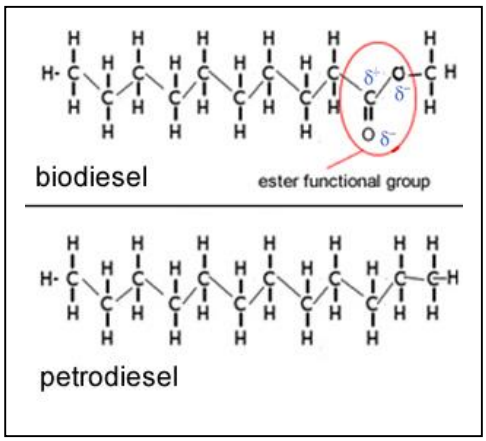
Fuels Biodiesel vs Petrodiesel

1) Pictured on the right are molecules of bio-diesel and petro-diesel. Their physical properties are determined by their molecular structure and their intermolecular bonding.



Cloud point is defined as the temperature at which a fuel starts to turn cloudy. Cloud point is used to determine how likely the fuel is to solidify in filters and obstruct fuel lines.

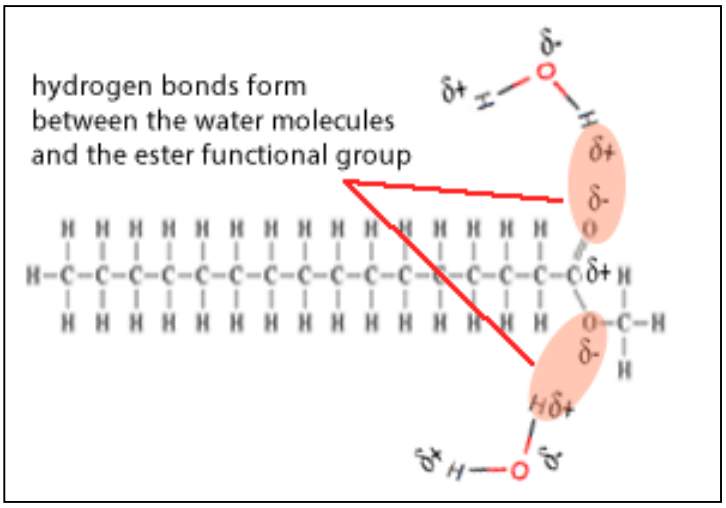
Flash point is the lowest temperature at which the vapour above a fuel ignites in air when exposed to flame.

Hygroscopic is the ability to attract water from the atmosphere at normal room temperature.

Looking at the structure of each molecule, fill in the table below.

Type of fuel	Type of intermolecular bonding. Circle the appropriate terms.	Melting temperature	Flash point	Cloud point
Petro-diesel	Hydrogen bonding Dispersion forces Dipole-dipole	Relatively high Relatively low	Relatively high Relatively low	Relatively high Relatively low
Bio-diesel	Hydrogen bonding Dispersion forces Dipole-dipole	Relatively high Relatively low	Relatively high Relatively low	Relatively high Relatively low

2) Which of the two diesels is hygroscopic and explain your reason.
Biodiesel is more hygroscopic than petro-diesel due to the polar nature of the ester group that attracts polar molecules, such as water.



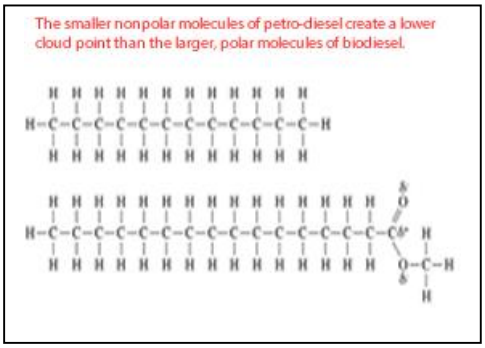
3) Which of the two fuels is more likely to undergo incomplete combustion to produce CO? Explain why
Petro-diesel is more likely than biodiesel to undergo incomplete combustion. Since oxygen is already present in the molecules of the methyl esters of biodiesel less oxygen is required to burn one mol of biodiesel than to burn one mol of petro-diesel.
$2C_{17}H_{34}O_2(l) + 49O_2(g) \rightarrow 34CO_2(g) + 34H_2O(l)$
$C_{17}H_{36}(l) + 26O_2(g) \rightarrow 17CO_2(g) + 18H_2O(l)$

4) Petro-diesel consists of molecules that are, on average, smaller than those found in biodiesel. The table on the right shows the major component of each fuel.

