LEAVING CERTIFICATE CHEMISTRY NOTES 2016/2017

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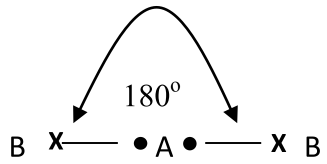
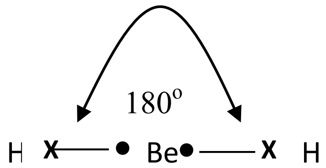
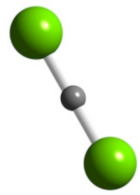
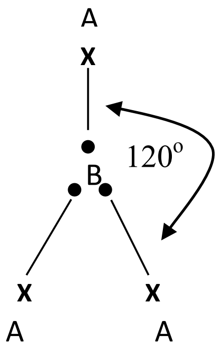
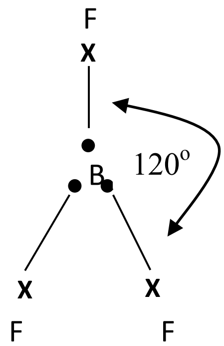
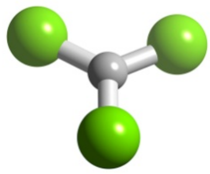
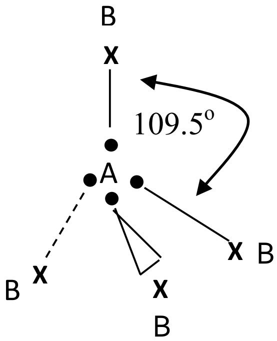
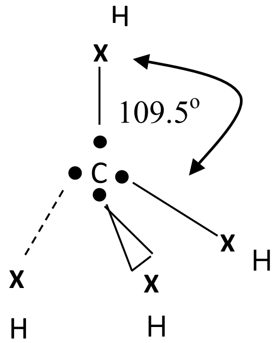
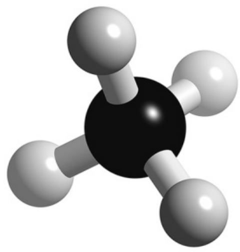
These notes are compiled based on the State Examinations Commission (SEC) syllabus with reference to teacher guidelines. All areas covered correlate with past exam papers (including 1990s) and some sample pre/mock papers. The "higher order questions" are designed to anticipate future questions which bring together multiple parts of the course to test understanding and reasoning. Marking schemes are also linked in to relevant parts with special attention on common student mistakes and how to achieve full marks in each question.

2.5 Shapes of Molecules and Intermolecular Forces

Simple Molecules

GENERAL SHAPE	EXAMPLES	3-D IMAGE
LINEAR 2 Bond Pairs **AB_2** 	**BeH_2** 	
TRIGONAL PLANAR 3 Bond Pairs **AB_3** 	**BF_3** 	
TETRAHEDRAL 4 Bond Pairs **AB_4** 	**CH_4** 	

Using Electron Pair Repulsion Theory to Explain Shapes of Molecules

Typical Exam Question –Describe the shape of ammonia

1. **N has 3 bonding** and **1 non-bonding** (lone) pair (Each H has 1 bond pair)
2. The bond arrangement causes the shape of the molecule to be **pyramidal**

