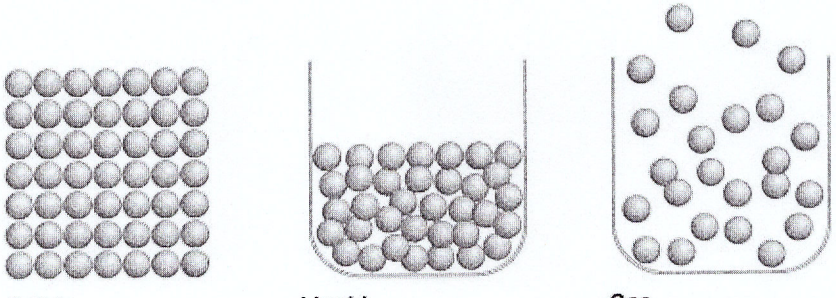
Properties of Chemicals

- Recall that *intermolecular forces* are the attractive forces that exist between entire molecules
- The state of a pure substance (solid, liquid, or gas) depends on the strength of the intermolecular forces
    - The particles in a solid are very tightly packed together indicating a strong intermolecular force between particles.
    - Whereas the particle in a gas are so far apart (because they move in all directions at great speeds), the intermolecular forces between particles is almost insignificant
- Recall, that the *melting point* is the temperature at which a substance changes from a solid to a liquid. The *boiling point* is the temperature at which a substances changes from a liquid to a gas.
    - When chemicals melt or boil, the intermolecular forces between the molecules are being overcome and broken

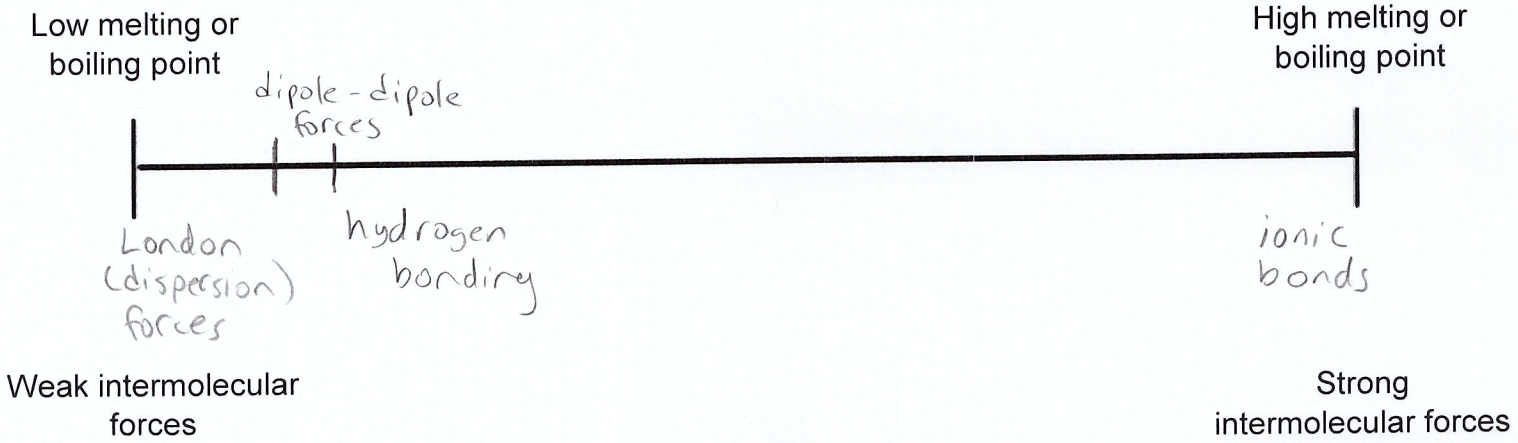


particles held firmly in place ∴ strong intermolecular forces

weaker intermolecular forces as particles can slide past each other

weakest intermolecular forces as particles are so spaced out from each other

- The melting and boiling points of different chemicals are indicators to the strength of attraction between molecules (ie. strength of intermolecular forces)
    - In order to predict the relative ranking of melting and boiling points of different chemicals, we need to know the strengths of the different intermolecular forces



