The name's Bond, - Chemical bond. 1.6

1. The hydrogen - oxygen bond in water is polarised as shown in the diagram below

$$\overset{\delta+}{H}—\overset{\delta-}{O}$$

(a) Explain why the bond is polarised as shown above.
(b) For any of the following bonds which is polar, draw similar diagram to show the bond polarity.

(i) hydrogen to chlorine (ii) nitrogen to chlorine (iii) hydrogen to sulphur

(iv) sulphur to chlorine (v) phosphorous to chlorine (vi) phosphorous to hydrogen

2. Whilst methane (CH_4) and ammonia (NH_3) both contain polar bonds the methane molecule is non polar and the ammonia molecule is polar. The effect of the polarity can be seen if we compare molecular masses and boiling points. Although both molecules have similar masses methane boils at 109 K and ammonia boils at 240 K.

(a) (i) Draw diagrams showing the molecular shape of methane and ammonia.
(ii) Explain using the diagrams why methane is non polar and ammonia is polar.
(b) Why must we consider molecular mass when examining the boiling point of covalent compounds?

3. On the basis of standard grade work we would expect that sodium chloride and titanium chloride would both be typical ionic solids. Sodium chloride is a solid which melts at 1074 K while titanium chloride is a liquid at room temperature which boils at 450 K.

(a) What type of bonding exists in each compound.
(b) Explain why not all metal - non metal compounds are ionic.

4. An anhydrous chloride of iron is a volatile red solid which dissolves in hexane. It also dissolves in water forming an aqueous solution from which a hydrated salt can be crystallised. The percentage composition by mass of the salt is shown in the table below.

Element	% by Mass
Iron	20·7
Chlorine	39·4
Hydrogen	4·4
Oxygen	35·5

(a) What type of bonding is present in the chloride of iron? Explain your answer.
(b) Calculate the empirical formula for the crystalline salt.
(c) Suggest the formula which would be used, along with the name, on the label of a bottle of the crystalline salt.

(1) (a) The O atom has a stronger pull on the bonding electrons than the H atom (O has a greater electronegativity than H). The two bonding electrons therefore spend more of their time around the O atom than the H atom. This results in the O atom having a partial negative charge (δ^-) and the H atom a partial positive charge ($\delta+$). The bond is said to be polarised

(b) (i) $\overset{\delta+}{H} - \overset{\delta-}{Cl}$

(ii) $N - Cl$ (Pure covalent)

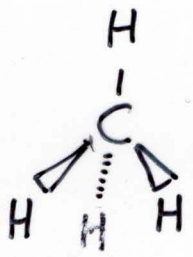
(iii) $\overset{\delta+}{H} - \overset{\delta-}{S}$

(iv) $\overset{\delta+}{S} - \overset{\delta-}{Cl}$

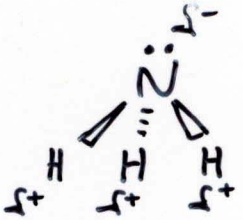
(v) $\overset{\delta+}{P} - \overset{\delta-}{Cl}$

(vi) $P - H$ (Pure covalent)

(2) (a) (i)



METHANE



AMMONIA

(ii) The methane molecule is tetrahedral in shape (The 4 C-H bonds point to the corners of a regular tetrahedron). The resulting molecule is non-polar because there is no net dipole in the molecule

The ammonia molecule is pyramidal in shape Each N-H bond is polar making each H atom partially positive and the N atom partially negative. As well as this there is a 'lone pair' of electrons on the N atom. This gives the N atom a fairly large -ve charge. The net result is a Net dipole in the molecule. The molecule itself is said to be polar

(b) Boiling points are related to the forces of attraction between molecules. (These are Van Der Waals forces, Permanent dipole - Permanent dipole interactions, and Hydrogen bonds).
Van Der Waals forces are always present and These are related to molecular mass. If other intermolecular bonds are present Then to make a fair comparison, The molecules must be of approximately equal mass.

(3) (a) SODIUM CHLORIDE – IONIC

TITANIUM CHLORIDE – COVALENT MOLECULAR

(b) Sodium chloride exists as a crystalline ionic substance. To melt the substance, ionic bonds must be broken, Thus the high temperature required. The difference in electronegatives between Na & Cl is large resulting in the formation of ions

Titanium chloride exists as a discrete molecular substance. To separate the molecules, only intermolecular bonds need be broken, Thus the low melting point temperature The difference in electronegativities between Ti & Cl is not great enough to form ions and an ionic crystal lattice.

(4)

(a) POLAR COVALENT.

The fact that the compound is VOLATILE suggests molecules (ionic compounds are very stable).

The ability to dissolve in hexane (a non polar solvent) suggests again molecules.

Being able to dissolve in water suggests polar bonding which would also be needed to attract water molecules in forming the hydrated salt.

(b)

Elements present	Fe	Cl	H	O
% by mass	20.7	39.4	4.4	35.5
mols	$\frac{20.7}{55.8}$	$\frac{39.4}{35.5}$	$\frac{4.4}{1}$:	$\frac{35.5}{16}$
	0.37	1.11	4.4	2.2
divide by smallest N°	$\frac{0.37}{0.37}$	$\frac{1.11}{0.37}$	$\frac{4.4}{0.37}$	$\frac{2.2}{0.37}$
	1	: 3 :	12 :	6.

