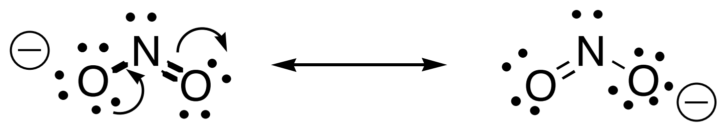
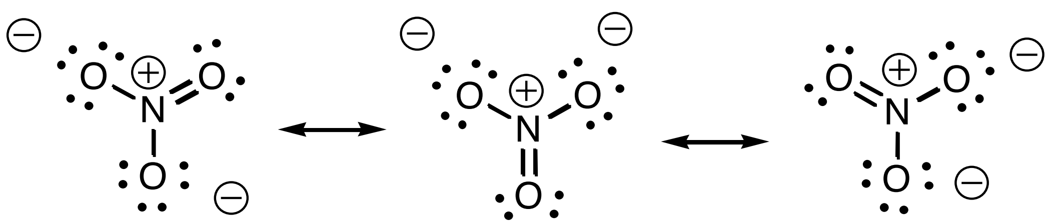
Resonance structure:

1. nitrite anion (NO_2^-)



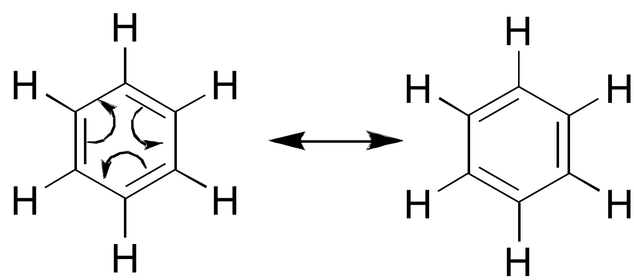
The two resonance structures shown above are equally valid.

2. nitrate anion (NO_3^-)

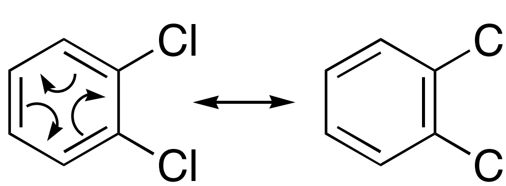


The structures above are all equally valid, only one needs to be drawn.

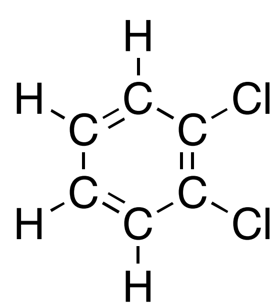
3. C_6H_6



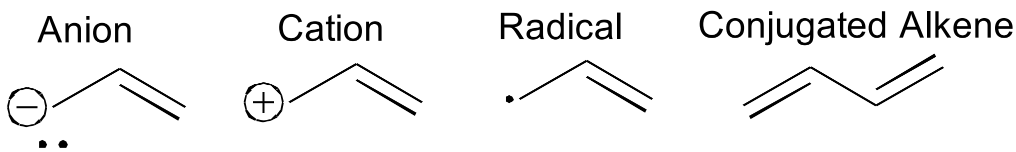
4. $C_6H_4Cl_2$



OR



Conjugated: separated by one and only one single bond from a double bond;
E.g.



Electronegativity:

- An atom's desire for electrons (negative charge).
- in Periodic table, electronegativity increases as you go from left to right (up to inert gases which are not electronegative) and as you go upwards
- Eg. Fluorine is the most electronegative atom (wants to gain the inert gas configuration of Ne)
- It influences acidity of H's attached, as well as the intermolecular forces between molecules.

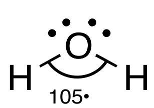
Intermolecular forces: (forces present between molecules)

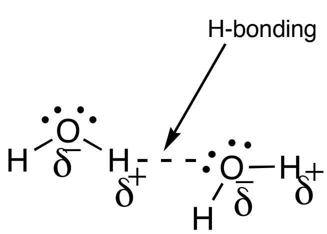
- Attractive intermolecular forces:
  - i) Hydrogen bonding – strongest on per atom basis (eg. base recognition in forming DNA helix)
  - ii) Dipole-dipole interaction
  - iii) London forces (Temporary dipole; Hydrophobic Bonding) – weakest on per atom basis

Hydrogen bonding:

- need a lone pair of electrons
- need hydrogen directly attached to a very electronegative atom (F, O, N) for Hydrogen bonding between molecules of same type
- strongest intermolecular attractive force on a per atom basis

eg. H-O-H (water)



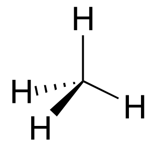


- oxygen is electronegative and it is sp^3 hybridized
- leads to high boiling point and high melting point by self-association
- HF, H_2O and NH_3 form hydrogen bonds
- $(CH_3)_3N$ forms no hydrogen bond itself, but if dissolved in water, it forms hydrogen bonds with water

Dipole moment:

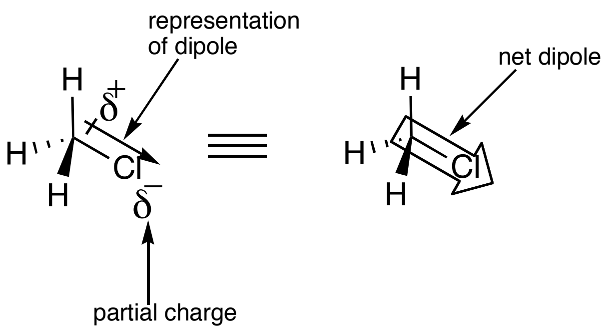
Eg.

