THE NATURE OF BONDS

1) TYPES OF BOND

Type of bonding	Ionic	Covalent	Metallic
Nature of bonding	Electrostatic attraction between positive and negative ions	Shared pair of electrons between atoms	Attraction between lattice of positive metal ions and delocalised outer shell electrons.
Types of structure which have this type of bonding	IONIC	SIMPLE MOLECULAR GIANT COVALENT	METALLIC
Strength of bonds	The smaller the ions and the greater the charge on the ions, the stronger the attraction between the positive and negative ions (usually).	The shorter the bond, the stronger the bond (usually). Double bonds are stronger than single bonds, while triple bonds are stronger than double bonds.	The smaller the metal ions, the greater the charge on the ions, and the more delocalised outer shell electrons there are, the stronger the attraction between the ions and electrons (usually).

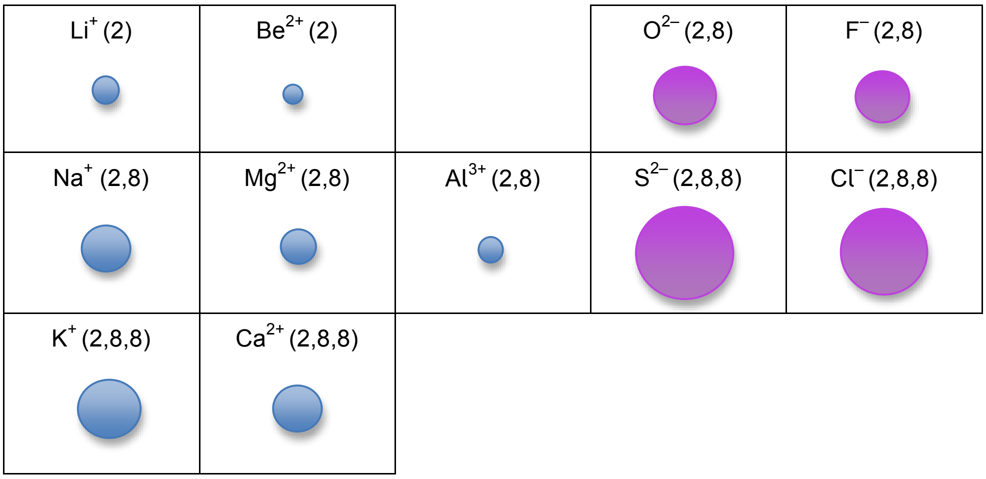
There are also three types of forces between molecules (van der Waals' forces, dipole-dipole attractions and hydrogen 'bonds'). These are **NOT** bonds because they are too weak.

2) IONIC BONDING

Strength of ionic bonding

The greater the charge on the ions, the stronger the ionic bonding. The smaller the ions, the stronger the ionic bonding (remember that ions get bigger down a group).

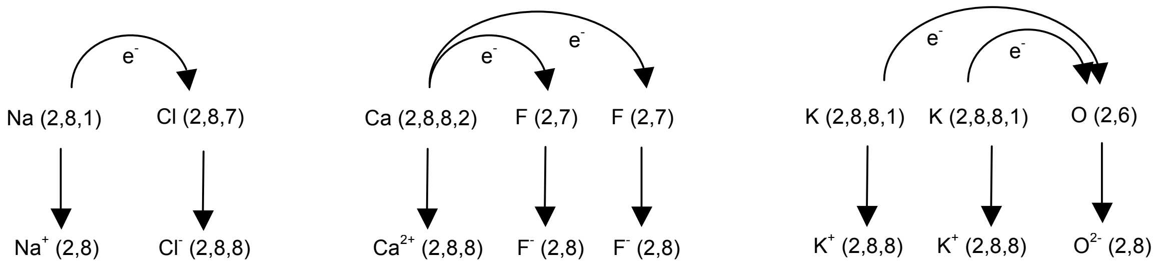
Relative size of some common ions:



TASK 1	Predict (with reasons) which one of each pair of ionic compounds will have the higher melting point by considering size and charge of ions.
a) sodium chloride v potassium chloride	
b) sodium fluoride v magnesium fluoride	
c) aluminium oxide v sodium oxide	

Formation of ions

Ions can be formed when a **metal** reacts with a **non-metal**. The metal atoms lose electrons to form positive ions while non-metal atoms gain electrons to form negative ions (both obtaining full outer shells). For example (in *over-simplified* GCSE terms)

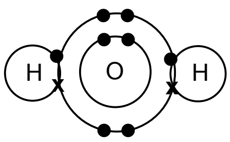
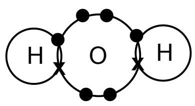
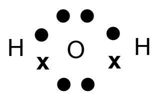


makes sodium chloride (NaCl) makes calcium fluoride (CaF_2) makes potassium oxide (K_2O)

Remember that ionic bonds are the attraction between positive and negative ions (and has nothing to do with the transfer of electrons!).