Electron Pair Repulsion Theory

Bond Angles

1. AB_3 with no lone pairs has a bond angle of 120°
   AB_3 with 1 lone pair has a bond angle of 107°

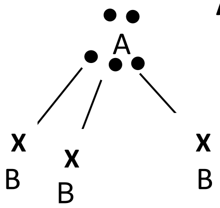
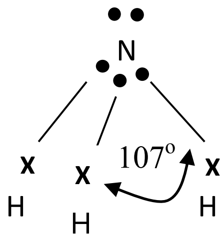
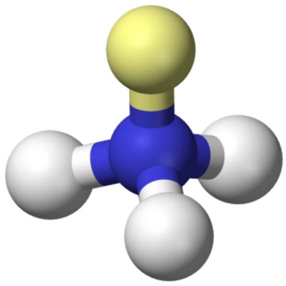
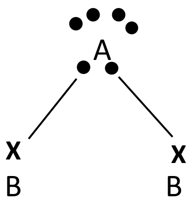
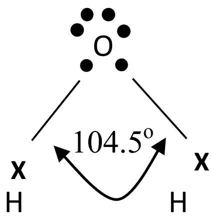
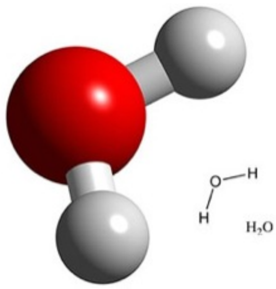
2. AB_2 with no lone pairs has bond angle of 180°
   AB_2 with 2 lone pairs has bond angle of 104.5°

Theory

- Lone pairs have greater repulsion of each other – i.e. lone pair in contact with lone pair will produce the greatest repulsion, followed by lone pair in contact with bond pair and finally the weakest, bond pair in contact with bond pair
- L.P:L.P > L.P:B.P > B.P:B.P (Repulsion) **
- Lone pair wants to get as far apart as geometrically possible from each other pushing bonds closer together **

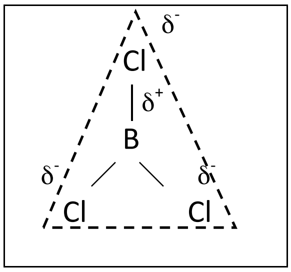
** **Both points are required to get full marks**

Complex Molecules

GENERAL SHAPE	EXAMPLES	3-D
PYRAMIDAL 3 Bond Pairs + 1 Lone Pair **AB_3**  A has to be in group 5 - 1 lone pair	**NH_3** 	
V-SHAPED 2 Bond Pairs + 2 Lone Pairs **AB_2**  A has to be in group 6- 2 lone pairs	**H_2O** 	

Relationship between Symmetry and Polarity in a Molecule

B – Cl



- Electronegativity difference = 1.12
- Therefore one may assume it is polar
- However, BCl_3 is actually non-polar
- This is due to unequal sharing of electrons between B and Cl (i.e. polarity) cancels due to symmetry of molecule
- Centres of positive and negative charges coincide
- BCl_3 has a trigonal planar shape which has symmetry

Intermolecular Forces

Attractive/Repulsive attractive forces **between** molecules

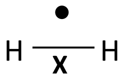
Types of Intermolecular Forces:

1. Van der Waal's forces
2. Dipole-dipole
3. Hydrogen Bonding

Van der Waal's Forces

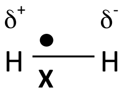
Very weak intermolecular forces

Up until now H_2 was represented as:



giving rise to **a pure covalent intramolecular bond**

But, in reality the 2 electrons in H_2 are moving from side to side creating temporary charges



creating temporary polarity, known as **a temporary dipole** within the molecule

The greater number of electrons in a molecule, the greater number of possible temporary dipoles, and therefore the greater intermolecular attraction

This means that Van der Waal's forces increase with an increasing size of molecule – i.e. bigger molecule has more electrons

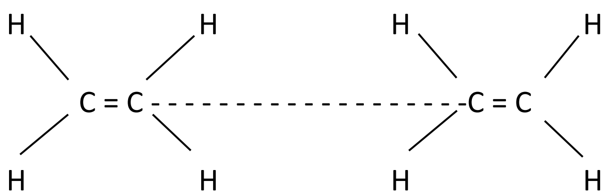
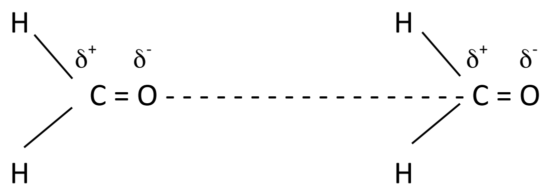
These weak intermolecular forces increase the boiling point with the more temporary dipoles

