

4.4 Intermolecular force 呀

Understandings:

- Intermolecular forces include London (dispersion) forces, dipole-dipole forces and hydrogen bonding.
- The relative strengths of these interactions are London (dispersion) forces < dipole-dipole forces < hydrogen bonds.

Applications and skills.

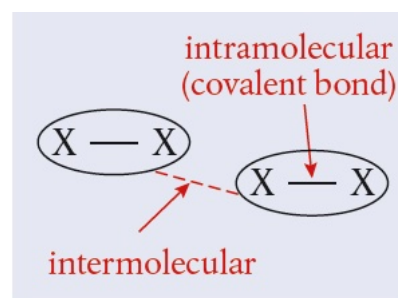
- Deduction of the types of intermolecular force present in substances, based on their structure and chemical formula.
- Explanation of the physical properties of covalent compounds (volatility, electrical conductivity and solubility) in terms of their structure and intermolecular forces.

Guidance:

- The term “London (dispersion) forces” refers to instantaneous induced dipole-induced dipole forces that exist between any atoms or groups of atoms and should be used for non-polar entities. The term “van der Waals” is an inclusive term, which includes dipole-dipole, dipole-induced dipole and London (dispersion) forces.

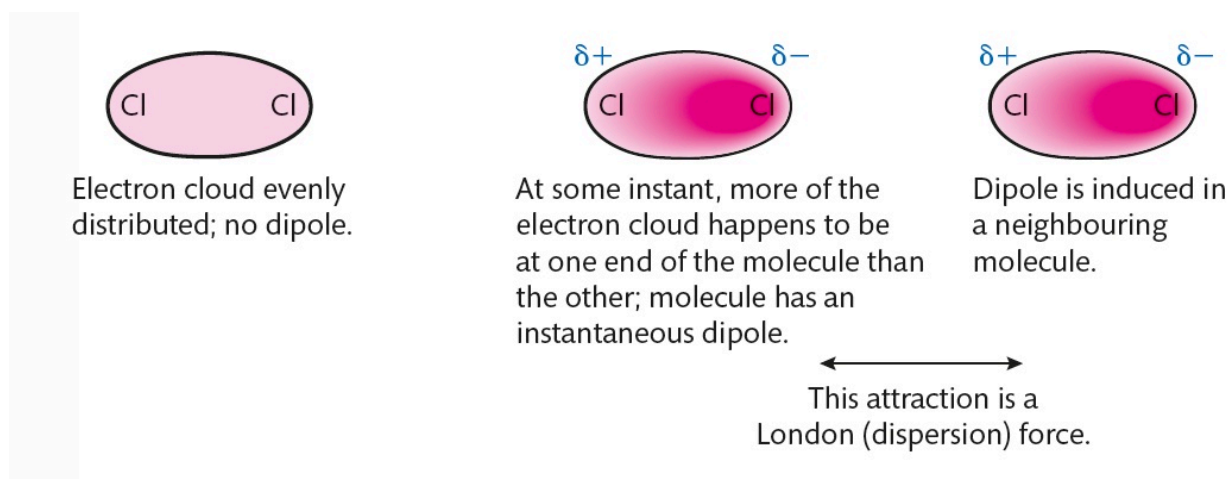
• 在开始之前先解释一波名词...

- Intra = within, 所以intramolecular 是同一个molecule之间的bond, 而inter则是不同molecule之间的bond
- Dipole: a pair of equal and oppositely charged (or magnetized poles物理里会提到) separated by a distance. (被分开的正负电荷)



• London Dispersion

- 简单来说, 虽然有些物质炒鸡稳定 (比如惰性气体) 然而他们表面也有带负电的电子 (云), 有的时候不那么均匀, 所以就会有temporary (instantaneous) dipole的产生。这个变化会影响旁边的原子, 形成induced dipole.
- 这种force非常的弱

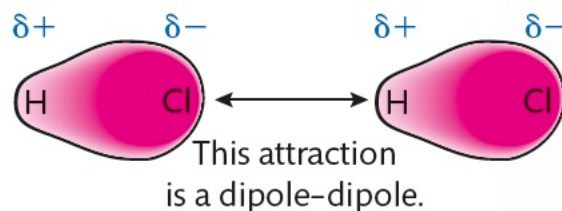


- 只在non-polar molecules里出现
- 实在是太弱了所以是气态的，boiling point也低。(little energy is required to break the bond)
- 虽然挺弱，但是它的存在解释清楚了为啥一些non-polar的substance可以被condensed/凝结成固体
- 其实polar-molecule里也有，就是被忽略了

• Dipole-dipole

- polar-bond

- 一半正一半负，你的正极吸引我的负极 (...)
- strength不确定，一般比London dispersion 强 => melting point 和boiling point 也比non-polar 的强
- 比较boiling point 之类的东西的时候要注意 molar mass 保持差不多...不然电子越多strength就越强...
- 大部分polar molecules都行 (PCl_3 , CHCl_3 , HCl , etc)
- Van der Waals' forces = London dispersion+dipole-dipole+dipole-induced dipole.