Fuel	Major component
petrodiesel	$C_{12}H_{26}$
biodiesel	$C_{19}H_{32}O_2$

a) Which fuel has the greatest viscosity and explain why you have come to this conclusion.
Biodiesel is more viscous than petro-diesel. Since viscosity is the ability of molecules to flow past each other, viscosity can hence be related back to the intermolecular forces at play between molecules. The greater the strength of the intermolecular bonds the greater the viscosity of the fluid. Biodiesel has larger molecules, hence greater dispersion forces as well as dipole-dipole bonding due to its ester functional group. Petro-diesel, on the other hand, only has dispersion forces that are weaker than those in biodiesel due to the smaller molecular mass of the molecules present in petro-diesel as compared to the larger molecules of biodiesel.

b) On the right are the structural formulae of a typical molecule in both petro-diesel and biodiesel. In cold, Northern hemisphere countries, which fuel is more likely to be used? Explain why.
Since the cloud point of biodiesel is significantly higher than that of petro-diesel, due to stronger inter-molecular forces at play, it is more likely to solidify in colder temperatures than petro-diesel. This has the impact of blocking fuel lines.



c) Provide three balanced chemical equations, those of photosynthesis, fermentation and combustion, to support the notion that ethanol is a carbon neutral fuel. Discuss why, in reality, ethanol is not totally carbon neutral.

Photosynthesis => $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

Fermentation => $C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$

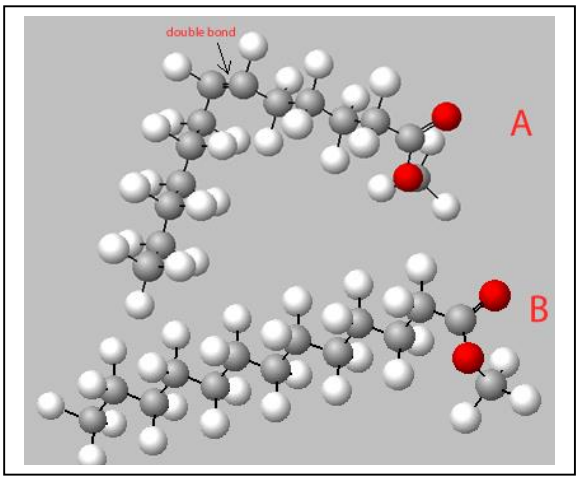
Combustion => $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

For every glucose molecule formed during photosynthesis 6 CO_2 molecules are absorbed from the atmosphere by the plant.
For every glucose molecule that undergoes fermentation to produce 2 ethanol molecules 2 CO_2 molecules are produced.
For every ethanol molecule that undergoes combustion 2 CO_2 molecules are produced.

In total 6 CO_2 molecules absorbed and 6 CO_2 molecules released during combustion. Net zero change in atmospheric CO_2.

This is not the complete picture, however, as you can see during fermentation ethanol in the aqueous state is formed and during combustion ethanol in the liquid state is burnt. To change in the state of ethanol from aqueous to liquid requires distillation and this process is very energy intensive as is the transport of the fuel itself.

d) Consider the two methyl esters shown on the right. Both have 14 carbon atoms, however, A has a double bond as indicated by the arrow. Suggest why one of this esters can be used as a biofuel in a cold climate while the other cannot.



Methyl ester A will have the lowest intermolecular force of the two esters due to its unsaturated nature which causes a kink. Hence this has the lowest cloud point and hence suitable for low temperature climates. Ester B is a straight chain and hence has greater intermolecular forces due to the nature of dispersion forces which are dependent on the closeness one molecule gets to the other.

5) The diagram below was adapted from the internet at: