Higher Chemistry: Unit 1 - Chemical Changes and Structure

Part B – Bonding, Structure and Properties

Lesson 4 – Van der Waal's Forces: London Dispersion Forces

Learning Outcomes

By the end of this lesson you should know:

1. Three types of Van der Waal's forces
2. How London Dispersion Forces arise
3. That some substances will have stronger London Dispersion Forces that others

Success Criteria

You will have been successful in this lesson if you:

1. Watch Ms Hastie's screencast of this lesson
2. Read and learn the material given
3. Attempt the tasks set
4. Complete Exercise 1.8 and check your answers.

There is also a further reading section to help you gain more depth of understanding for this section.

MS Teams will be monitored throughout the week by a chemistry teacher. If you need help or clarification with either the task or the content of the lesson, just ask.

Links to Prior Knowledge

You may wish to revise the following to help you understand this lesson:

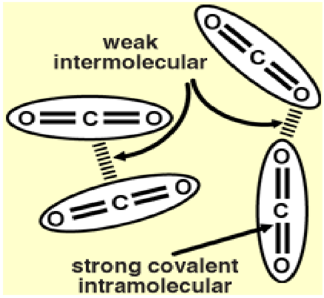
- National 5 chemistry – covalent molecular bonding

- Data booklet https://www.sqa.org.uk/sqa/files_ccc/ChemistryDataBooklet_NewH_AH-Sep2016.pdf

Introduction - You don't need to write this part down, just read it, or watch Ms Hastie's lesson below…

WATCH – Ms Hastie's screencast of this lesson: LDFs

Van der Waals forces are the forces of attraction between molecules. These are also known as intermolecular forces and are much weaker than the strong covalent bond found within molecules.



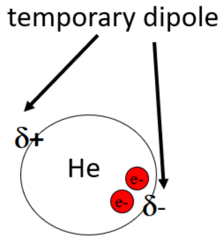
We are going to learn about 3 types of Van der Waals forces:

1. London Dispersion Forces
2. Permanent dipole to permanent dipole interactions
3. Hydrogen Bonds

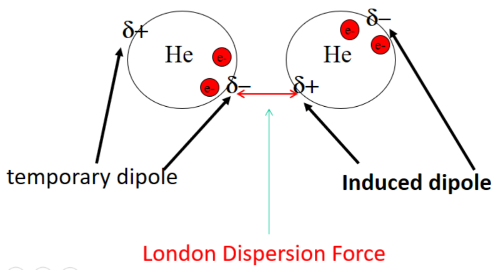
When a substance melts or boils, it is the Van der Waals forces that are broken, not the strong covalent bonds within the molecule. As such, the melting and boiling point of a molecular substance is dependent on the strength of the Van der Waals Forces. It is possible for a molecule to have more than one of these types of forces.

We will start with London Dispersion Forces (LDFs) because these exist between all atoms and molecules. LDFs arise due to the movement of electrons around an atom.

Electrons move around the atom in random directions, which means that at any one time, there is often more electrons on one side of the atom that the other. This electron density causes a temporary dipole. In other words, one side of the molecule is slightly more positive (δ+) and the other side is slightly more negative (δ-).



Now imagine that another atoms comes close by. The electrons of the nearby atom are repelled by the electron density of the temporarily dipole, pushing them to the other side of that atom, creating a second dipole. This called an induced dipole.



The result is an attraction between the two dipoles, which is what we call the London Dispersion Forces.

Notes - Below is the summary you should write/ save / print a stick into your notes

Intermolecular forces of attraction (Van der Waals')

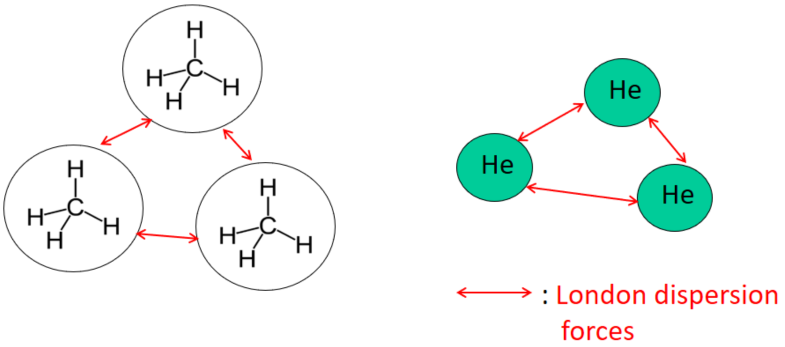
Van der Waals are the weak forces of attraction between molecules. These are weaker than metallic, ionic and covalent bonds and include:

