with 3 bonding pairs?

Trigonal planar, 120°

E.g. Boron trifluoride, BF_3

What is the shape and bond angle of a molecule with 4 bonding pairs?

What is the shape and bond angle of a molecule with 4 bonding pairs?

Tetrahedral, 109.5°

E.g. Methane, CH_4

What is the shape and bond angle of a molecule with 5 bonding pairs?

What is the shape and bond angle of a molecule with 5 bonding pairs?

Trigonal bipyramidal, 90° and 120°

E.g. Phosphorus pentafluoride, PF_5

What is the shape and bond angle of a molecule with 6 bonding pairs?

What is the shape and bond angle of a molecule with 6 bonding pairs?

Octahedral, 90°

E.g. Sulfur hexafluoride, SF_6

What is the shape and bond angle of a molecule with 2 bonding pairs and 2 lone pairs?

What is the shape and bond angle of a molecule with 2 bonding pairs and 2 lone pairs?

Non-linear/bent, 104.5°

E.g. Water, H_2O

What is the shape and bond angle of a molecule with 3 bonding pairs and 1 lone pair?

What is the shape and bond angle of a molecule with 3 bonding pairs and 1 lone pair?

Pyramidal, 107°

E.g. Ammonia, NH_3

Predict the shape and bond angle of the ammonium ion

Predict the shape and bond angle of the ammonium ion

Ions have the same shapes as molecules.

The ammonium ion has 4 bonding pairs so it has a tetrahedral shape and a bond angle of 109.5°.

What is electronegativity?

What is electronegativity?

The ability of an atom to attract the bonding pair of electrons in a covalent bond.

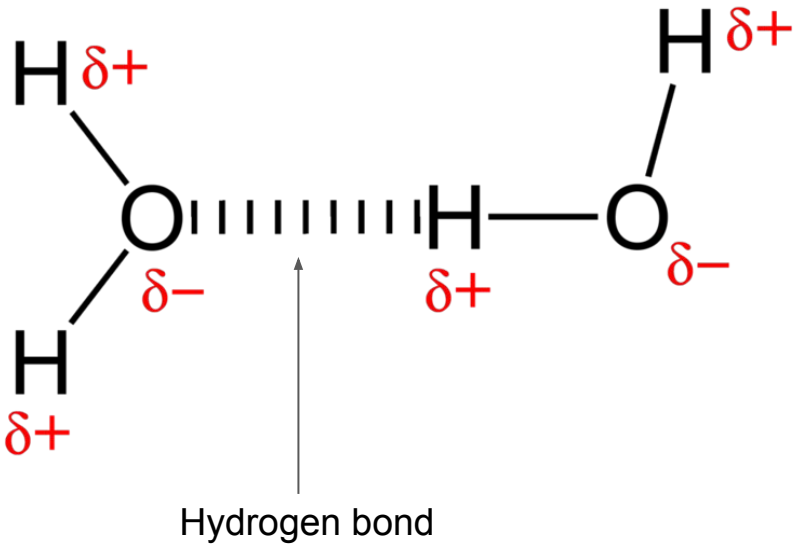
What is hydrogen bonding?

What is hydrogen bonding?

- The strongest type of intermolecular force.
- A type of permanent dipole-dipole interaction.
- Occurs when a hydrogen atom is bonded to a very electronegative atom (nitrogen, oxygen or fluorine), which is close to another electronegative atom that has a lone pair of electrons.

