This term…

Week 1 – week 4	Finish off CHEM3.4
Week 5 – week 7	Start the fundamentals of CHEM3.6, some of class will start CHEM3.3
Week 8 and 9	Exam week (sitting CHEM3.5 and CHEM3.4)
Week 10	Some of class will finish CHEM3.3 Some of class will finish CHEM3.6

Why do we care about polarity?

The polarity of a molecule affects the physical properties of the molecule. We will focus on

- boiling point
- melting point
- solubility

How?

Intermolecular forces

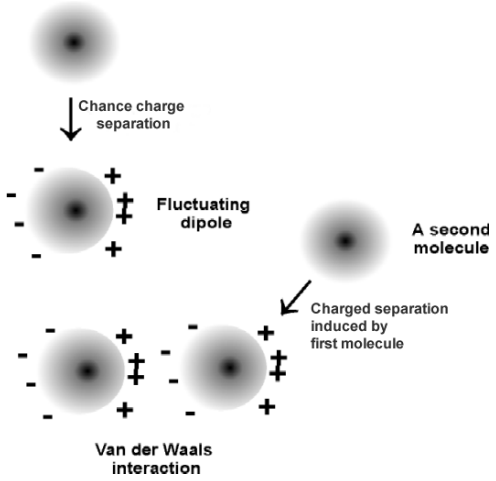
There are three types of intermolecular forces

- Temporary dipoles (van der Waals forces or London forces)
- Permanent dipoles
- Hydrogen bonding

Intermolecular forces

van der Waals forces

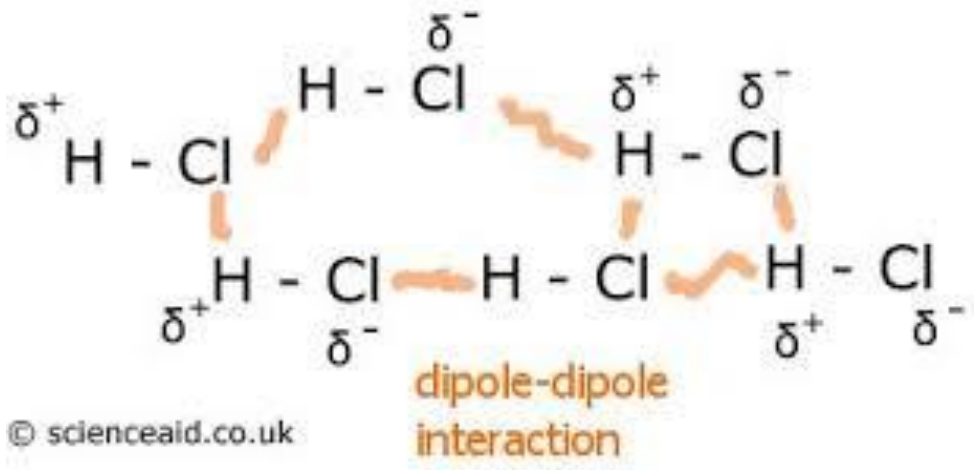
- All molecules have these
- Weakest of the three types of intermolecular force
- Temporary dipoles formed in a molecule in an instant of time causing molecules to be temporarily attracted to each other
- Increase in strength as molecular mass increases



Intermolecular forces

Permanent dipoles

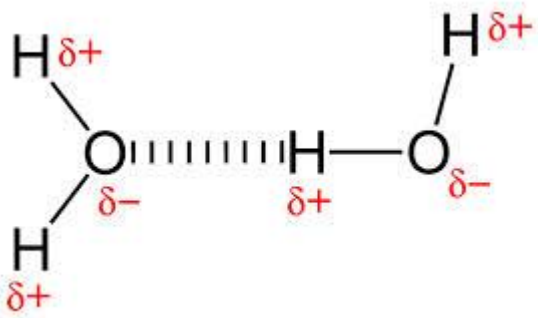
- All polar molecules have these
- Stronger than van der Waals forces (~10x stronger)
- Permanent dipoles occur due to the polarity of the compound, opposite ends of compounds attracted to each other