Empirical formula = $FeCl_3H_{12}O_6$.

(c) Formula : $FeCl_3(H_2O)_6$

Name : hydrated iron III chloride.

Shapes of Species 1.7

1. Draw Lewis dot cross diagrams for the following substances:

(a) fluorine (b) methane

(c)water (d) ammonia

2. Ammonia can act as a proton acceptor and form an ammonium ion.

(a) Use VSEPR theory to draw the shape of the following
(i) Ammonia (ii) an ammonium ion
(b) Ammonium ions contain a dative covalent bond. Explain this term.
(c) Although theory would predict that the dative NH bond in ammonium ions would be of a different length from the covalent NH bonds, we find that all the NH bonds are the same length. Explain this fact.

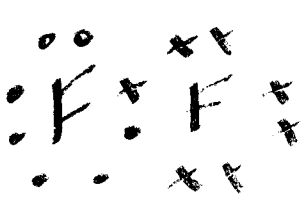
3. Fluorine is the most reactive non metal. It forms compounds with most other elements. Five of the compounds of fluorine are BF_3, NF_3, CF_4, PF_5, and SF_6. For each comound

(a) Calculate the number of bonding and non bonding electron pairs.
(b) Name and draw the shape of the molecules.
(c) In CF_4 the bond angle is 109·5°, whereas in NF_3 the bond angle is 107°. Explain this.
(d) There are two different bond angles in PF_5. Draw a molecule of PF_5 with the angles labelled and the size of each angle shown.

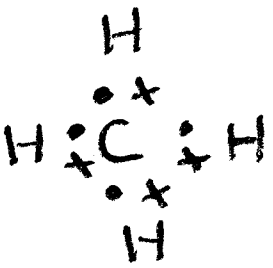
4. Chlorine and fluorine react together to produce a compound of formula ClF_3. This molecule contains three chlorine-fluorine single bonds. Each fluorine atom contributes **one** electron to the bonding.

(a) How many bonding and non bonding electron pairs surround the central chlorine atom in the molecule?
(b) What would be the three dimensional arrangement of electron pairs (both bonded and non bonded) around the chlorine atom?
(c) The fluorine atoms may occupy different positions in this shape giving three possible shapes for each molecule. Draw **two** of these showing the angles between the bonds.

1 (a)

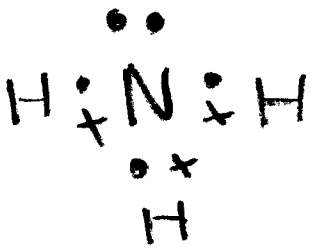


(b)



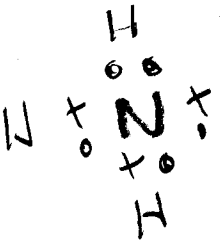
(c)

(d)



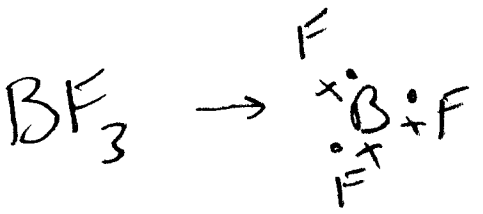
2. (i) from 1(d) it can seen that ammonia has 3 bonding and 1 non-bonding electron pairs in outer shell of central N atom therefore shape of electron 4 pairs will be tetrahedral However bonding pairs will be pyramidal shape

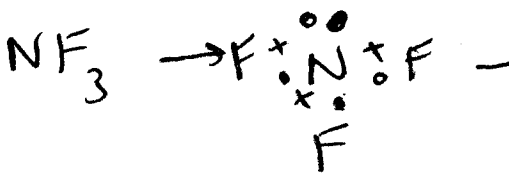
(ii) the ammonium has the following electron arrangement

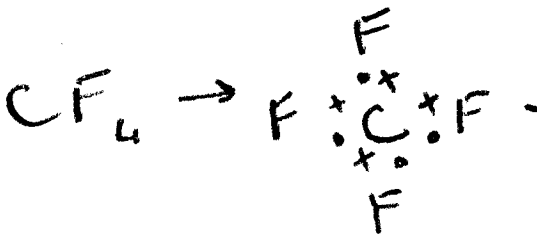


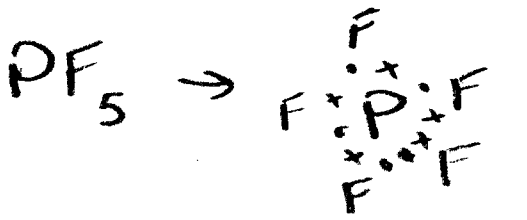
Therefore it has a total four electron pairs which are all bonding pairs therefore shape will be tetrahedral.

