Co-ordinate (dative covalent) bonding:

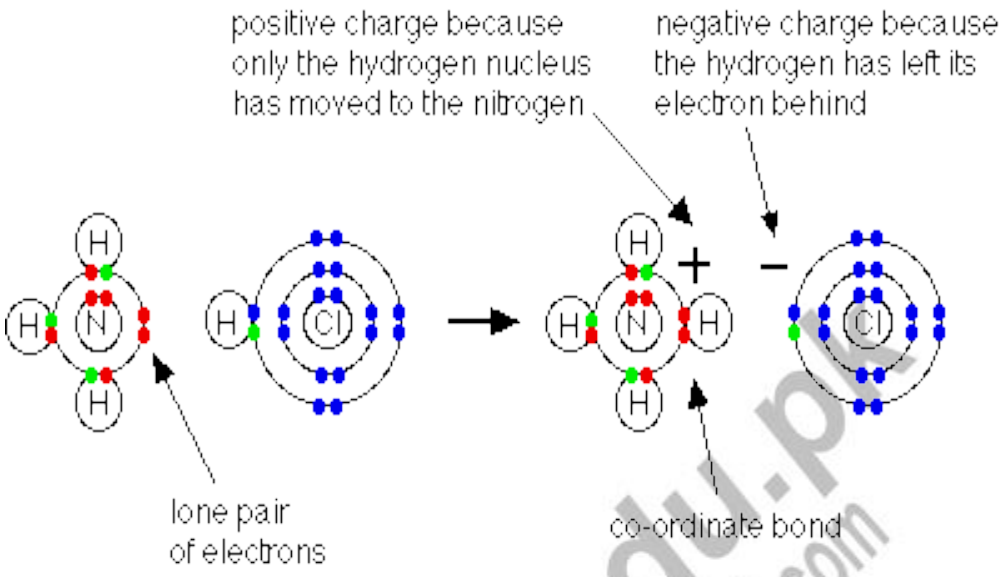
A covalent bond is formed by two atoms sharing a pair of electrons. The atoms are held together because the electron pair is attracted by both of the nuclei.

In the formation of a simple covalent bond, each atom supplies one electron to the bond - but that doesn't have to be the case. A co-ordinate bond (also called a dative covalent bond) is a covalent bond (a shared pair of electrons) in which both electrons come from the same atom.

The reaction between ammonia and hydrogen chloride:

If these gases are allowed to mix, a thick white smoke of solid ammonium chloride is formed.

Ammonium ions, NH_4^+, are formed by the transfer of a hydrogen ion from the hydrogen chloride to the lone pair of electrons on the ammonia molecule.

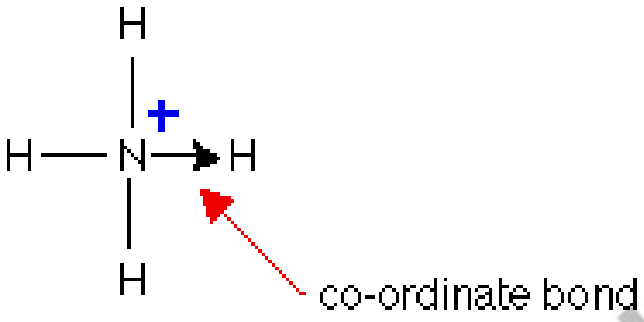


When the ammonium ion, NH_4^+, is formed, the fourth hydrogen is attached by a dative covalent bond, because only the hydrogen's nucleus is transferred from the chlorine to the nitrogen. The hydrogen's electron is left behind on the chlorine to form a negative chloride ion.

Once the ammonium ion has been formed it is impossible to tell any difference between the dative covalent and the ordinary covalent bonds. Although the electrons are shown differently in the diagram, there is no difference between them in reality.

