Answer the questions below then check your answers.

1. If a molecule, atom or ion has a lone pair of electrons, what does this mean?

2. How is a dative covalent bond different from a normal covalent bonds?

3. Draw a dot and cross diagram for the molecule boron trifluoride (BF_3). Only draw the outer shell electrons

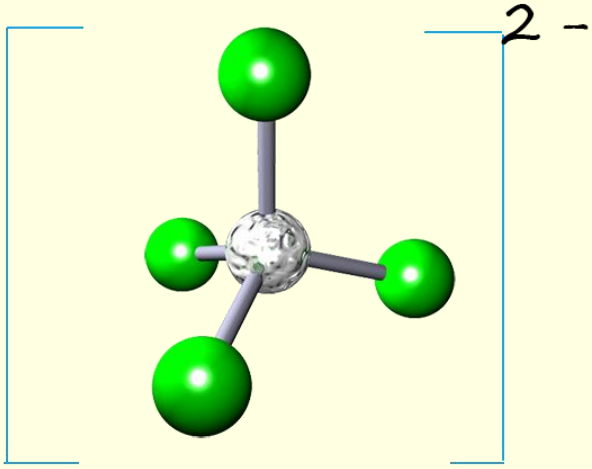
a. Boron trifluoride (BF_3) is described as an electron deficient molecule, what do we mean by this statement?

b. Draw a dot and cross diagram to show the bonding in ammonia (NH_3), show any lone pairs present.

c. Draw a diagram to show how ammonia can form a dative covalent bond with a molecule of boron trifluoride.

4. When a dilute acid is added to water the hydrogen ions in the acid form dative covalent bonds to water molecules. Draw a diagram clearly showing the formation of the dative bond.

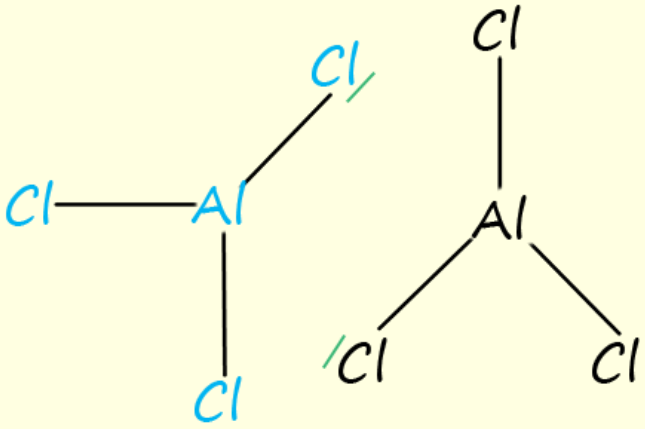
5. The cobalt ion can form 4 co-ordinate bonds to chloride ions as shown in the diagram opposite.



a. What charge is on the metal cobalt ion?

b. Explain why the chloride ion is able to form dative covalent bonds with the cobalt ion.

6 Complete the diagram below to show how two aluminium chloride ($AlCl_3$) molecules are able to dimerise and form Al_2Cl_6 molecules.



Answers

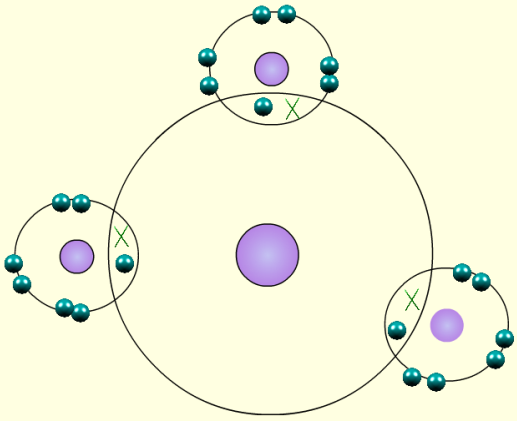
1. If a molecule, atom or ion has a lone pair of electrons, what does this mean?

   It contains a non-bonding pair of electrons.

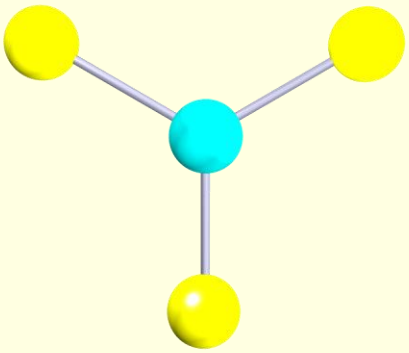
2. How is a dative covalent bond different from a normal covalent bonds?