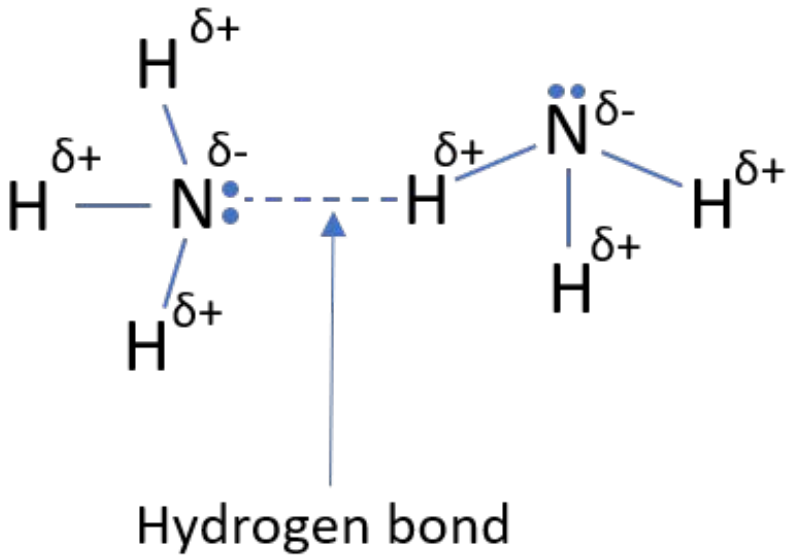
Draw a hydrogen bond between two water molecules

Draw a hydrogen bond between two water molecules



Draw a hydrogen bond between two ammonia molecules

Draw a hydrogen bond between two ammonia molecules



How does hydrogen bonding affect the viscosity of a substance?

How does hydrogen bonding affect the viscosity of a substance?

Hydrogen bonds increase viscosity of a substance because these bonds (as well as any other intermolecular forces) make the substance more resistant to flow.

How does hydrogen bonding create surface tension in water?

How does hydrogen bonding create surface tension in water?

Hydrogen bonding increases surface tension.

Water molecules at the surface of the liquid are attracted more strongly to other water molecules around them than the layers of water molecules below, creating tension at the surface of the liquid.

What is bond energy?

What is bond energy?

The measure of the strength of a chemical bond.

What is bond length?

What is bond length?

The average distance between the nuclei of two bonded atoms.

What is bond polarity?

What is bond polarity?

When two different atoms are joined by a covalent bond, there will be a difference in electronegativity between the two atoms.

Electrons will be drawn towards the atom with the greatest electronegativity. This atom will have a slightly negative charge while the other will be slightly positive. This charge difference is a dipole. If a bond is polar, it has a dipole.

Why can non-metal oxides undergo hydrolysis?

Why can non-metal oxides undergo hydrolysis?

Oxygen is very electronegative. As a result, a permanent dipole forms across the covalent bond and the atom that oxygen is bonded to becomes partially positive. When the oxide is added to water, lone pairs on oxygen from the water molecules are attracted to the partially positive atom in the oxide, causing hydrolysis.

How does the reactivity of a covalent bond depend on bond length?

How does the reactivity of a covalent bond depend on bond length?

- As bond length increases, bond strength decreases.
- This is because there is less electrostatic attraction between the two nuclei and the shared pair of electrons between them.
- As bond strength decreases, reactivity increases as less energy is required to break the bond.

How does the reactivity of a covalent bond depend on bond polarity?

How does the reactivity of a covalent bond depend on bond polarity?

Generally, the **greater** the bond polarity, the **more** reactive the molecule.

What is a permanent dipole and when does it occur?

What is a permanent dipole and when does it occur?

A permanent dipole is a permanent difference in the partial charges of covalently bonded atoms.

This occurs when there is a significant difference in electronegativities of the bonding atoms. The more electronegative atom has greater ability to attract the bonding pair of electrons meaning it has a slight negative charge. The other atom has a slight positive charge.

How do induced dipole-dipole interaction occur?

How do induced dipole-dipole interaction occur?

The random motion of electrons means that at any one point in time, there may be an uneven charge distribution. This establishes an instantaneous dipole between the two atoms which can then induce dipoles in neighbouring atoms/molecules.

Why is bromine liquid at room temperature?

Why is bromine liquid at room temperature?

Although bromine only has induced dipole-dipole forces between molecules, Br_2 molecules contain lots of electrons so these temporary dipoles are quite strong.

Why can Group 18 elements become liquid despite the fact that they exist as single atoms?

Why can Group 18 elements become liquid despite the fact that they exist as single atoms?

