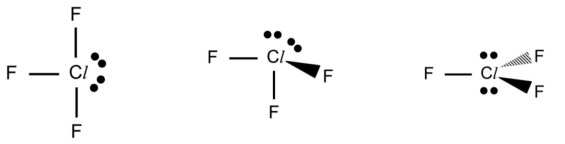
Chemical bonding

Created	@June 4, 2025 7:24 PM
Tags	

Explaining stability of different arrangements of same molecules by applying principles of VSEPR theory

1 (c) (i)



Arrangement **A**
Net dipole moment

Arrangement **B**
Net dipole moment

Arrangement **C**
No net dipole moment

1 (c) (ii) Based on VSEPR theory,

1) The electron pairs (bond pairs and lone pairs) around the central atom arrange themselves to be as far as possible to minimize repulsion.

2) Lone pair–lone pair repulsion > lone pair–bond pair repulsion > bond pair–bond pair repulsion.

Arrangement **A** is the most stable as the lone pair electrons are 90° to only two other bond pair electrons while arrangements **B** and **C** have lone pair electrons 90° to all three bond pair electrons.

Arrangement **C** is more stable than **B** as the lone pair electrons in **C** are further apart as compared to arrangement **B**.

▼ Tips

- For molecules with 5 electron regions, lone pair of electrons preferentially occupy the equatorial position as it is 90degrees to 2 other electron regions in axial position
- If lone pair is in axial position, it is 90 degree to 3 other electron regions and hence repulsion is not minimised
- The closer the electron regions are, the smaller bond angle, the more repulsion is experienced

How the intermolecular forces arises

- Instantaneous dipole-induced dipole
  - Id-id arises due to random movement of electrons giving rise to uneven distribution of electron cloud of a molecule, creating a instantaneous dipole which induces a similar dipole moment on adjacent molecules
- Hydrogen bonding
  - hydrogen bonding which arises due to attraction between the lone pair electron of a highly electronegative element (O atom in methanol) and a highly electron deficient H atom bonded directly to highly electronegative element O
- Permanent dipole-dipole
  - Pd-pd arises due to overall net dipole moment
  - electronegativity differences between 2 atoms creates a dipole moment for bond And these Dipoles not cancelled out completely
  - partial positive charge atom on a molecule would have pd-pd interaction with partial negative charge atom on another molecule

Explanation for AlCl3 having a higher boiling/melting point than SiCl4 (not in syllabus)

Both $AlCl_3$ and $SiCl_4$ have simple molecular structures.
Hence, $AlCl_3$ and $SiCl_4$ have low boiling points as a small amount of energy is required to overcome the weak instantaneous dipole – induced dipole interaction between molecules.
However, $AlCl_3$ exists as a dimer of Al_2Cl_6.
Since Al_2Cl_6 has a larger molecular size than $SiCl_4$, $SiCl_4$ has stronger instantaneous dipole – induced dipole interaction between its molecules than $SiCl_4$. Thus Al_2Cl_6 has the higher boiling point than $SiCl_4$.

▼ Tips

- If Questions show a molecule with a larger MR having a lower bp/mp, it's usually because the other molecule exists as a dimer and hence end up

having a larger mr and stronger id-id

Comparing bp/mp

	Explanation
Ionic compounds	Have giant ionic lattice structures held by strong ionic bonds between cations and anions Compare lattice energy, $\|\text{L.E.}\| \propto \|+q-q\|/\|r+r+\|$ by *q*uoting the sizes of ions found in data booklet and charge . Hence one of the ionic compound has a smaller interionic distance and higher product of charges, More exothermic lattice energy, More energy required to break stronger ionic bonds, higher mp/bp
Halogens/ halogen halides	Has Id-id attraction between molecules. Down the group, increasing electron cloud size due to increasing mr and hence greater amount of energy to overcome stronger Id-id as dipoles are more easily induced and hence increasing bp and mp **HF as the highest boiling point as more energy required to overcome the stronger hydrogen binding between HF Molecules than the id-Id**
Ionic compound vs simple covalent compound	Ionic compound has a giant ionic lattice structure with strong ionic bond between oppositely charged ions while simple covalent compound has a simple molecular structure with weak imf of attractions such as Id-id between