1. London dispersion forces *(LDFs)*
2. Permanent dipole to permanent dipole interactions *(Pd-Pd Interactions)*
3. Hydrogen bonds *(H Bonds)*

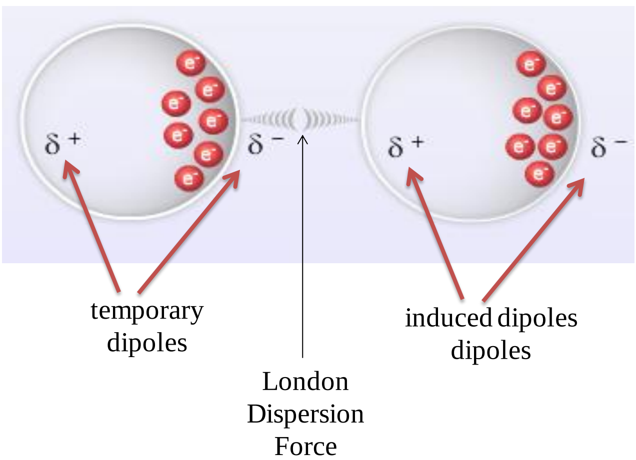
1. London Dispersion Forces (LDFs)

London Dispersion Forces are weak forces of attraction which operate between all atoms and molecules. LDFs are the weakest Van der Waals forces.

Even the noble gases (monatomic) and non-polar molecules have LDFs between them.



Definition: LDFs are the forces of attraction between **temporary dipoles and induced dipoles** caused by movement of electrons in atoms and molecules.



Strength of London Dispersion Forces

The strength of LDFs increase as the number of electrons increase.

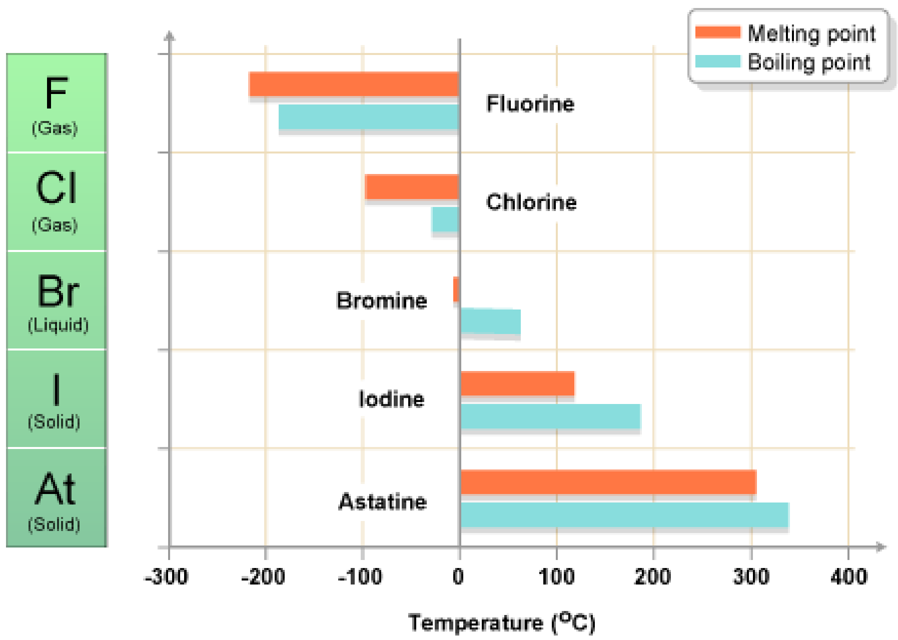
Substances with similar numbers of electrons will have similar strengths of LDFs.

Stronger LDFs → Higher melting and boiling point

TASK:

1. *Use your data booklet to find the number of electrons for each of the halogens in the table below. (remember the halogen exist as diatomic molecules, so for fluorine, the number of electrons in an F_2 molecule is 2 x 9 = 18)*

2. *How does the number of electrons in each molecule relate to the melting and boiling point of the halogens? (Answer below)*



The melting point and boiling point of the halogens increase as you go down the group because the number of electrons increase, causing stronger LDFs between the molecules.

Learning Outcomes

You should now know:

1. Intermolecular forces acting between molecules are known as Van der Waal's
2. London dispersion forces, permanent dipole-permanent dipole interactions and hydrogen bonds are all types of Van der Waals Forces.
3. London dispersion forces operate between ALL atoms and molecules are the weakest intermolecular force.
4. LDFs are formed as a result of electrostatic attraction between temporary dipoles and induced dipoles caused by movement of electrons in atoms and molecules.
5. The strength of London dispersion forces is related to the number of electrons within an atom or molecule.