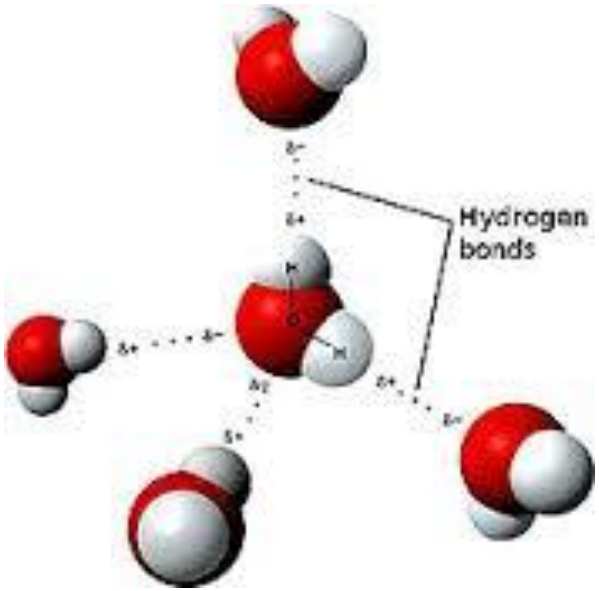


Intermolecular forces

Hydrogen bonding

- Only formed between molecules where there is an H-F, H-O or H-N bond and an acceptor F, O or N atom
- Stronger than van der Waals and permanent dipoles (~10% of the strength of a covalent bond)





Intermolecular forces

Workbook pg 41, 42

Physical properties

- boiling point
- melting point
- solubility

These properties are affected by the strength of the <u>inter</u>molecular forces holding different molecules together **<u>NOT</u>** the covalent bonds holding individual molecules together (<u>intra</u>molecular forces, Lewis diagrams)

Strength of intermolecular forces

hydrogen bonding > permanent dipole > van der Waals

The strength of the van der Waals forces between molecules increases as the molecule gets larger.
Why?

There are more protons and electrons in larger molecules, so there are more protons and electrons to attract adjacent particles and so the temporary dipole force is stronger.

eg I_2 and H_2 both only have van der Waals forces but I_2 is a solid and H_2 is a gas.
I_2 has more protons and electrons so the spontaneous dipole created is larger. This means the van der Waals forces will be stronger, and the molecule is a solid.

Melting and boiling points

- Compounds which can form hydrogen bonds have high melting and boiling points, why?

  Because the hydrogen bonds between molecules are strong and require a lot of energy to break

- Compounds which only have van der Waals forces have low melting and boiling points, why?

  Because the van der Waals forces between molecules are not strong and do not require a lot of energy to break

- Heavy compounds have higher melting and boiling points, why?

  Because they have more protons and neutrons so the temporary dipole created is larger.
  It also requires more energy to move a larger molecule.

Solubility

- Compounds which can form hydrogen bonds are soluble in water, why?

  Because they can break the hydrogen bonds between water and form hydrogen bonds to the water molecules

- Compounds which can not form hydrogen bonds are not soluble in water, why?

  Because they can not break the hydrogen bonds between water molecules

- Compounds which are non-polar are soluble in non-polar solvents (organic solvents), why?

  Because van der Waals forces can be easily broken when the substances are mixed and are replaced with similar forces

2014 Exam Q2 (a)

QUESTION TWO

(a) The boiling points of ammonia, NH_3, fluorine, F_2, and hydrogen chloride, HCl, are given in the table below.

Complete the table to identify the attractive forces between the molecules in their liquid state.

Molecule	**Boiling point / °C**	**Attractive forces**
Ammonia, NH_3	−33	
Fluorine, F_2	−188	
Hydrogen chloride, HCl	−85	

(b) Discuss the differences between the boiling points of NH_3 and HCl, in terms of the strength of the attractive forces between the particles involved.

Then describe why F_2 has the lowest boiling point.

2014 Exam Q2 (a)

Q	Evidence
TWO (a)	NH_3 = Hydrogen bonds, instantaneous dipoles F_2 = Instantaneous dipoles HCl = Permanent dipoles, instantaneous dipoles

Achievement	Achievement with Merit	Achievement with Excellence
• Any TWO significant forces correct. • Outlines a reason for the boiling point for one of the substances.	• Links the strength of attraction to the boiling point AND Correctly compares the significant intermolecular forces in the three species. OR Correctly compares all the intermolecular forces for two species.	• Full discussion.

