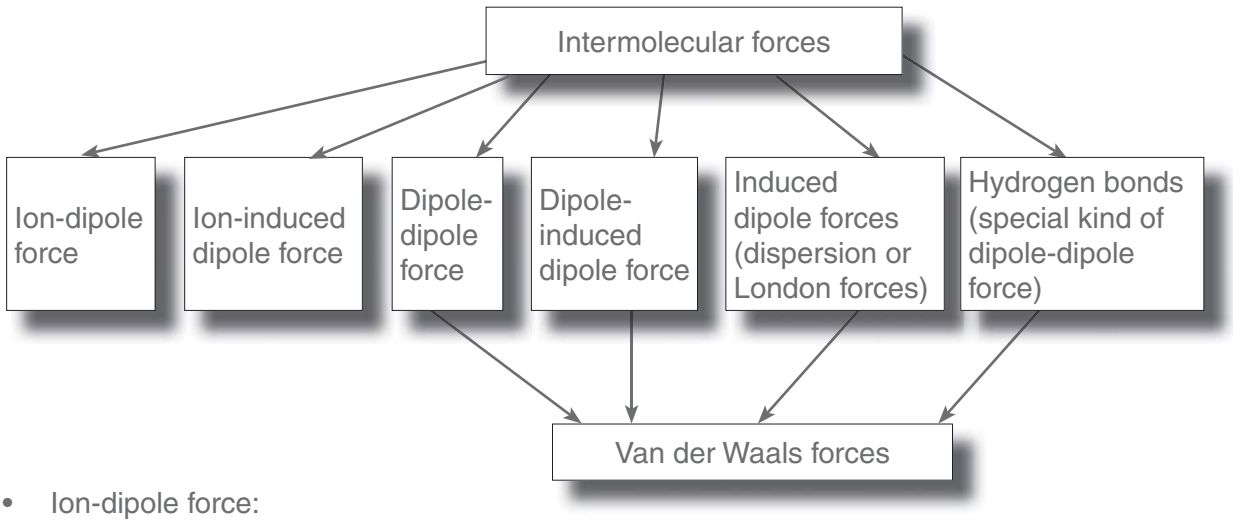
## Summary

- The following are the different types of intermolecular forces.




- Ion-dipole force:
  Occurs when a dipole approaches a positive or negative ion.
  The dipole will move so that the side closest to the ion has the opposite charge.
  Example: NaCℓ is dissolved in water.

- Ion-induced dipole forces:
  An ion affects the electron cloud around an atom or molecule when it is nearby, causing a temporary dipole.
  Examples: $Na^+$ and hexane

- Dipole-dipole forces:
  Attractive forces between the slightly positive atom in a polar molecule and the slightly negative atom in another polar molecule.
  Examples: $NH_3$, $SO_2$, HBr, $H_2S$, ICℓ, HCℓ

- Dipole-induced dipole forces:
  A polar molecule can induce a temporary dipole in a non-polar molecule or an atom.
  Example: $O_2$ in water.

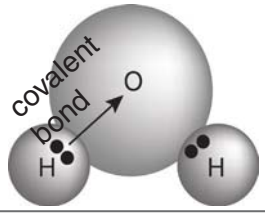
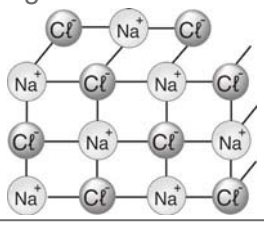
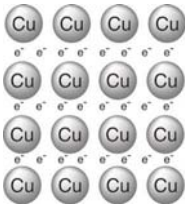
- Induced dipole forces (dispersion or London forces):
  When two non-polar atoms or molecules approach each other, there is a slight rearrangement of their electron clouds. A weak, short, temporary dipole is formed, which comes and goes and alters direction.
  Examples: $H_2$ and $N_2$

- Hydrogen bond:
  This is an exceptionally strong dipole-dipole force in comparison with other Van der Waals forces. It occurs between molecules in which hydrogen is bonded to nitrogen, oxygen or fluorine.

