Lesson 6 Trends of organic molecules

Click to revise trends

Firstly a few definitions.

Viscosity – is the liquid's resistance to flow

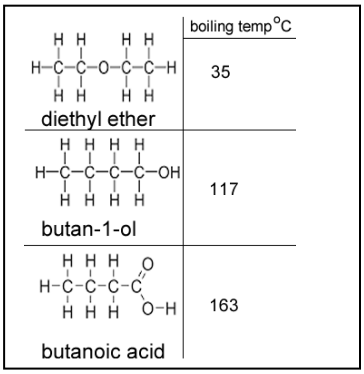
Flash point – relates to liquid fuels and is the lowest temperature , below the boiling point of the fuel, at which a liquid's vapour can form an ignitable mixture in air.

Note flash point is not on the 2024 -27 study design, however, the examiner may give the definition of flash point and ask for response.

Viscosity, flash point, boiling and melting points are all influenced by the type of intermolecular forces acting between molecules and the strength of these forces. The relative strength of the three intermolecular forces is Hydrogen bonding > dipole-dipole > Van der Waals dispersion forces and depends on the functional groups present on the molecule.

Let's take a look at the trends in boiling temperature.

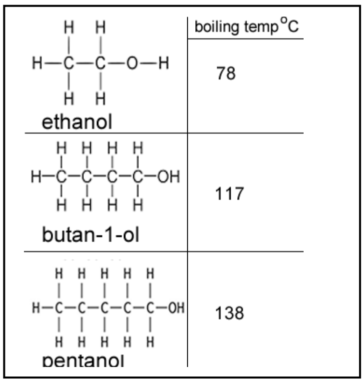
1. Boiling temperatures increase as the number of carbons is increased.
2. Branching decreases boiling temperatures.
3. The more polar the functional groups the greater the melting temperature.



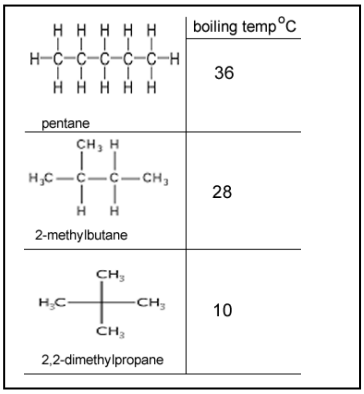
Starting with the functional groups present consider the two molecules shown below. Both diethyl ether and butan-1-ol have identical molecular weights and yet the boiling temperature of diethyl ether is 35°C while the boiling temperature of butan-1-ol is 117°C.

Butan-1-ol exhibits hydrogen bonding as it's predominant intermolecular force while the dominant intermolecular force in diethyl ether is the weaker dipole-dipole bonding.

Consider the impact of the more polar carboxyl (COOH) group on butanoic acid, which exhibits both dipole-dipole and hydrogen bonding, it cause the boiling temperature to jump significantly.

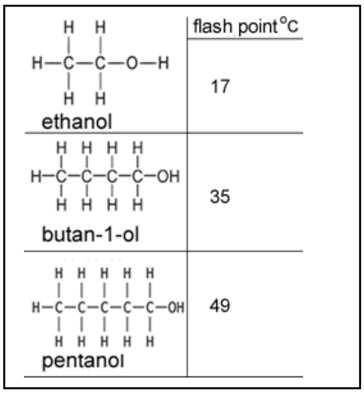


As the number of carbons increases in the molecule so does the boiling temperature. Consider the alcohols shown on the right. They all have hydrogen bonding, due to the hydroxyl (OH) functional group and yet as the carbon chain grows so does the melting temperature. The difference here is the Van der Waals dispersion forces, which are proportional to the length of the chain, or size of molecule. As the size of the molecule increases so do these, relatively weak, forces of attraction.