Merit level answer

• From the three molecules, NH_3 has the highest boiling points due to the strength of the hydrogen bonding between the particles, these bonds require much more energy to break than F_2 and HCl in order for it to boil. Hydrogen bonds are the strongest ~~###~~ form of intermolecular forces. Significant force linked to boiling point for all 3.

HCl has the next highest boiling point because its = i attractive forces do not require as much energy to break than NH_3 but require more than F_2, its attractive forces are ~~temporary~~ permanent dipole forces which are the second strongest attractive forces out of the three.

F_2 has the lowest boiling point out of the three molecules ~~beta~~ because of the weak temporary dipole forces that hold the particles together, because of this, F_2 has the lowest boiling point, its attractive forces do not require as much energy as NH_3 and HCl to break.

Rishi's answer

- NH_3 is a polar molecule due to the difference in electronegativity between N and H. So it has permanent dipole-dipole attractions. It also has temporary induced dipoles between it's molecules. Also it consists of a H atom bonded to a highly electronegative element such as N, O, F. So it has the ability to form hydrogen bonds with other molecules. These hydrogen bonds are stronger than the permanent & temporary dipoles so they require a great deal of energy to separate (bonds must be broken to change $NH_3(l) \rightarrow NH_3(g)$). Therefore NH_3 has the highest boiling point.

Lastly F_2 is non-polar so it only contains temporary dipoles between it's molecules. These forces are much weaker than the hydrogen bonds in NH_3 and the permanent dipoles in HCl. Therefore a lower amount of energy is required to vaporize F_2 compared to HCl and NH_3, so it has the lowest boiling point.

2013 Exam Q3 (a)

QUESTION THREE

(a)

Molecule	Boiling point / °C
Hydrazine, N_2H_4	114
Fluoromethane, CH_3F	–78.4
Decane, $C_{10}H_{22}$	174

Use the information in the table above to compare and contrast the boiling points of hydrazine, fluoromethane, and decane in terms of the relative strengths of the attractive forces between the particles involved.

What do we need to cover in this question?

What key words/statements will we use?

2013 Exam Q3 (a)

If We can observe that Fluoromethane has the lowest boiling point, Hydrazine has the next highest boiling point, and Decane has the highest boiling point. boiling point indicates the strength of bonds and intermolecular forces in a molecule. From this we can de
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Provides evidence towards achievement as the answer relates the boiling point to the strength of the intermolecular forces.

2013 Exam Q3 (a)

Fluoromethane does not have a very high boiling point in comparison. This is because polar bonds between the C-F make the molecule polar and hence there is dipole-dipole interaction. Compared to hydrogen bonding, this does not require as much energy to break and so the boiling point is low.

the largest boiling point. Hydrazine has a relatively high boiling point due to the hydrogen bonding that exists due to the high

Evidence given for Merit. If reference was made to the presence of temporary dipoles in all three molecules and their particular importance for decane, the excellence may have been awarded.

2013 Exam Q3 (a)

Overall, boiling point. $C_{10}H_{22} > N_2H_4 > CH_3F$.

∴ Size of intermolecular forces $C_{10}H_{22} > N_2H_4 > CH_3F$.

∴ In this case, temporary dipole attraction is the most significant in determining the relative strengths of attractive forces for $C_{10}H_{22}$.

and between N_2H_4 and CH_3F, Hbonding is the most significant.

largest e^- cloud

∴ $C_{10}H_{22}$ has the strongest temporary dipole attractions.

CH_3F and N_2H_4 have similar strength of temporary dipole attractions.

∴ C-H is non polar.

∴ $C_{10}H_{22}$ doesn't have permanent dipole attractions.

$C^{\delta+}-F^{\delta-}$ have atoms of different electronegativities.

∴ C-F is polar

CH_3F is tetrahedral shaped

∴ Bond dipoles do not cancel

∴ CH_3F is polar

∴ CH_3F has permanent dipole attractions //

to form H bonding between molecules.

∴ H-bonding is relatively stronge than permanent dipole attractions.

2013 Practise Exam Q3 (c)

(c) Use the information in the table to answer the following question.

Molecule	Boiling point °C	Molar mass/g mol^{-1}
Water, H_2O	100	18.0
Oxygen, O_2	–183	32.0
Hydrogen sulfide, H_2S	–62	34

Compare and contrast the boiling points of water, oxygen, and hydrogen sulfide in terms of the similarities and differences in the relative strengths of the attractive forces present between particles.