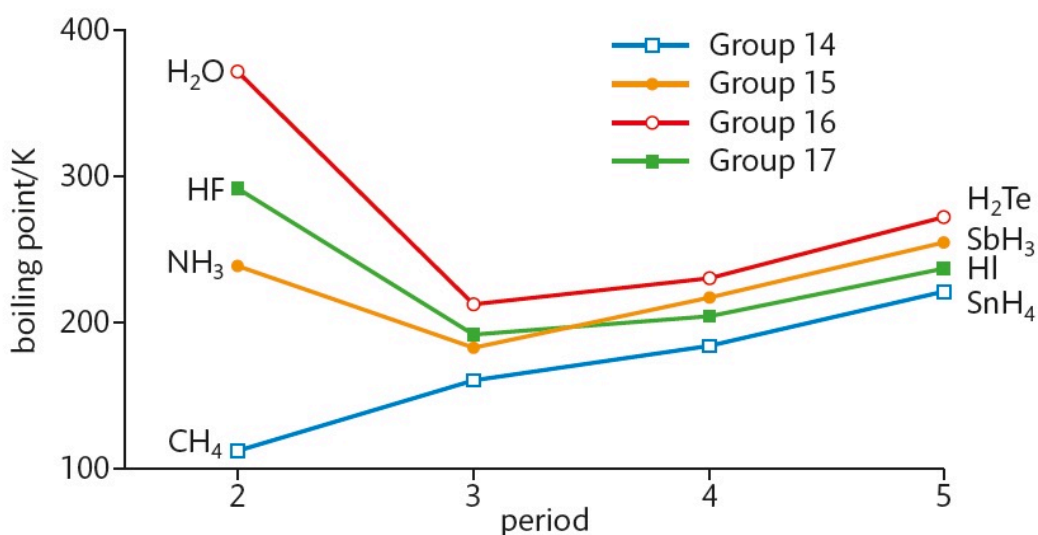


London dispersion force, e.g.	$\text{Cl}_2 \cdots \text{Cl}_2$	} van der Waals forces
dipole-dipole attraction	$\text{HCl} \cdots \text{HCl}$	
dipole-induced dipole	$\text{HCl} \cdots \text{Cl}_2$	

// 关于上图中的一大波名词的记忆逻辑: temporary原因是它是induced的, 转了个方向随时转回去
 > 鉴于它这么弱赶紧给起个厉害的名字 (London dispersion) + van der Waals 可能是看在并没有人想分清出它到底是不是permanent/大家都是dipole四舍五入下差不多的面上起的

• Hydrogen Bonding!

- 很强, strongest intermolecular attraction => high boiling points
- H-N, H-F, H-O
- 毕竟H就1个电子，没有什么shielding
- 然后就解释了bug一样的这张图



- 本来boiling point increases down the group, 结果hydrogen bond实在太强了
- 那么为啥increase down the group 呢!
 - Van der Waals forces increase as number of electrons of (halogen) atom increases.
- 在有机里解释就比较恐怖, 指路Chapter 13 biochemistry...

总结一下——

		Non-polar molecules	Polar molecules	Molecules which contain H-O, H-N, or H-F	increasing strength of intermolecular force ↓
London dispersion forces	} van der Waals' forces	✓	✓	✓	
Dipole-dipole attractions			✓	✓	
Hydrogen bonding				✓	

Melting point & Boiling point ↑ when intermolecular forces ↑ -> covalent < ionic

Intermolecular force ↑ as molecular size ↑ -> predictions of boiling point (↑)

Physical Properties:

	Ionic compounds	Polar covalent compounds	Non-polar covalent compounds	Giant covalent
Volatility	low	higher	highest	low
Solubility in polar solvent, e.g. water	soluble	solubility increases as polarity increases	non-soluble	non-soluble
Solubility in non-polar solvent, e.g. hexane	non-soluble	solubility increases as polarity decreases	soluble	non-soluble
Electrical conductivity	conduct when molten (l) or dissolved in water (aq)	non-conductors	non-conductors	non-conductors except graphite, graphene and semi-conductivity of Si and fullerene

我不管我就是懒的写

(咳咳)

Electron conductivity

- Presence of delocalized electrons
- Covalent compounds can't conduct electricity (unless in conditions when they can ionize, like aqueous state of HCl)

Solubility

- Non-polar的可以在non-polar solvents 里溶解 - London-dispersion forces
- Polar 的可以在Polar solvents里溶解 - dipole interaction & hydrogen bonding
- 特殊情况：有些polar molecule的non-polar部分占大多数，于是solubility就减少了。
- Polar substances 的dipole-dipole interaction 让他们没法和solvent interact
- Giant molecular substance基本哪都溶不了，因为需要过多的energy 才能break the strong covalent bonds in their structure

还没完。

Ionic solid 中有一些可以在polar solvent 里溶解，原因是water is polar and the partial charges on water are attracted to oppositely charged ion.

然而这玩意solid state的时候不行... -> held in a fixed position by the strong attraction forces. 顺便，lack of moving charged particles -> does not conduct electricity.