   Once formed a dative covalent bond is identical to a normal covalent bond. The only difference is in the way the bond is formed. In a covalent bond 2 electrons are shared, with each electron in the bond coming from a different atom or ion. In a dative covalent bond one atom or ion supplies both the electrons in the bond.

3. Draw a dot and cross diagram for the molecule boron trifluoride (BF_3). Only draw the outer shell electrons.

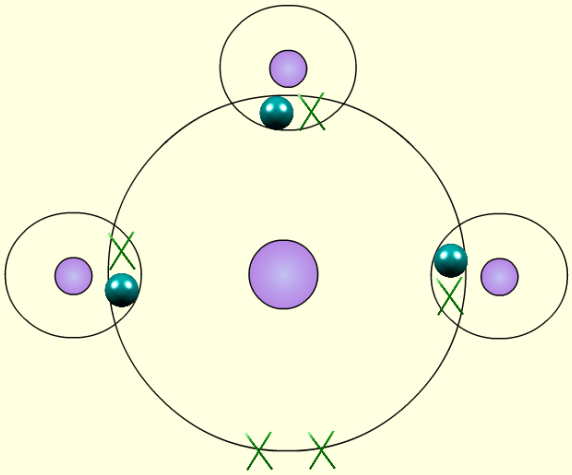


a. Boron trifluoride (BF_3) is described as an electron deficient molecule, what do we mean by this statement?

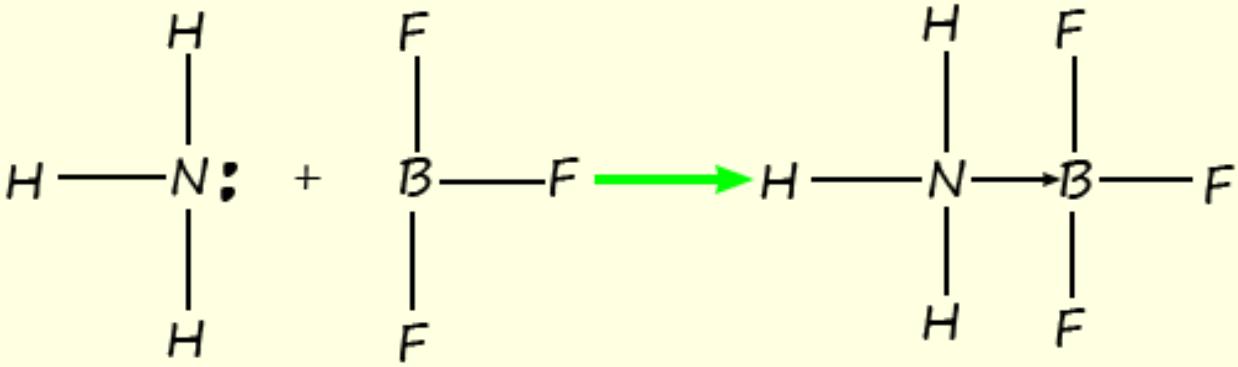


The boron trifluoride molecule is shown opposite. The central boron atom makes 3 covalent bonds to each of the fluorine atoms. Since the the central boron atom is only making 3 bonds, it only has 6 electrons in its outer or valence shell, 2 electrons less than the octet. So it is described as electron deficient. This also means it will have empty orbitals which can accept electrons and complete its octet.

b. Draw a dot and cross diagram to show the bonding in ammonia (NH_3), show any lone pairs present.

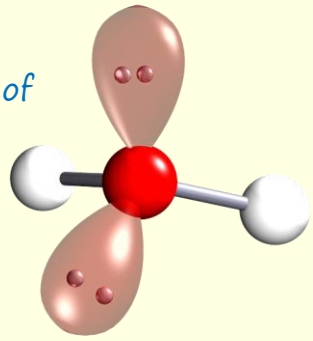


c. Draw a diagram to show how ammonia can form a dative covalent bond with a molecule of boron trifluoride.