	Explanation
	molecules More energy to overcome stronger ionic bonds
Polar vs polar molecule	Both have a simple molecular structure consisting of pd-pd AND ld-id interactions between molecules. One molecule has a a larger electron cloud, dipoles more easily induced causing stronger I'd-I'd, more energy to overcome
Polar vs non-polar	Both molecules have simple molecular structures and have ld-id forces if total number of electrons similar: ld-id forces between the two molecules are comparable as they have the similar size of electron cloud The additional pd-pd in the polar molecule result in more significant intermolecular forces of attraction and hence more energy to overcome as total imf of polar molecule is stronger

- If question does not follow the expected trends for mp/bp can use the following reasons:
    - Compound has a higher packing efficiency due to the Shape of molecule (eg: linear vs square planar), imf will be stronger between molecules and needs more energy to overcome
- Note: when comparing imf, compare it with the same type of imf

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Theoretical vs experimental lattice energy value

- Theoretical L.E is calculated using a model where ions are assumed to be spherical
- For ions like aluminium ions, it has a small radius and large ionic charge, high charge density
- Causes aluminium ion to polarised electron cloud of anions(need to specify) to a significant extent, deviating from model of spherical ions

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Why does dimerisation occur

- An atom consists of unpaired electron
- Dimerisation of the unpaired electron can be paired to form a more stable product via dative bind

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Why can some elements form dative bonds

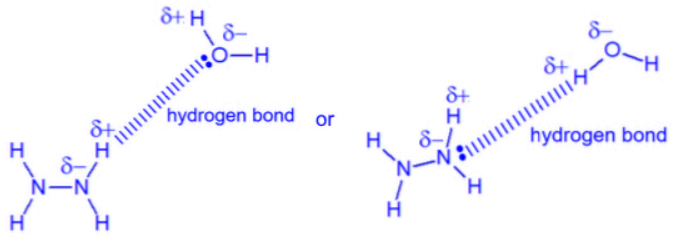
- there is a energetically accessible vacant 3p/3d orbital to accept a lone pair of electrons to form a dative bond (look at the electronic configuration to see if there is a vacant orbital)

Explaining shape and bond angle of molecule

- By VSEPR theory, electron pairs are arranged in a way such that it minimises inter-electronic repulsion around central atom (specify according to question)
- Since molecule has __ number of bond pair of electrons and __ number of lone pair of electrons, the molecule will adopt (shape of molecule)
- Since lone pair-lone pair repu**lsion greater than lone pair–bond pair repulsion which is them greater than bond pair–bond pair repulsion** , , the bond angle is __

Illustrating hydrogen bonds

(ii) Hydrazine is soluble in water. Use a suitable diagram to illustrate the interactions between a hydrazine molecule and a water molecule.



Marking points:
- lone pair electrons on N or O atom
- δ+ and δ− between H atom and N or O atom
- show hydrogen bond between lone pair and H atom
- label hydrogen bond or H bond

each mistake deduct **[1/2]**

[1]

Why can noble gases in period 3 and above can react with other atoms

- state the period which element is in
- Able to expand octet due to availability of vacant energetically accessible orbitals to accommodate additional electrons from other atoms during covalent bond formation

Why can certain elements can form covalent bonds with only certain elements and not the rest?

- Has a smaller atomic radius and hence has a shorter bind length and is stronger

Illustration of ion dipole interactions

between H_2O molecules.

(ii)

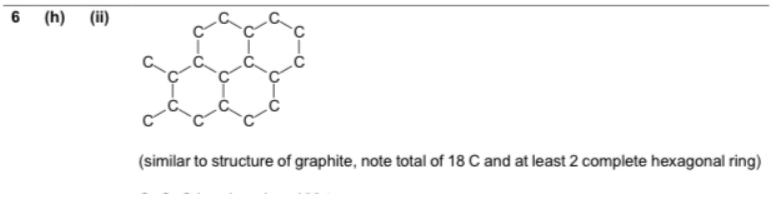
Note: for Cl^-, need to show both H atoms of each H_2O molecule is pointing towards Cl^-.

