Chem 11 Unit 4

POLARITY, MOLECULE SHAPE, and BEHAVIOUR

Polarity is unequal distribution of a charge on a molecule caused by:

1) some degree of ionic character in the bonding (i.e. unequal electron sharing)
2) asymmetry of molecular shape (i.e. imperfect geometry…often due to lone pairs on the central species)

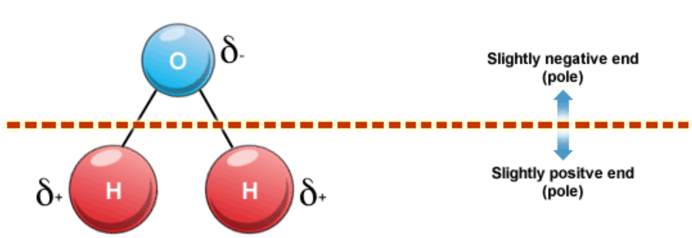
When a molecule is POLAR, there is the creation of a **DIPOLE.**

A "positive like" end and a "negative like" end

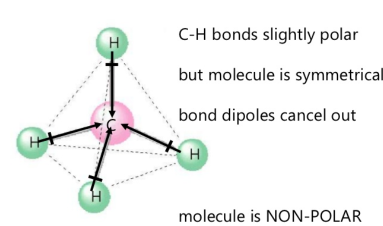
Polarity increases the attraction / repulsion with neighbouring molecules.

The polarity of a molecule determines the intermolecular forces between the molecules, which then affects the physical properties of the molecule. These physical properties include, but aren't limited to, boiling point, freezing point, viscosity, surface tension and solubility. Polar molecules would have stronger intermolecular forces than nonpolar molecules. As a result these polar molecules would have higher boiling points, freezing points, surface tension.

For example, at 25°C, water, H_2O (a polar molecule) is liquid and methane, CH_4 (a non polar molecule) is a gas.

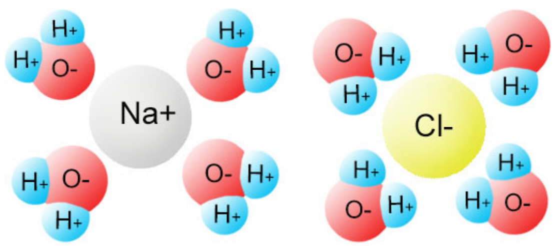


Example 3 Methane



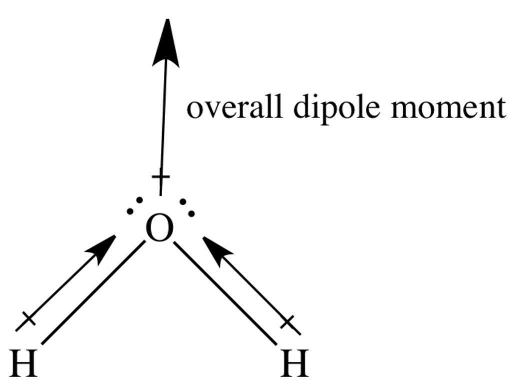
Polar molecules are more effective solvents with other polar molecules OR ionic solids. Therefore, the phrase "like dissolves like" is often used to suggest that one should match polarities for optimum solubility.

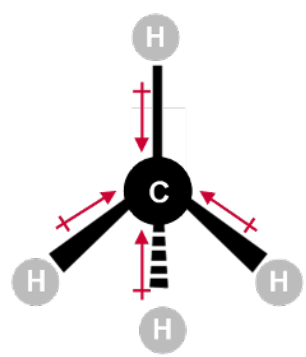
So, NaCl Dissolves in water:



Water is a has a Δe of 1.4 which suggests a 39% ionic character, and 61% covalent character.
This Δe corresponds to a polar covalent bond between O and H.
The O is the negative dipole (partial negative end) and the H is the positive dipole (partial positive end) and overall, water is a polar molecule.
The basic shape of the water molecule is tetrahedral, with an actual shape that is called "V-shape" or "BENT". The bond angles are 104°.