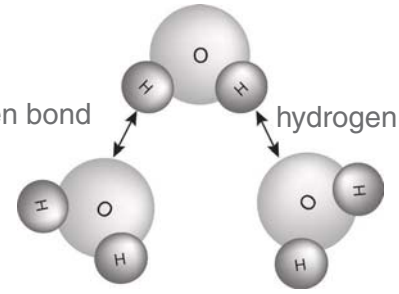
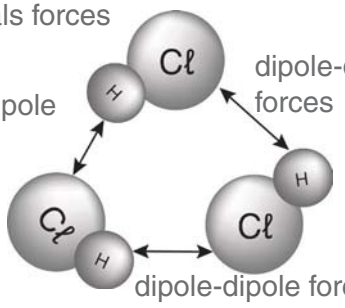
# Summary

- Interatomic forces are those forces that hold the different atoms together in a molecule.

Chemical bonds: strong bonds inside molecules or structures

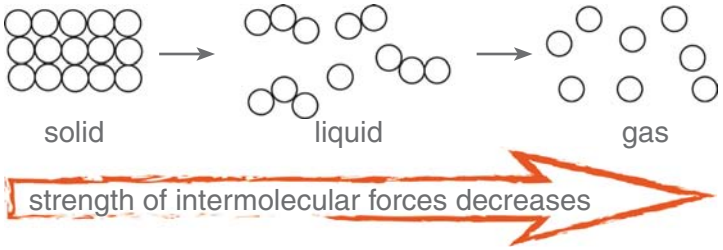
| | Covalent bond | Ionic bond | Metallic bond |
|---|---|---|---|
| 1. Bond | Between non-metals and non-metals<br>Sharing of electrons | Usually between metals and non-metals<br>Electron transfer | Between metals<br>Positive atomic core and sea of electrons |
| 2. Bonds | Covalent bond | Electrostatic attraction/coulombic forces | Electrostatic attraction |
| 3. Examples | $O_2$, $C\ell_2$, $H_2O$, $HC\ell$ Giant structures: diamond and graphite | $NaC\ell$, $MgSO_4$, $KC\ell$ | Cu, Fe, Zn, Cu |
| 4. Structure | E.g. $H_2O$   | E.g. $NaC\ell$   | E.g. Cu   |

- Intermolecular forces: forces that hold molecules together.

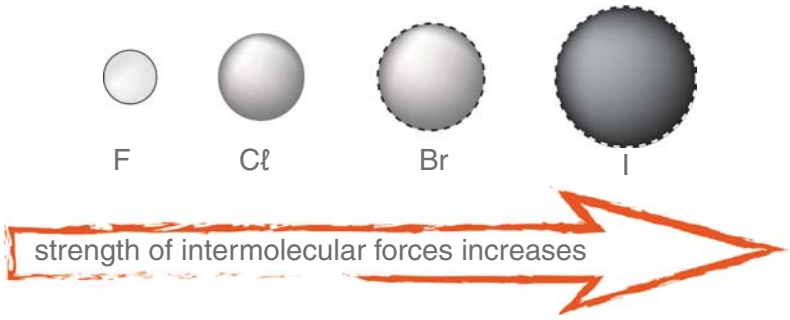
| Hydrogen bond (strong) | Other Van der Waals forces (weak) |
|---|---|
| Hydrogen bond<br>(strong dipole-dipole force) | Van der Waals forces<br>Dipole-dipole, dipole-induced dipole and induced-dipole forces (dispersion or London forces)<br>(weak) |
| Between molecules in which hydrogen is bonded to N, O or F. | The remainder of the covalent molecules, e.g. $H_2$, $HC\ell$, $SO_2$ |
| hydrogen bond hydrogen bond   | Van der Waals forces<br>dipole-dipole forces<br>dipole-dipole forces<br>dipole-dipole forces   |

## Summary

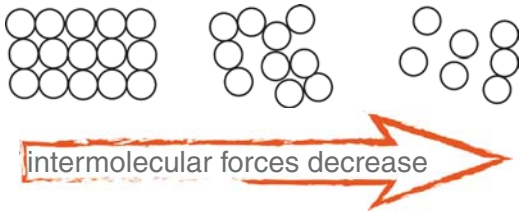
- The influence of intermolecular forces on:
  1. the state of the molecules:




  2. size of molecules:



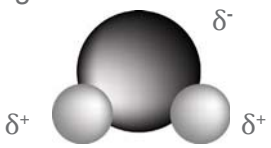
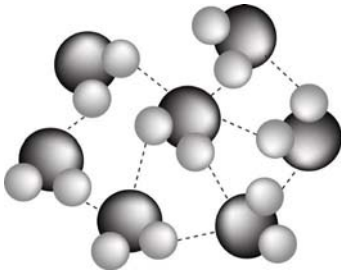
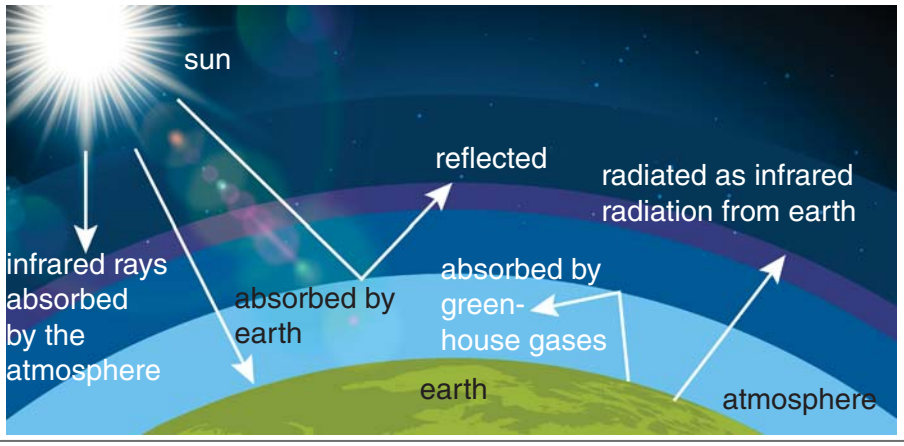

  3. density:
     Density is the number of particles per unit volume.
     The closer the molecules of a material, the stronger the intermolecular forces.




  4. boiling and melting points:
     The stronger the intermolecular forces, the higher the melting and boiling points.
  5. viscosity:
     An indication of a liquid's resistance to flow.
     A substance with a high viscosity does not flow easily.
     The stronger the intermolecular forces, the greater the viscosity.
  6. thermal expansion:
     Means that the material expands on heating.
     Particles absorb energy, so the intermolecular forces are overcome or weakened, and the particles move apart.
  7. thermal conductivity:
     Covalent structure: no free electrons to help transmit the heat.
     Metallic bonds: valence electrons are free to help with conduction of heat.

# Summary

- The microscopic structure of water:

| | |
|---|---|
| Covalent bond | Two H atoms joined to one O atom |
| Polar molecule | • O atom's electronegativity is much bigger than the H atoms'. Therefore it attracts the shared pair of electrons more than the H atoms do.<br>• O atom becomes slightly negative.<br>• H atoms become slightly positive.<br>• O has two single pairs<br>• Difference in charge, known as a dipole. |
| The shape is angular | Lewis structure:  Space-filling:  Diagram:  |
| Intermolecular forces are strong hydrogen bonds. | Hydrogen bonds form between slightly positive H of one molecule and slightly negative O of another molecule.<br>These intermolecular forces are strong. It requires large amounts of energy to overcome these bonds, therefore the melting and boiling points of water are high.<br>  <br>water molecules |
| $H_2O(g)$ is a greenhouse gas. | Because $H_2O$ is a polar molecule, it absorbs a lot of heat energy for a small rise in temperature. The polar nature of water causes it to be able to absorb infrared radiation from the sun. As a result, the ocean acts as a heat reservoir and keeps the earth's climate moderate.<br>  |

## Summary

Properties of water:

- High specific heat capacity:
  Specific heat capacity is the amount of energy necessary to change the temperature of 1 kg of a substance by 1 °C.
- Melting and boiling points:
  There are strong hydrogen bonds between the different water molecules. A lot of energy is necessary to overcome these strong forces, therefore their boiling and melting points are higher than expected.
- Density of water and ice:
  The density of water is dependent on its temperature.
- Cohesion:
  Forces between the same type of particles
- Adhesion:
  Forces between different types of particles
- Surface tension:
  This is caused by the cohesive force of molecules on the surface of water.
- Capillary action:
  Capillarity is the tendency of a liquid to rise in a tube as a result of surface tension. Capillarity is related to the adhesive properties of water molecules.

## Notes