- The random movement of electrons within the atoms means that temporary dipoles are induced within the atoms.
- Temporary dipoles may induce dipoles in neighbouring atoms.
- If the temperature is low enough, there will not be enough energy to overcome these weak dipole-dipole forces between the atoms, meaning the gas will condense.

Why do boiling points increase down Group 18?

Why do boiling points increase down Group 18?

The number of electrons and the atomic radius increases so there are stronger temporary dipole-dipole forces between the atoms. These stronger forces require more energy to overcome, meaning a higher temperature is required to boil the liquid to turn it into a gas.

What is metallic bonding?

What is metallic bonding?

The electrostatic attraction between positive ions and delocalised electrons.

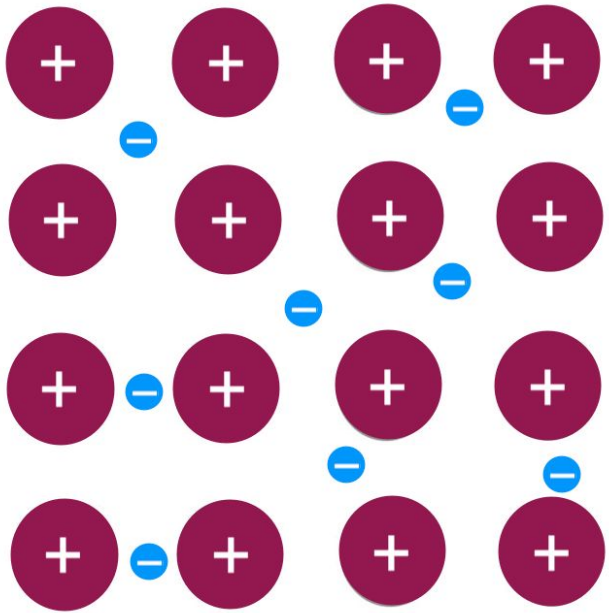
A giant metallic lattice is formed with the cations (positive ions) fixed in place.

Draw a diagram to represent metallic bonding

Draw a diagram to represent metallic bonding

Positive charges = ions

Negative charges = electrons



Why can metals conduct electricity?

Why can metals conduct electricity?

Metallic bonding means there are delocalised electrons that are free to move and carry charge throughout the entire structure.

Why do metals have a high melting point?

Why do metals have a high melting point?

The strong electrostatic attraction between positive ions and delocalised electrons requires a lot of energy to overcome to melt the substance.

Why are metals ductile and malleable?

Why are metals ductile and malleable?

The regular structure and delocalised electrons allow the layers of cations to slide over each other.

List some properties of giant covalent structures

List some properties of giant covalent structures

- High melting points - the network of many strong covalent bonds requires a lot of energy to overcome.
- Cannot conduct electricity - no mobile charged particles.
- Insoluble - the covalent lattice is too strong to be broken.

List some properties of simple covalent structures

List some properties of simple covalent structures

- Low boiling points - weak intermolecular forces (London forces) between molecules.
- Cannot conduct electricity - no mobile charges.

List some properties of ionic compounds

List some properties of ionic compounds

- High melting/boiling points - strong electrostatic attraction between oppositely charged ions required a lot of energy to break.
- Electrical conductor when aqueous or molten - the ions are free to move to carry charge. When solid, the ions are fixed so cannot carry charge.
- Soluble in polar solvents - charged parts of the solvent are attracted to the oppositely charged ions.

List the properties of molecules with hydrogen bonds between them

List the properties of molecules with hydrogen bonds between them

- Very high melting/ boiling points - hydrogen bonds are much stronger than London forces meaning more energy is needed to overcome them.
- Soluble in water - strong permanent dipoles allow the formation of hydrogen bonds with water.
- Non-conductors - no mobile charges so are unable to conduct electricity.

Is bond breaking endothermic or exothermic?

Is bond breaking endothermic or exothermic?

Endothermic (energy is taken in)

Is bond making exothermic or endothermic?

Is bond making exothermic or endothermic?

Exothermic (energy is released)