E.g. Oxygen (16 electrons) has a much higher boiling point than Hydrogen (1 electron) – *syllabus*

Dipole-dipole

- Intermolecular forces between polar molecules
- Differ from Van der Waal's forces **by permanent dipoles due to the polarity** of the molecule

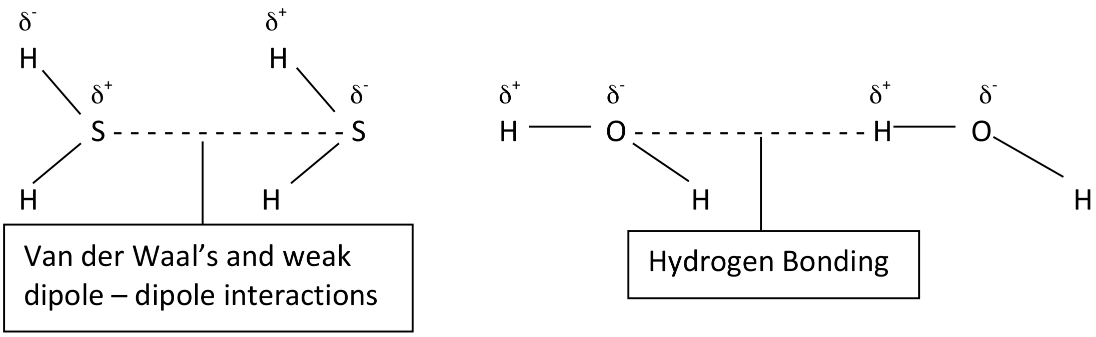
- Due to permanent dipole the boiling point of molecules with dipole-dipole interactions are much higher than molecules with Van der Waal
- ***Syllabus:*** **Ethene C_2H_4 (Mr=28) should have similar boiling point to Methanal HCHO (Mr=30), however Methanal has a much higher boiling point due to stronger intermolecular bonding**

Ethene contains Van der Waal's forces only:	Methanal contains dipole-dipole forces only:
	

Hydrogen Bonding

> **Intermolecular attraction** involving a slightly positive hydrogen atom bonded to a **small** **highly** electronegative element such as F, O or N

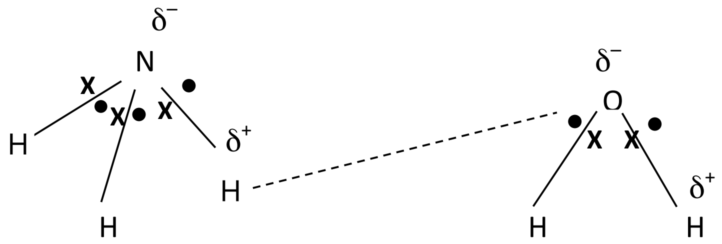
- This is because the **molecules are highly polar**
- E.g. in water molecules, O – H is highly polar (large electronegativity value)
- **H_2S should have a higher boiling point to water due to greater relative molecular mass. But since the H – S bond is less polar than the O – H bond in water it has a much lower boiling point than water –** ***syllabus example***



H_2S has an electronegativity difference of 0.38 which means it is between polar and non-polar

Application of Knowledge: Dissolving Properties

Ammonia and Water:



Process

- ➢ The slightly negative O in water bonds with the H in ammonia
- ➢ The slightly negative N in ammonia bonds with H in water
- ➢ Breaking of hydrogen bonds in water
- ➢ Forming of hydrogen bonds between ammonia and water

Note: Even though both compounds contain hydrogen bonding, water has a much higher boiling point because of larger electronegativity difference in the OH bond than the NH bond of ammonia

2012: state how bonding in PH_3 differs from NH_3, H_2O, HCl

- PH_3 = non-polar
- NH_3, H_2O, HCl = polar

Reason for this difference in bonding?

- Tiny electronegative different in PH_3

- Large electronegative difference in the others
- As the bonding type gets stronger:
    - Increase in boiling point
    - Increase in melting point