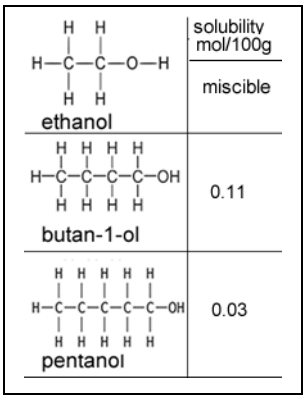
Now consider the impact of branching on the boiling temperature. As you can see from the molecules shown on the right, the greater the branching the lower the temperature. The molecules shown on the right rely on Van der Waals dispersion forces as the main force of attraction between the molecules. These forces are weak and act over small distances, the inability of the molecules to pack close together, due to branching, reduces the attraction of the Van der Waals dispersion forces, Refer to the link above for a detailed explanation.

Trends in flash point follow those of boiling temperature.
Consider the alcohols shown on the right. As the intermolecular forces of attraction increase so does the flash point of each molecule.



Viscosity is again related to the strength of intermolecular bonding and the relative strength of Van der Waals forces, dipole-dipole and hydrogen bonding acting between molecules. This in turn is related to how molecules pack together. Branching, therefore, reduces the impact of the intermolecular forces to attract molecules and reduces the viscosity of relatively smaller molecules, while an increase in the length of the linear molecules significantly increases the Van der Waals forces of attraction and allow for tangling amongst molecules, hence an increase in viscosity.

Solubility in water, however, is directly related to the degree of polarity of the molecule and the length of the hydrocarbon chain. The longer the hydrocarbon chain the
less soluble in water a molecule is.



1) List the following molecules in order of increasing solubility. Give an explanation
   a) i. pentanoic acid
      ii. ethanoic acid
      iii. hexanoic acid

   b) List the following molecules in order of increasing viscosity. Give an explanation

      i. 1,2,3-pentanetriol
      ii. 1-pentanol
      iii. 1,2-pentanediol

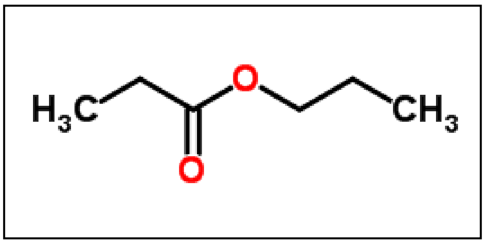
2) Consider the molecules shown below.

   a) $CH_3CH_2CH_3$
   b) CH_3CH_2OH
   c) CH_3CHO
   d) CH_3COCH_3

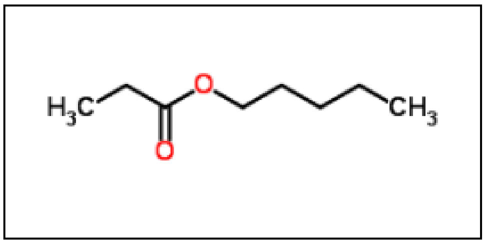
      i. List the following molecules in order of increasing boiling point.

      ii. To what homologous group does each molecule belong to?

3) Consider the two molecules shown on the right.
a) Name each molecule.



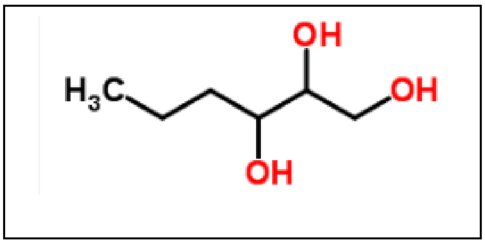
b) Which has the highest boiling temp? Explain



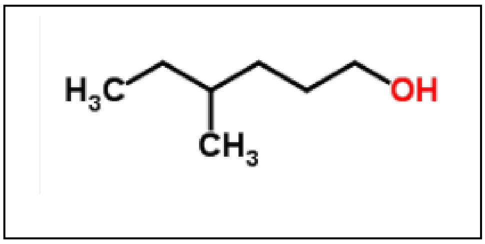
c) Which has the highest solubility in water? Explain

4) Consider the two molecules shown on the right.

a) Name each molecule



b) Which has the highest boiling temp? Explain



c) Which has the highest solubility in water? Explain