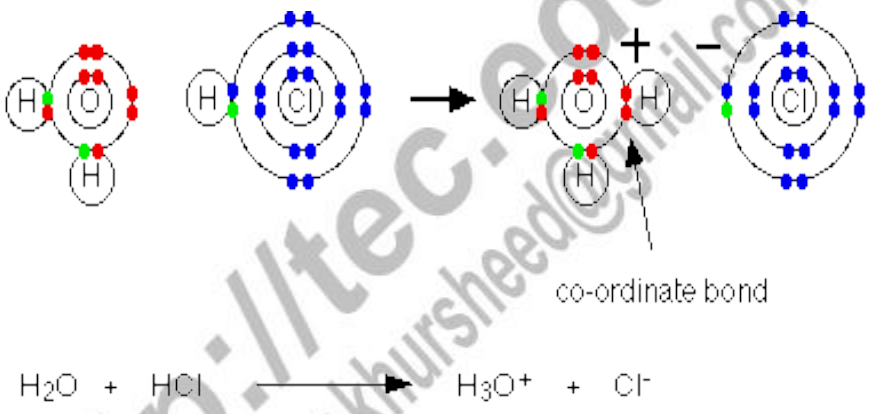
Representing co-ordinate bonds:

In simple diagrams, a co-ordinate bond is shown by an arrow. The arrow points from the atom donating the lone pair to the atom accepting it.



Dissolving hydrogen chloride in water :

Something similar happens. A hydrogen ion (H^+) is transferred from the chlorine to one of the lone pairs on the oxygen atom.



The H_3O^+ ion is variously called the hydroxonium ion, the hydronium ion or the oxo-nium ion.

In an introductory chemistry course (such as GCSE), whenever you have talked about hydrogen ions (for example in acids), you have actually been talking about the hydroxonium ion. A raw hydrogen ion is simply a proton, and is far too reactive to exist on its own in a test tube.

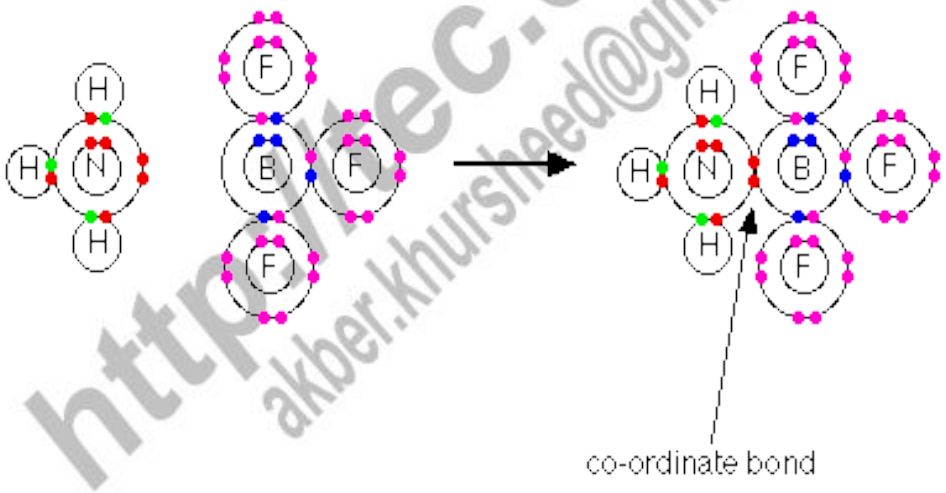
If you write the hydrogen ion as $H^+_{(aq)}$, the "$_{(aq)}$" represents the water molecule that the hydrogen ion is attached to. When it reacts with something (an alkali, for example), the hydrogen ion simply becomes detached from the water molecule again.

Note that once the co-ordinate bond has been set up, all the hydrogens attached to the oxygen are exactly equivalent. When a hydrogen ion breaks away again, it could be any of the three.