Dipole notation is as follows:





The dipole moments shown here in methane cancel each other out. Therefore, methane is nonpolar.

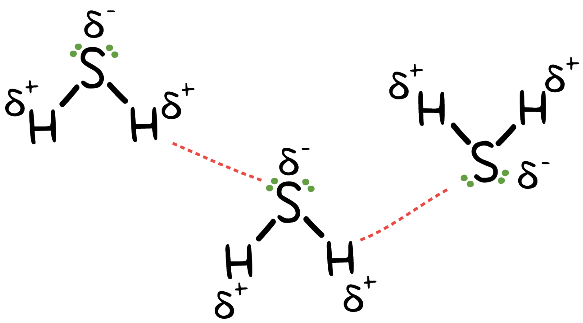
The net dipole is also known as the overall dipole moment.

INTERMOLECULAR FORCES

Intermolecular forces are weak bonds that form between molecules that help keep the molecules close to one another in the liquid and solid states.

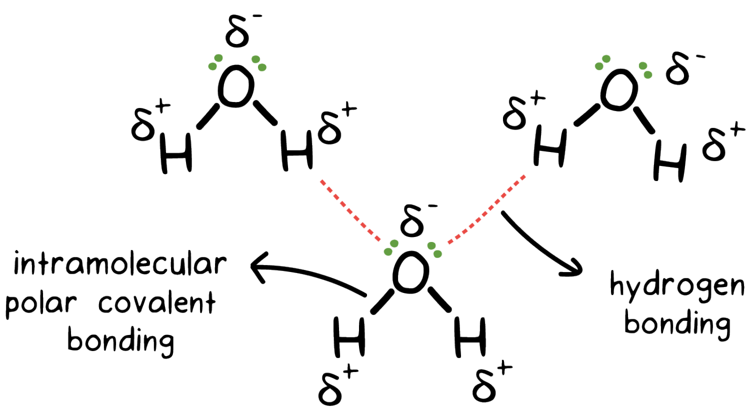
TYPE ONE: DIPOLE-DIPOLE FORCES:

A DIPOLE-DIPOLE force exists when the positive end of polar molecules attract the negative ends of other polar molecules. This force holds the molecules together in the liquid or solid phase and keep the substance from evaporating.

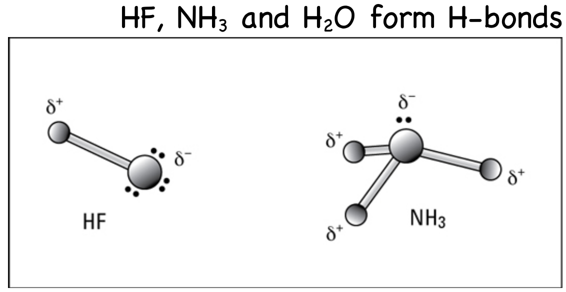


A subtype of DIPOLE-DIPOLE FORCES is **HYDROGEN BONDS:**

These bonds fall under the category of Dipole-Dipole Forces but they are extra strong so they are classified separately:



HF, NH_3 and H_2O form H-bonds



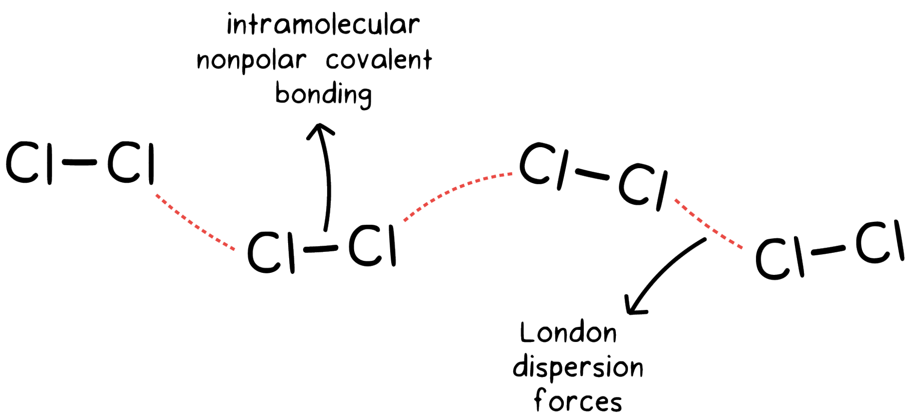
Hydrogen bonds are SO STRONG for2 reasons:

1) Hydrogen has no inner orbital electrons to repel the negative end of the polar molecule, so the hydrogen nucleus gets close to the other molecule.
2) There is a strong dipole because the Δe between H, F, N, O is large.

TYPE TWO: LONDON FORCES:

London Forces explain how non-polar molecules like carbon dioxide, nitrogen gas, chlorine gas, and methane are attracted to each other enough to form solids or liquids. When 2 non-polar molecules come close together (as they do in liquids or solids), the nucleus of one particle will attract the electrons of the other particle, resulting in a "momentary dipole." London Forces have 1/10 of the attraction of dipole-dipole forces. For example, CH_4 and CO_2 boil at such low temperatures because the only force holding their non-polar molecules together in the liquid state is the weak London Forces.

Example of London Dispersion forces:



***Note:

H_2O and H_2S and CO_2 are all similar molecules in terms of structure / chemical formula.

BUT

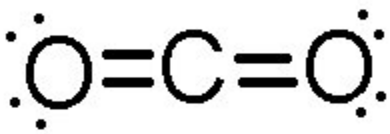
H_2O: Polar molecule → Bent shape → Hydrogen Bonds → Boiling point = 100°C
H_2S: Polar molecule → Bent shape → Dipole-Dipole forces → Boiling point = 60°C
CO_2: NONPolar molecule → Linear shape → London Forces → Boiling point = -78°C

As you can see, the POLARITY of the molecule, and the resulting INTERMOLECULAR FORCES, changes the PROPERTIES and BEHAVIOUR of the molecule.

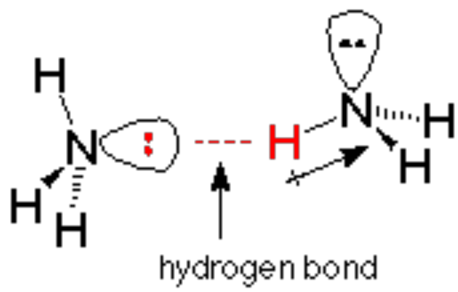
This was only a simple introduction to Intermolecular Forces between molecules.

APPENDIX of MOLECULES

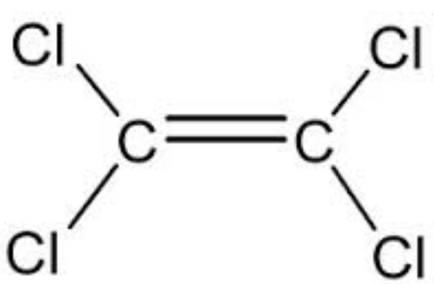
Using your knowledge of Δe, drawing Lewis Dot and Structural Diagrams, and drawing 3-dimensional molecule shapes based on VSEPR Theory, you should be able to look at each molecule and determine it's overall molecule polarity, intermolecular forces, and possible behaviours such as solubility or boiling point.



CO_2, a linear, non-polar molecule, with polar covalent bonds between the C and O atoms. There are WEAK attractive London forces between non-polar CO_2 molecules.



NH_3, a POLAR molecule, with a tetrahedral basic shape and a trigonal pyramid actual shape, containing polar covalent bonds between the N and H atoms.
As a result of the NET DIPOLE, the ammonia molecules form Hydrogen bonds.



A NON-polar, totally symmetrical molecule like C_2Cl_4, known as tetrachloroethene, is used for DRY CLEANING clothes because it attracts to the non-polar grease stains that are NOT effectively removed by polar water molecules.
The dry cleaning process is NOT dry at all (C_2Cl_4 is a liquid). The word "DRY" refers to the absence of water in the cleaning process.