    - Remember when comparing the strength of London dispersion forces, the bigger molecule (ie. the one with more electrons) will have stronger London dispersion forces

total e⁻, not just valence e⁻

- *Conductivity* is another physical property that can distinguish between ionic and molecular compounds
    - **Conductivity** is the ability of a substance to conduct electrical charge (or a substances ability to allow an electrical current to flow)
    - **Electrical current** is the directional flow of electrons or ions
- Solid ionic compounds have valence electrons that are held solidly in place; therefore they cannot conduct electricity
    - However, since ionic compounds are made if ions, when dissolve in water the ions are able to move past one another allowing them to carry an electrical current
- Most molecular compounds *cannot* conduct an electrical current because they are not made up of ions and also the valence electrons are not free to move through the molecule

Practice Problems

1. Chloroform, $CHCl_{3(l)}$, has the same shape as methane, $CH_{4(g)}$. The boiling point of methane is -182°C and the boiling point of chloroform is 61°C. Explain this difference.

$CHCl_3$ has a higher boiling point b/c it is not a symmetrical tetrahedral shape like CH_4. ∴ $CHCl_3$ will have dipole-dipole forces rather than just London (dispersion) forces that are present in CH_4.

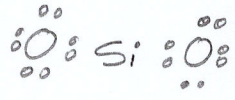
2. List the following substances in order of increasing boiling points: C_2H_5OH, SiO_2, C_3H_8.

C_2H_5OH ↓ hydrogen bonding ∴ highest boiling point

C_3H_8 ↓ nonpolar = London (dispersion) forces only

$(6e^-)3 + (1e^-)8 = 24e^-$

SiO_2



O - Si - O ∴ nonpolar as well

$1(14e^-) + 2(8e^-) = 30e^-$ ∴ stronger = London (dispersion) forces only

C_3H_8	low ↓
SiO_2	
C_2H_5OH	high

3. Use bonding theory (ie. strengths of intermolecular forces) to explain why glycerol, $C_3H_5(OH)_{3(l)}$, flows much slower that water, $H_2O_{(l)}$.

3 places to make a hydrogen bond ∴ molecules have a much stronger attraction to each other than water and cannot slide by each other as easily.

4. Predict which substances will have the higher boiling point in each of the following pairs. Explain your predictions.

a. NH_2Cl or PH_2F

NH_2Cl has hydrogen bonding vs. dipole-dipole forces present in PH_2F

b. CH_3OH or $C_2H_5NH_2$

both have hydrogen bonding but CH_3OH will have higher boiling point b/c great ΔEN b/w O-H vs. N-H

c. CH_3F or F_2

CH_3F has dipole-dipole force b/c molecule is not symmetrical ∴ making it polar.

F_2 only has London (dispersion) forces b/c it is nonpolar

d. $AlCl_3$ or PH_3

$AlCl_3$ ionic compound vs. PH_3 which is molecular

e. NH_3 or PH_3

has hydrogen-bonding vs. PH_3 which has dipole-dipole forces

f. C_4H_{10} or Cl_2

both are nonpolar and ∴ only have London (dispersion) forces, but C_4H_{10} is a bigger molecule = greater forces

g. neon or krypton

both only have London (dispersion) forces, but krypton is bigger (ie. has more e^-) ∴ has stronger forces

h. KCl or ICl

ionic compound vs. ICl which is molecular

i. C_2F_2 or C_2HCl

C_2HCl is a polar molecule and ∴ has dipole-dipole forces

C_2F_2 is nonpolar and only has London (dispersion) forces

j. C_2H_5F or CH_3Cl

both molecules are unsymmetrical; making them polar with dipole-dipole forces. But C-F has a greater ΔEN than C-Cl ∴ giving C_2H_5F a higher boiling point

k. NaCl or CO

ionic compound vs CO which is molecular

l. NH_3 or CH_4

has hydrogen-bonding vs. CH_4 which is nonpolar and only has London (dispersion) forces