1. Methane CH_4



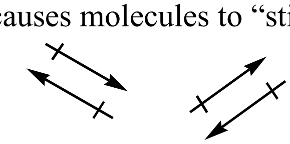
- Non-polar (net-zero dipole)
- Gaseous
- Low BP -164 ^{o}C
- Low MP -182 ^{o}C

2. Methyl chloride, CH_3Cl, $ClCH_3$

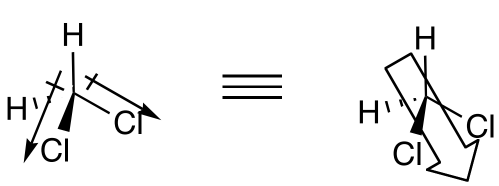


- H and C have similar electronegativity values (non-polar bond)
- Cl is very electronegative – due to the fact that it only needs one electron to get inert gas configuration. (C-Cl and C-F are polar bonds)
- Electron density is pulled towards chlorine atom – so a net dipole toward chlorine atom – net dipole is the vector sum of individual bond dipoles

* dipoles in different molecules tend to line-up temporarily with each other (partial positive / negative charge on the molecule) – causes molecules to "stick" to each other

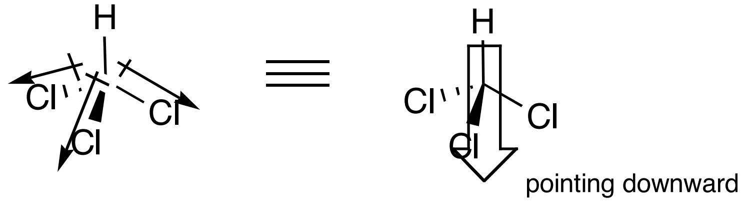


3. Dichloromethane, methylene chloride, CH_2Cl_2



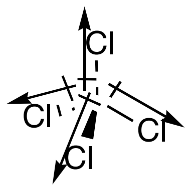
- Liquid at room temperature BP 40 ^{o}C MP – 95 ^{O}C
- More polar than methyl chloride

4. trichloromethane, chloroform, $CHCl_3$



- More polar than methylene chloride   BP 61 ^{o}C   MP – 64 ^{o}C

5. tetrachloromethane, carbon tetrachloride, CCl_4 (TOXIC)

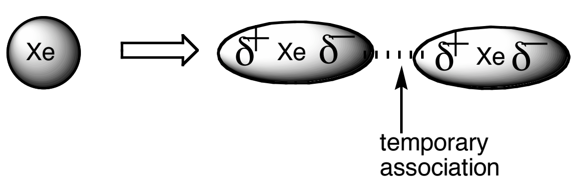


- net-zero dipole

- Non-polar molecule
- Has temporary dipoles and as chlorine is polarizable (see below), high BP

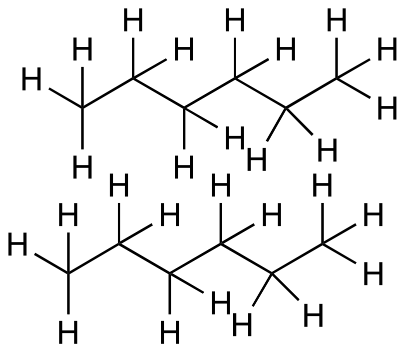
London Forces (temporary dipole):
- also know as dispersion forces
- Principal effect in hydrophobic interaction

Atoms	boiling point	
		Small atom/ Low polarizability
He	-269 ^{o}C	↓
Ne	-246 ^{o}C	
Ar	-186 ^{o}C	
Kr	-153 ^{o}C	
Xe	-108 ^{o}C	Large atom/ High polarizability



- the larger the atom (expanded electron density), the easier the formation of temporary dipoles

- Hydrophobic interaction: - hexane

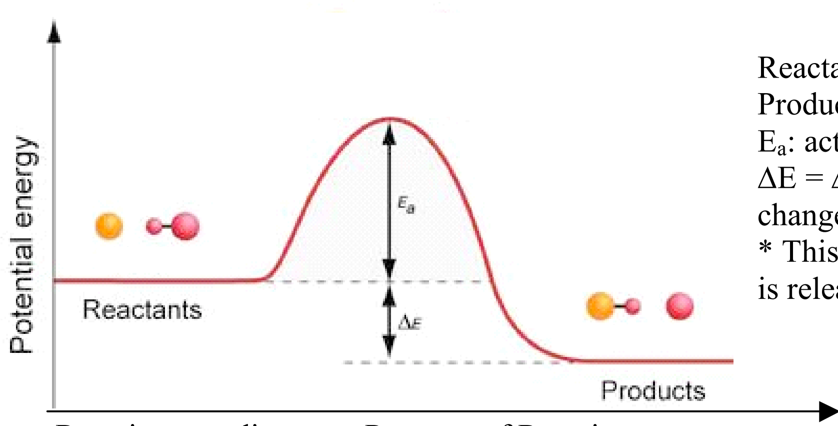


- two hexane molecules have a small attraction to one another at room temperature (hydrophobic interaction)
- longer alkane chains can have such large forces to become solid-like wax

Reactivity:

CH_4 (Methane) $+ \; 2O_2 \xrightarrow[\text{heat}]{} CO_2 + 2H_2O$

<u>Energy Diagram for the Reaction</u>



Reaction coordinate => Progress of Reaction

Reactants: CH_4 and O_2
Products: CO_2 and H_2O
E_a: activation energy
$\Delta E = \Delta G$: energy (enthalpy) change for the reaction
* This reaction is exothermic; heat is released during the reaction.