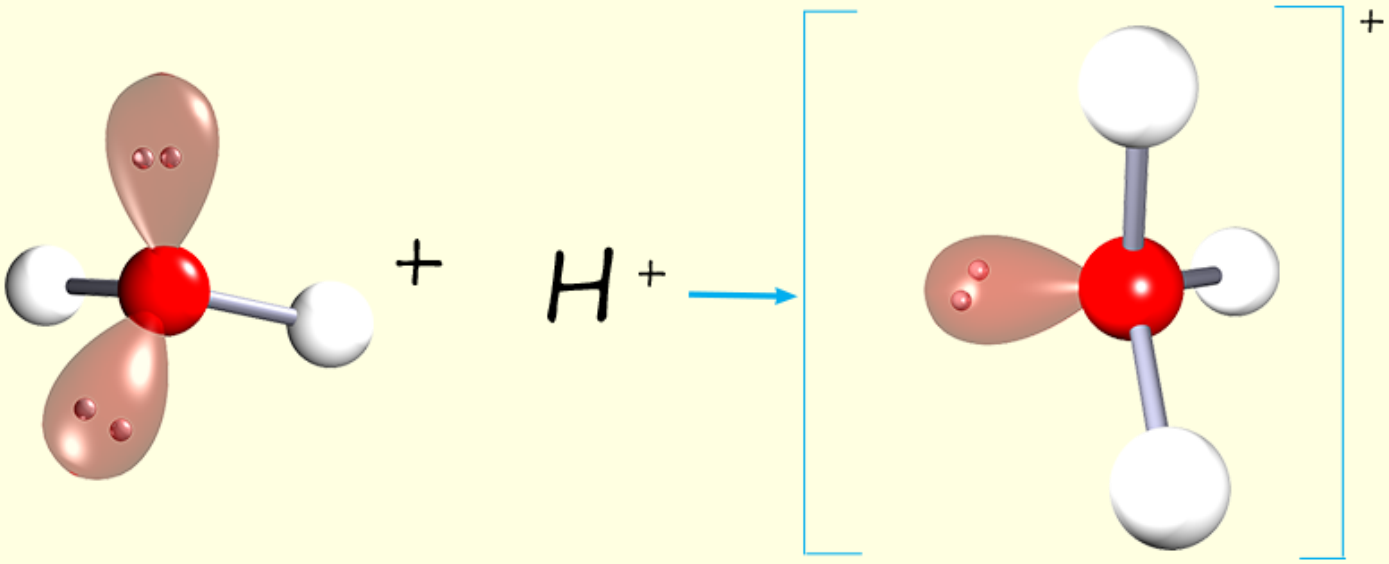


4. When a dilute acid is added to water the hydrogen ions in the acid form dative covalent bonds to water molecules. Draw a diagram clearly showing the formation of the dative bond.

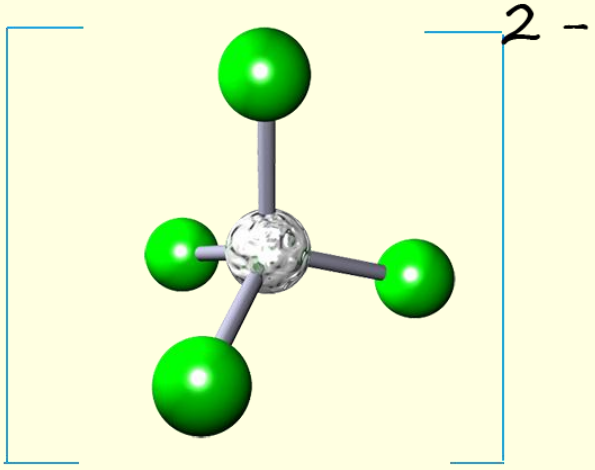
A water molecule has 2 lone pairs or 2 non-bonding pairs of electrons as shown in the drawing opposite. These lone pairs of electrons can be used to form dative covalent bonds.



The hydrogen ion has no electrons to form a covalent bond to the water molecule, so the water will supply both electrons and form a dative covalent bond with the hydrogen ion (H^+).



5. The cobalt ion can form 4 co-ordinate bonds to chloride ions as shown in the diagram opposite.



a. What charge is on the metal cobalt ion?

Molecule has a 2- charge, each chloride has a - charge, this makes 4- from all the chlorides, so charge on cobalt ion must be 2+.

b. Explain why the chloride ion is able to form dative covalent bonds with the cobalt ion.

The chloride ion has 4 lone pairs and so can form multiple dative covalent bonds. Though do not assume that because it has 4 lone pairs it will form 4 dative covalent bonds. This is unlikely as chloride ions are small and will not be able to fit 4 other species round them. You would also have to consider the geometry of the bonds being formed.

6 Complete the diagram below to show how two aluminium chloride ($AlCl_3$) molecules are able to dimerise and form Al_2Cl_6 molecules.