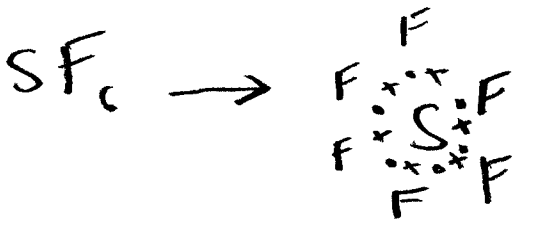
3(a)

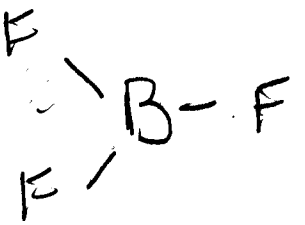
BF_3 →  → 3 bonding pairs
0 non bonding pairs

NF_3 →  → 3 bonding pairs
1 non bonding pairs

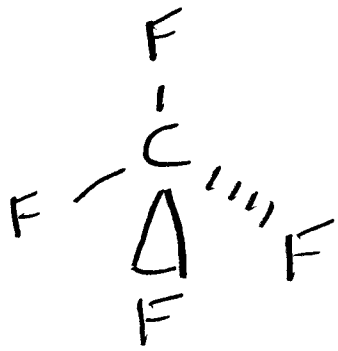
CF_4 →  → 4 bonding pairs
0 non bonding pairs

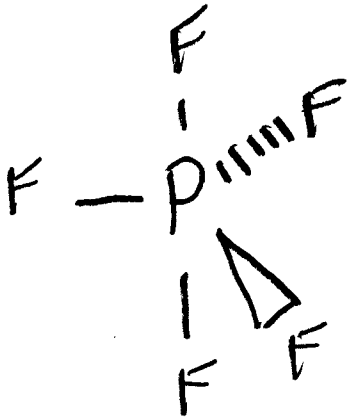
PF_5 →  → 5 bonding pairs
0 non bonding pairs

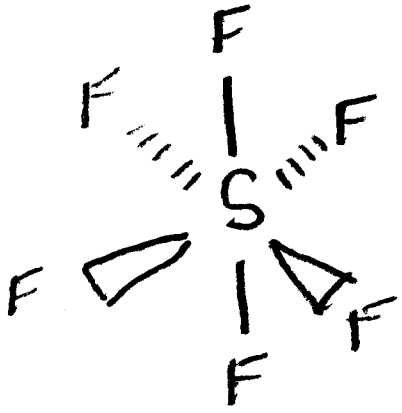
SF_6 →  → 6 bonding pairs
0 non bonding pairs

(b) BF_3  trigonal

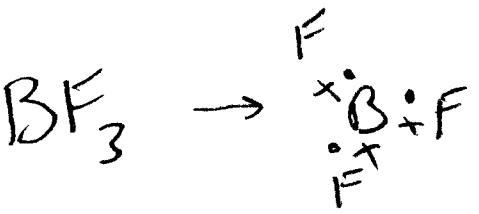
NH_3  pyramidal

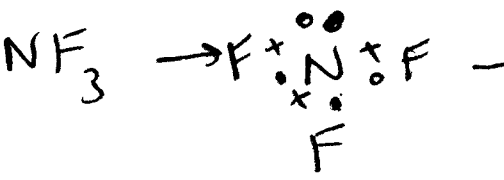
CF_4  tetrahedral

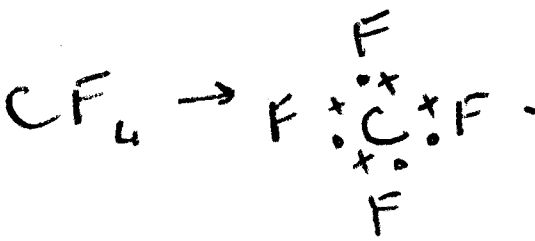
PF_5  trigonal bipyramidal

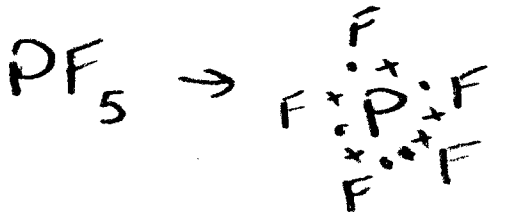
SF_6  octahedral

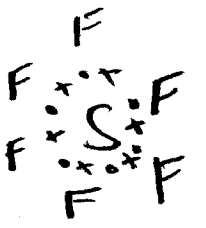
3(a)

BF_3 →  → 3 bonding pairs
0 non bonding pairs

NF_3 →  → 3 bonding pairs
1 non bonding pairs

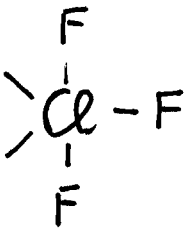
CF_4 →  → 4 bonding pairs
0 non bonding pairs

PF_5 →  → 5 bonding pairs
0 non bonding pairs

SF_6 →  → 6 bonding pairs
0 non bonding pairs

ClF_3

Chlorine $1s^2\ 2s^2\ 2p^2\ 3s^2\ 3p^5$



TRIGONAL BIPYRAMIDAL

(a) 3 bonding pairs
2 non bonding pairs

(b) Trigonal Bipyramidal (more probably. T- shaped)

(c)