1) Consider the following equation

$2A(g) + C(g) \rightarrow 2D(l)$ $\Delta H = -121.5$ kJ mol^{-1}

$D(l) + C(g) \rightarrow 2G(l)$ $\Delta H = -141.5$ kJ mol^{-1}

a) Give the ΔH for the following reactions.

i. $A(g) + ½ C(g) \rightarrow D(l)$ ΔH = *-60.80 kJ mol^{-}*

ii. $4D(l) \rightarrow 4A(g) + 2C(g)$ ΔH = *+243.0 kJ mol^{-}*

iii. $2A(g) + 2G(g) \rightarrow 3D(l)$ ΔH = *20.0 kJ mol^{-}*

b) Consider the equation given below.
$2A(g) + C(g) \rightarrow 2D(g)$
Will the ΔH for this equation most likely be :

i. -111.5 kJ mol^{-}

ii. +121.5 kJ mol^{-}

iii. -131.0 kJ mol^{-}

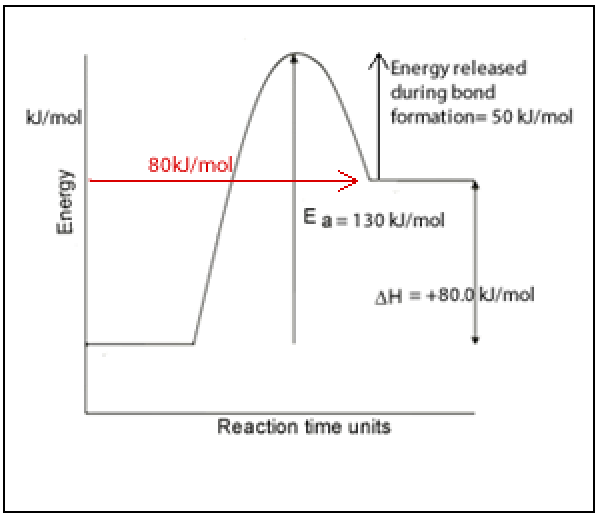
iv. +131.0 kJ mol^{-}

c) Explain your answer to b) above.
The amount of energy given out will be slightly less than 121kJ mol^{-}. Energy is retained by the system as product "D" is now in the gaseous state which requires more energy to maintain hence less energy is given out to the surroundings.

2) Consider the thermochemical equation given below.

$2A(g) + C(g) \rightarrow 2D(l)$ $\Delta H = +80.0$ kJ mol^{-1}

Draw the energy profile of this reaction given that 130 kJ/mol of energy is needed to break bonds. Label:



i. The energy content of the products

ii. The ΔH of the reaction

iii. The activation energy

iv. The amount of energy released during bond formation.

3) Consider the thermochemical equation below

A(g) + C(g) → 2D(l) $\Delta H = -121.5$ kJ mol^{-1}

What mass, in grams of reactant "C" is required to produce 364.5 kJ of energy given the molar mass of "C" is given as 100.00 g mol^{-}? Give the answer to the right number of significant figures.

Step 1 Find the mol of "C" required to produce 364.5 kJ of energy.

=> Write the stoichiometric ratio given by the balanced thermochemical equation.

=> Since for every one mol of "C" consumed 121.5 kJ of energy is released we write the expression

1 / 121.5 = x / 364.5

=> x = 3.000

Step 2 find the mass of "C"

=> 3.000 X 100.00 = 300.0 grams (4 sig figs)

4) Consider the gaseous fuel propane.

i. Write a balanced thermochemical equation for the complete combustion of liquid octane, at SLC.

$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$ $\Delta H = -1.092 \times 10^4$ kJ mol^{-}

The ΔH is obtained by reading the molar heat of combustion (kJ/mol) from the data sheet, which is 5460, multiplying it by 2, since the equation specifies 2 mol of octane react completely and giving a sign of negative to indicate an exothermic reaction.

ii. Using the equation derived in i. above calculate the amount, in kilograms, of gas produced if 3.56 Megajoules of energy are required to be released.

Step 1 calculate the mol of CO_2 that will be generated.