Further Reading

To learn more about the bonding continuum. Follow the links below:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zt9887h

Read page 6

Evans2 chem web: https://www.evans2chemweb.co.uk/login/index.php#

Username: snhs password: giffnock

Select any teacher → revision material → CfE Higher → Structure and Bonding

Questions

Complete Exercise 1.8 and check your answers

Exercise 1.8 – London Dispersion Forces

1. Hydrogen has the formula H_2. The intramolecular forces in hydrogen are much greater than the intermolecular forces.

(a) Explain the meaning of the underlines words.
(b) (i) Write an equation, including state symbols to represent the change occurring when liquid hydrogen boils.
(ii) Which bonds are broken when hydrogen boils?
(iii) What does this indicate about the relative strengths of Intermolecular forces and covalent bonds?

2. The only forces between atoms of the noble gases are London Dispersion Forces. Differences in these forces are responsible for the variation in boiling points of the noble gases.

(a) Construct a table showing the boiling points of the noble gases from helium to radon.
(b) Explain the trend observed in the boiling points of the noble gases.
(c) What name is given to substances like the noble gases which exist as single atoms?
(d) Describe the origin of London Dispersion Forces.

3. In a sample of methane gas there are two types of forces of attraction. These are covalent bonds and London Dispersion Forces. Although covalent bonds are much stronger than London dispersion forces, it is the London Dispersion Forces which are responsible for the variation in boiling points of the alkanes.

(a) Construct a table showing the boiling points of the first five alkanes.
(b) Draw a diagram showing two molecules of methane. Label the diagram to show the difference between London Dispersion Forces and covalent bonds.

4. Covalent bonds are very strong, yet hexane has a low boiling point.

(a) What is the boiling point of hexane?
(b) Explain why hexane has a low boiling point, despite containing strong covalent bonds.

5. The boiling points of the halogens depend on the London Dispersion Forces which exist between halogen molecules.

With reference to the boiling points and numbers of electrons of fluorine and chlorine (from the data booklet), show that the London Dispersion Forces between halogen molecules depend on the number of electrons in the halogen molecule.

Exercise 1.8 – ANSWERS

1. (a) **Intra**molecular means bonds between atoms.

Intermolecular means forces of attraction between molecules

(b) (i) $H_2(l) \rightarrow H_2(g)$ (l = liquid, g = gas)

(ii) London dispersion forces (accept Van der Waals forces)

(iii) Intermolecular forces are much weaker than covalent bonds.

2. (a)

Noble Gas	Boiling Point / °C
helium	-269
neon	-246
argon	-186
krypton	-153
xenon	-108
radon	-62

(b) The boiling points of the noble gases increase as we descend the group because the number of electrons in the molecules increase. This causes an increase in the strength of London dispersion forces which means more energy is needed to overcome these forces.

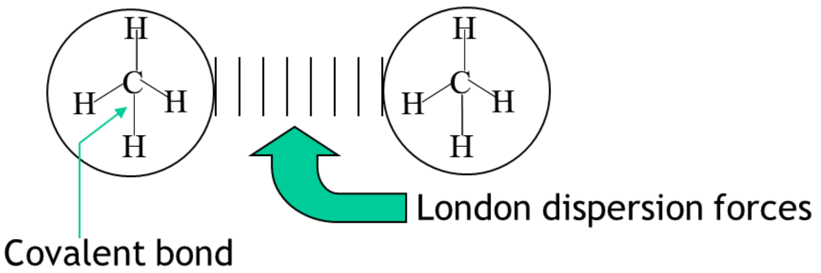
(c) Monatomic

(d) LDFs are forces of attraction between temporary dipoles and induced dipoles between atoms or molecules, caused by the movement of electrons around the atoms or molecules.

3. (a)

Alkane	Boiling Point / °C
methane	-162
ethane	-189
propane	-42
butane	-1
pentane	36

(b)



4. (a) 69°C

(b) When hexane boils it is the weak London dispersion forces between the molecules that are broken and not the strong covalent bonds. (Therefore only a relatively small amount of energy is needed to break the London dispersion forces.)

5. Fluorine, which has 18 electrons per molecule, has a boiling point of -188°C and chlorine, which has 34 electrons per molecule, has a boiling point of -34°C. As chlorine has a greater number of electrons than fluorine the London dispersion forces between the chlorine molecules are stronger. Therefore more energy is required to break the LDFs between chlorine molecules, causing chlorine to have a higher boiling point.