- Note that opposite charges attract

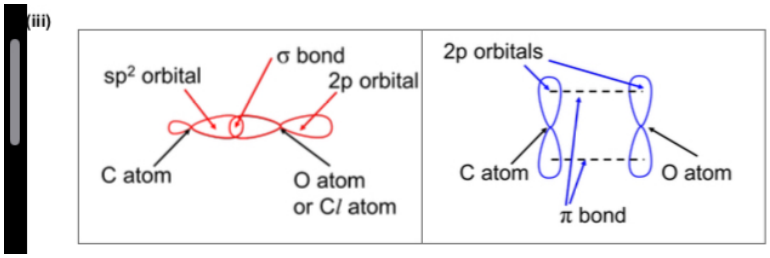
Explaining how sigma and pi bonds are formed

- State type of hybridisation between each atom
- Sp3 hybridisation: 4 sp3 orbital
- Sp2 hybridisation: 3sp2 orbitals, 1 unhybridised orbital
- Sp hybridisation: 2 sp orbitals, 2 unhybridised orbital
- Head on overlap of hybridised orbital/ s orbital between X and Y atoms to form sigma bond
- Lateral overlap side way to form pi bonds between the atoms

Drawing of graphene layer



Diagrams to show how orbital overlaps formed



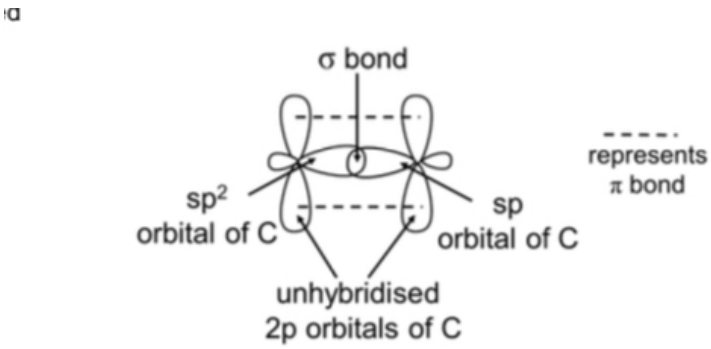
Explain what is electronegativity

- The measure of ability of an element to attract a shared pair of electrons in a covalent bond towards itself

Describing covalent bondings in a compound with reference to hybridisation of atoms and orbital overlaps

- C=C bond formed by one sigma bond head on overlap between (state hybridisation of atoms) hybrid orbital of atom1 and with (hybridisation) hybrid orbital of atom 2 And One pi bond sideway overlap between Un hybridised 2p/3p orbital of atom 1 with 2p/3p orbital of atom2

Diagram:



- Hybrid orbital is one long one short

What is meant by sp hybridisation

involves mixing of **one 2s orbital of C** and **one 2p orbital of C** to produce **two sp hybrid orbitals** arranged in a **linear geometry**. There are **two unhybridised 2p orbitals** for the carbon

How are electrons arranged in a sp2/sp3/sp

- Identify how many hybrid orbitals and how many unhybridised orbital
- Identify how many valence electrons
- Identify which electron resides in the sp2 and which electron resides in the p orbital
- The hybridised orbital with unpaired electrons Identify which will undergo head on overlap with another hybrid orbital of a different atom/ s orbital of a different atom

- The other unpaired electrons Identify which in p orbital undergoes side way overlap with unhybridised orbital of atom to form a pi bond

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Explaining solubility of a compound in a solvent

- Identify what imf when solute dissolve in solvent
  - Ion dipole interaction when there is water
  - if don’t have say it does not form favourable interaction with solvent, hence insoluble
- Identify imf between solute and imf between solvent
- Structure: Energy released when solute form imf with solvent is sufficient/insufficient to compensate energy required to overcome the bonds in solute and solvent and hence soluble