3) COVALENT BONDS

- Covalent bonds can be formed when a **non-metal** reacts with a **non-metal**.
- The atoms share electrons to obtain stable electron structures ("full outer shells").
- Two shared electrons make a **single bond**, four shared electrons make a **double bond**, and six shared electrons makes a **triple bond**.
- For example in water:

all the electrons	**dot-cross diagrams**		**stick diagram**
	outer shell electrons only	outer shell electrons only (without shell circles)	
			H—O—H

Drawing "dot-cross" diagrams

1) Draw a stick diagram (use this table to give some help).

Atoms	Group 4 atoms	Group 5 atoms	Group 6 atoms	Group 7 atoms	H
Common* number of covalent bonds	4	3	2	1	1

* Note that elements in period 3 and beyond can fit more than 8 electrons in their outer shell (due to availability of d orbitals in the shell). For example, P and S atoms can have more than electrons in the third shell (extra electrons occupy 3d orbitals).

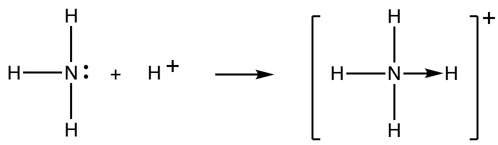
2) Re-draw the molecule without the sticks.
3) Draw a dot and a cross instead of each stick (i.e. ●**x** for a single bond, ●**x**●**x** for a double bond, etc.). Dots and crosses represent electrons from different atoms.
4) Work out how many electrons there are in the outer shell of each atom (e.g. atoms in Group 7 have 7 electrons in their outer shell), and then add in any of these electrons that are not already drawn on in the covalent bonds. (If the species has an electric charge, then that means that there are additional electrons (negative charge) or fewer electrons (positive charge)

TASK 2 Draw stick and then dot-cross diagrams for each of the following molecules and ions.	
1) F_2	11) NH_4^+
2) NH_3	12) $AlCl_4^-$
3) O_2	13) BCl_3
4) H_2S	14) SF_6
5) CH_4	15) $BeCl_2$
6) H_2	16) $BeCl_4^{2-}$
7) PF_3	17) IF_4^+
8) PF_5	18) C_2H_2
9) SO_2	19) SO_4^{2-}
10) CO_2	20) NO_3^-

Co-ordinate (dative covalent) bonds

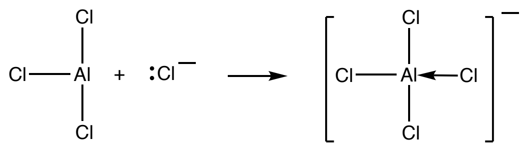
- A co-ordinate bond (dative covalent bond) is one where both the electrons come from the same species.
- They are often drawn with → rather than –, with the arrow showing the direction in which the electrons are donated.
- However, once formed, co-ordinate bonds are identical to other covalent bonds. For example, all four bonds in NH_4^+ are identical (although one was formed as a co-ordinate bond with both electrons being donated from the lone pair on the N to the H^+).

e.g. NH_4^+ $NH_3 + H^+ \longrightarrow NH_4^+$



lone pair of electrons donated from N of NH_3 to H^+

e.g. $AlCl_4^-$ $AlCl_3 + Cl^- \longrightarrow AlCl_4^-$



lone pair of electrons donated from Cl^- to Al of $AlCl_3$

TASK 3 Draw a diagram to show the formation of a co-ordinate bond in the following. In each case, state how the bond forms.	
a) BF_3 with F^- to form BF_4^-	
b) PH_3 with H+ to form PH_4^+	

4) METALLIC BONDS

The stronger the attraction between the positive metal ions and the delocalised electrons, the stronger the metallic bonding. The smaller the metal ions, the greater the charge on the ions and the more delocalised outer shell electrons there are, the stronger the metallic bonding.

TASK 4 Predict (with reasons) which one of each pair of metals will have the higher melting point.	
a) sodium v potassium	
b) sodium v magnesium	
c) potassium v aluminium	