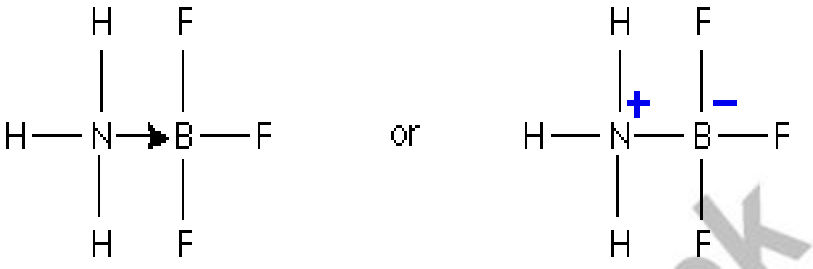
Bonding between Ammonia & Boron tri-fluoride, BF_3

If you have recently read the page on covalent bonding, you may remember boron tri-fluoride as a compound which doesn't have a noble gas structure around the boron atom. The boron only has 3 pairs of electrons in its bonding level, whereas there would be room for 4 pairs. BF_3 is described as being ***electron deficient.***

The lone pair on the nitrogen of an ammonia molecule can be used to overcome that deficiency, and a compound is formed involving a co-ordinate bond.

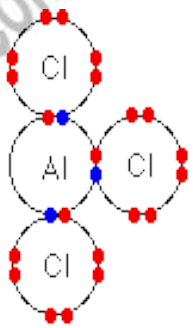


Using lines to represent the bonds, this could be drawn more simply as:



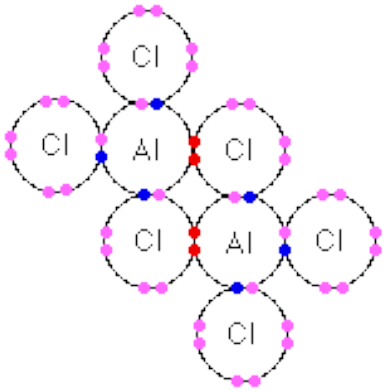
The second diagram shows another way that you might find co-ordinate bonds drawn. The nitrogen end of the bond has become positive because the electron pair has moved away from the nitrogen towards the boron - which has therefore become negative.

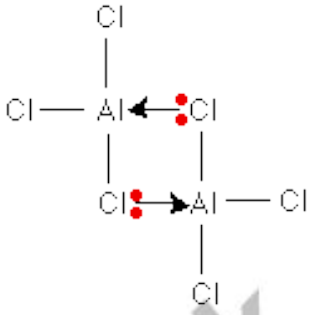
The structure of aluminum chloride:



The dots-and-crosses diagram shows only the outer electrons.

$AlCl_3$, like BF_3, is electron deficient. There is likely to be a similarity, because aluminum and boron are in the same group of the Periodic Table. The bonding between the two molecules is co-ordinate, using lone pairs on the chlorine atoms. Each chlorine atom has 3 lone pairs, but only the two important ones are shown in the line diagram.

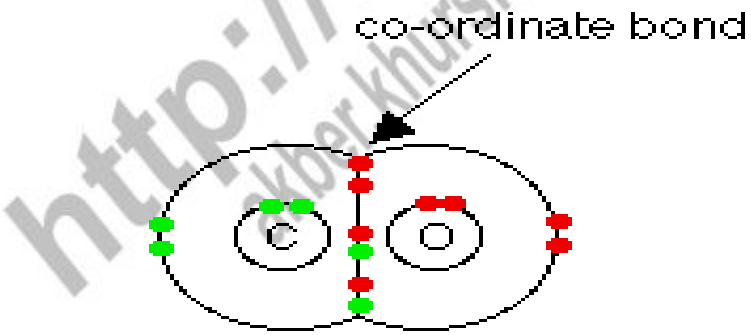




Energy is released when the two co-ordinate bonds are formed.

Carbon monoxide CO:

Carbon monoxide can be thought of as having two ordinary covalent bonds between the carbon and the oxygen plus a co-ordinate bond using a lone pair on the oxygen atom.



Nitric acid: HNO_3

In this case, one of the oxygen atoms can be thought of as attaching to the nitrogen via a co-ordinate bond using the lone pair on the nitrogen atom.