=> Derive the ratio that relates the mol of CO_2 produced with the amount of energy in kJ given out. For every 16 mol of CO_2 produced 10920 kJ of energy if released.

Hence give the expression below where x is the mol of CO_2.

=> 16/10920 = x / 3560 kJ

=> x = 5.216

Step 2 Calculate the mas in kg.

=> 5.216 X 44.0 = 2.30 X 10^2 grams = 2.30 X 10^{-1} kg. (3 sig fig)

iii. Using the ideal gas equation (PV = nRT) calculate the volume, in litres, of gas <u>produced</u> if a limited amount of octane burns in excess oxygen to produce 3.489 X 10^4 kJ of energy at 25°C and 101.3 kpa pressure.

Step 1 Calculate the mol of CO_2 produced.

=> Derive the ratio that relates the mol of CO_2 produced with the amount of energy in kJ given out. For every 16 mol of CO_2 produced 10920 kJ of energy if released.

Hence give the expression below where x is the mol of CO_2.

=> 16/10920 = x / 3.489 X 10^4

=> 51.121 mol

Step 2 Transform the ideal gas equation to give the expression for volume (litres).

=> V = nRT / P

Step 3 Convert the units to the appropriate format necessary for the ideal gas equation>

T = 298 °K

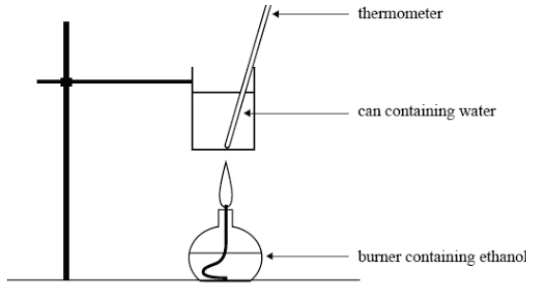
R = 8.31

P = 101.3 kPa

n = 51.121

V(litres) = 51.121 X 8.31 X 298 / 101.3 = 1.25 X 10^3 litres.

5) A student was set the task of determining the molar heat of combustion of ethanol using the setup shown on the right.
An amount of 100 mL of water was placed in the can at 25.0° C and heated using an ethanol burner.
The ethanol burner was weighed before and after burning and a mass loss of 0.46 grams was recorded. The final temperature of the water was recorded at 49.2 °C.



a) Calculate the molar heat of combustion given the experimental results above. Give the answer to the right amount of significant figures.
Step 1 Calculate the mol of ethanol used.
=> 0.46 grams / 46.0 = 1.00 X 10^{-2}

Step 2 Calulate the energy absorbed by the water.
=> E(joules) = 4.18 X (100 mL and 0.997 g/mL) X 24.2 °C
=> E = 10,085 J = 10.085 kJ

Step 3 Calculate the molar heat of combustion of ethanol
=> 10.085 / 0.0100 = 1.01 X 10^{3} kJ
=> 1.0 X 10^{3} kJ/mol (2 sig figs , as the mass of ethanol(0.46 grams) was given to two sig figs)

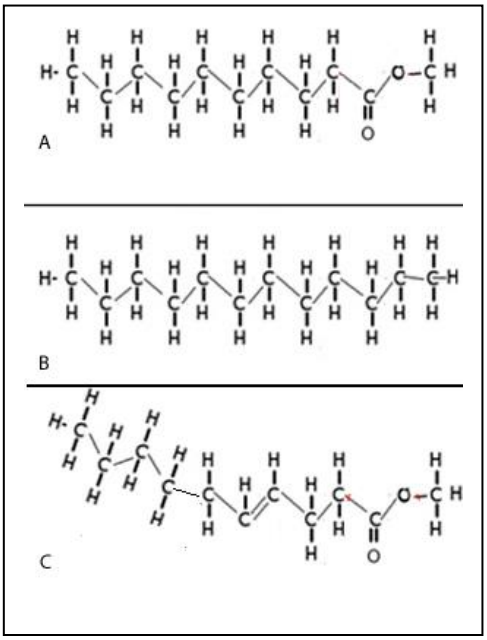
b) Compare your result to the molar heat of combustion given for ethanol in the data sheet and discuss the reason for any discrepancy.
The literature molar heat of combustion is 1360kJ/mol .
The experimental value is lower due to the poor insulation of the setup. We cannot assume that all the energy released is absorbed by the water. A great deal of energy loss has caused the discrepancy.
c) How can the validity of the results be improved?
There are a number of ways of improving the validity of an experiment. In this case using a better insulated vessel to stop a significant amount of energy given out to the environment rather than finding its way into the water. Using electronic scales that give mass to three decimal places. Controlling all other variables, such as room temperature, or using the same scales and conducting multiple trials.
d) Give one example of a random error and discuss how it may have impacted on the result.
Any plausible random error.
Eg.
- Experiment conducted by the window with periodic draft dispersing the heat away from the can via convection currents. This would lead to a lower value for the molar heat of combustion.
- Temperature of the room suddenly changed due to air-conditioner been turned on. This would decrease the temperature increase and would lead to a lower value of the molar heat of combustion.

e) Give one example of a systematic error and discuss how it may have impacted on the result.

Any plausible systematic error.

Eg. Scales were not properly calibrated. This would give a consistent error but would have little impact on the final result as difference in mass of the spirit burner that is measured would cancel when the two values of mass after burning is subtracted from mass before burning.

6) Consider the molecules shown on the right of three different types of fuels. Give a reason for each of your answers. Which of the molecules pictured belong to a fuel that:



i. needs to be stored in air tight containers from fear of being contaminated by atmospheric water,

A and C

A and C are polar molecules from biodiesel fuels. The polar molecules are more able to attract polar water molecules and are said to be hygroscopic as opposed to B which is part of petrodiesel and is hydrophobic.

ii. are renewable sources of energy,

A and C

A and C are molecules found in biodiesel are formed from a renewable supply of plant oil through a process known as transesterification.

iii. with the lowest viscosity,

B

Viscosity is the ability for molecules to flow past each other. Molecules that have strong intermolecular bonding also have high viscosity. Molecules A and C have intermolecular bonds composed of dispersion forces and dipole-dipole bonding as compared to B which only had dispersion forces. This greater attraction between the molecules of A and C tend to oppose molecules from flowing past each other with ease as molecules of B flow with relative ease. Fuel B is most likely to have the lowest viscosity of the three.

iv. can be used as an effective fuel in very low temperature climates,

B

A and C have stronger intermolecular bonding of dipole-dipole bonding and dispersion forces whereas B only has the weaker dispersion forces. The relative strong intermolecular bonds of A and C tend to lead to a higher cloud point then the weaker intermolecular bonds found in B which tend to create much lower cloud points. Cloud Point is the temperature at which crystals of liquid fuel start to form. A higher cloud point means that the liquid will solidify at a higher temperature and hence it is less desirable for use in low temperature climates.

v. has a very low flash point,

B

Flash point is the temperature at which vapours of a fuel can be ignited with a ignition source. Since molecules B only has dispersion forces and hence has the weaker *intermolecular bonds of all three molecules it will easily vaporise at low temperatures and hence form vapours in high concentrations that can be ignited.*

vi. is least likely to be bio-degraded,

B

Ester linkages are easily broken down in nature and hence methyl esters found in biodiesel are biodegradable whilst the alkanes found in petrodiesel are not biodegradable.

vii. is most likely to be bio-degraded,

C

Not only does C have an ester link which is easily broken down in nature, biodegradable, but it also has a very reactive double bond which undergoes reactions that can break down the molecule.

viii. is more likely to undergo incomplete combustion in low oxygen environments,

B

Since methyl esters in biodiesel already have oxygen atoms they are more likely to undergo complete combustion in low oxygen environments than the petrodiesel that must rely totally on oxygen from the atmosphere.

ix. has energy content measured in kJ/gram and not in kJ/mol.

A, B and C

Biodiesel and petrodiesel are mixtures and not pure substances. Only pure substances can have their energy content expressed in kJ/mol.

x. has the most impact on anthropogenic Climate Change.

B

Fossil fuels have the most impact on man-made (anthropogenic) climate change. Biodiesel is made from plants oils that undergo photosynthesis to trap atmospheric CO_2 in organic molecules that we then use to form biodiesel.