Ongoing revision 9

1) Two chemical reactions occur as follows.
   i. $CH_2CHCH_2CH_2CH_2CH_3 + Br_2 \rightarrow X$
   and

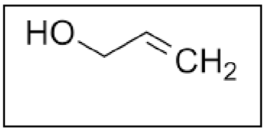
   ii. 2-chlorohexane + NaOH(aq) $\rightarrow$ Y

   a) What type of reaction is:
      i. *Addition*
      ii. *Substitution*

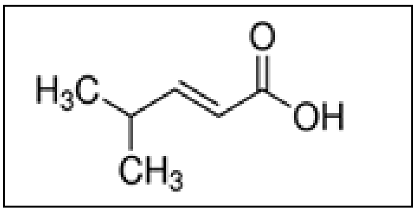
   b) What is substance:
      i. X = *1,2-dibromohexane*

      ii. Y = *hexan-2-ol*

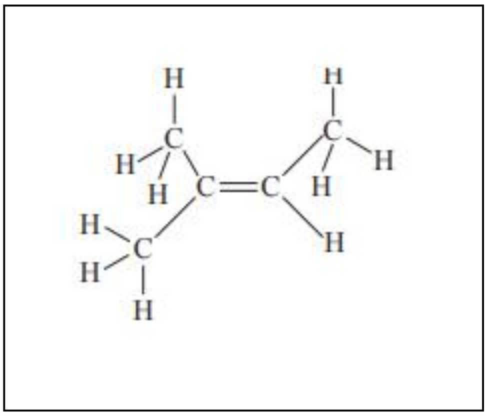
   c) Write the IUPAC name for the molecule shown on the right.
      prop-2-en-1-1ol



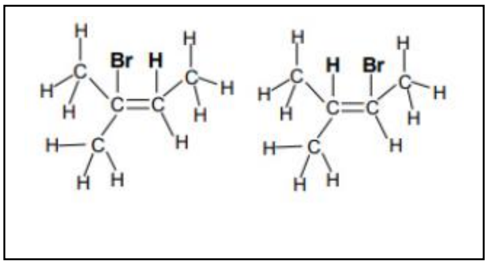
   d) Draw the structural formula for the compound 4-methyl-pent-2-enoic acid



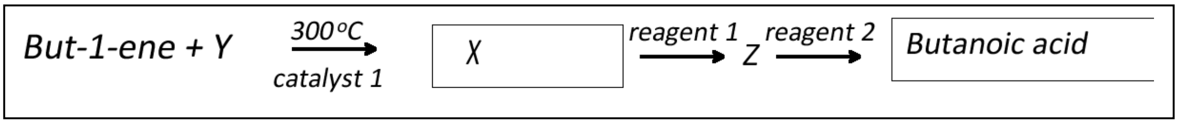
   e) The molecule with the structural formula shown below reacts with hydrogen bromide, HBr, to form $C_5H_{11}Br$.



   Draw all possible isomers of the product $C_5H_{11}Br$



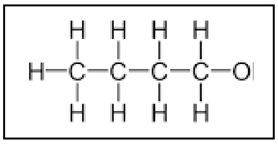
f) Butanoic acid is formed from but-1-ene according to the reaction pathway below.



i. What is reactant Y *H_2O*

ii. What is catalyst 1 *H_3PO_4*

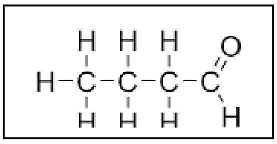
iii. X = *butan-1-ol*



iv. What is reagent 1 *$Cr_2O_7^{-2}$*

v. What is reagent 2 *$Cr_2O_7^{-2}$*

vi. Give the structural formula of Z



2) Liquid octane was placed in a bomb calorimeter and ignited.

a) Write a balanced chemical equation for the combustion of liquid octane (C8H18) in excess oxygen.

$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$

b) Calculate the ΔH for the reaction represented by the equation above if 1.140 grams of pure octane (FM=114.23 amu) generated 5.098 kJ of heat energy when completely burnt.

Step 1 - Calculate the mol of octane

=> 1.140/ 114.23 = 1.00 X 10^{-2} mol

Step 2 - Calculate the molar heat of combustion of octane

=> 5.098 kj / 0.0100 = 509.8 kJ/mol

Step 3 Calculate the ΔH

=> The equation has 2 mol of octane reacting hence the ΔH = 2 X 509.8KJ = -1.02 X 10^3Kj/mol

c) Using the ΔH value in b) calculate the volume, in litres, of carbon dioxide produced at SLC, if an unknown mass of octane delivered 3100 kJ of energy

Step 1 Calculate the mol of carbon dioxide produced if 3100 kJ of energy is released.

=> apply the ratio

mol of CO_2 / Energy released

16/ 1020.0 kJ = x / 3100

x = 48.6 mol

Step 2 Calculate the volume of CO_2 at SLC.

=> 48.6 X 24.8 = 1205 litres.

d) In a sealed 2.00 litre reaction vessel was placed 0.132 mol of octane gas and 2.874 mol of oxygen gas. The mixture was ignited and the amount of heat released was calculated at 51.00 kJ. If all the products are in the gaseous state:

i) give the expression for the equilibrium constant for this reaction

$$\frac{[CO_2]^{16}\,[H_2O]^{18}}{[C_8H_{18}]^{2}\,[O_2]^{25}}$$

ii) calculate following at equilibrium.

i. $[C_8H_{18}]$ =

Step 1 Calculate the amount of octane in mol used up

=> 2 / 1020 = x / 51.00

=> x = 0.100

Step 2 calculate the amount of octane remaining

=> 0.132 – 0.100 =0.032

Step 3 calculate []

=> 0.032 /2 =0.016M

ii. $[CO_2]$ =

Step 1

=> Calculate the mol of CO_2 produced.

=> Since 0.100 mol of octane was used up according to the ratio 0.800 mol of CO_2 is created

Step 2 calculate []

=> 0.800 / 2 = 0.400M

iii) What conditions favour maximum yield of CO_2?

- low temperatures and low pressure.

3) The table on the right lists some of the properties of bio and petro diesels. ***Flashpoint*** is the lowest temperature at which a fuel will ignite if exposed to a flame. A fuel with a higher flashpoint is safer than one with a lower flash point.

Fuel	Major component	Energy content (MJ/kg)	CO_2 emission (kg CO_2/kg of fuel)
petrodiesel	$C_{12}H_{26}$	43	3.17
biodiesel	$C_{19}H_{32}O_2$	38	2.52

a) Describe and explain the difference in the safe handling, under the same conditions, of the two fuels.

The higher the flashpoint of the fuel the safer it can be stored and handled. Biodiesel has the higher flashpoint. Flashpoint is linked to intermolecular bonding, the greater the intermolecular bonding the higher the flashpoint. Biodiesel has greater intermolecular bonding than petrodiesel . Biodiesel has dipole-dipole bonding due to the ester functional group and larger dispersion forces than petro diesel as the molecules of biodiesel are larger.

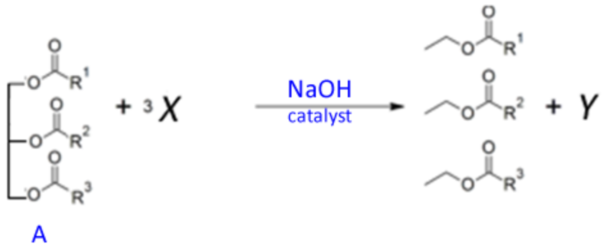
b) Viscosity is an important physical property for fuels used in cold, Northern hemisphere climates. Describe and explain which fuel is best suited to cold climates.

Petrodiesel is best suited to cold climates as it has the lowest viscosity of the two fuels. It's intermolecular bonding is weaker than biodiesel as it is only due to weak dispersion forces. Whereas the intermolecular bonding of biodiesel is due to both larger dispersion forces, due *to the bigger molecules, and also due to dipole-dipole bonding due to the ester functional groups.*

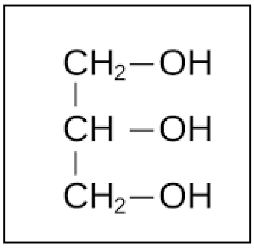
c) Biodiesel is produced via the pathway shown on the right.

i. To which group of food molecules does "A" belong to? *Triglycerides*

ii. Name "X" *ethanol*



iii. Draw the structural formula of "Y".



d) Which of the following molecules represent a:

1) $C_{12}H_{25}$ COOH

2) $C_{10}H_{19}COOH$

3) $C_{11}H_{19}COOH$

4) $C_8H_{16}O_2$

i. monounsaturated fatty acid ---- *2 and 4*

ii. poly unsaturated fatty acid ----- *3*

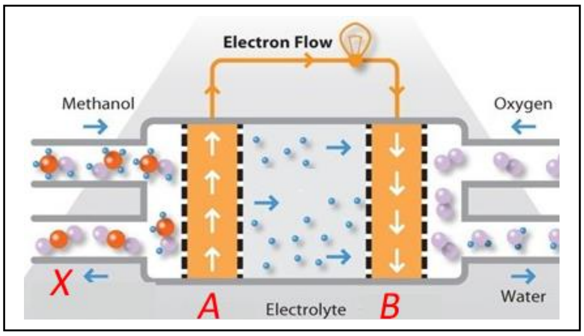
iii. saturated fatty acid ---- *1*

Saturated = $C_nH_{2n+1}COOH$

Monounsaturated = $C_nH_{2n-1}COOH$

Polyunsaturated = $C_nH_{2n-3}COOH$

4) Methanol is an important fuel. Methanol fuel cells are used to generate electrical power to power computers and even electric vehicles.



a) Some say it is a more practical option than hydrogen. Explain why

Hydrogen is a liquid at low temperatures and very high pressure. Infrastructure for the storage and delivery of liquid hydrogen is expensive and poses a greater safety risk than liquid methanol which can be stored as a liquid at normal temperature and pressure.

b) What is the polarity of electrode "A"? *Electrode "A" is the anode and is negative.*

c) Write the equation to the reaction taking place at electrode "A"

$CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e$

d) Write the equation to the reaction taking place at electrode "B"

$4e + 4H^+(aq) + O_2(g) \rightarrow 2H_2O(l)$

e) Write a balanced chemical equation to the overall reaction taking place in the fuel cell.

$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$

f) What moves from electrode "A" to electrode "B" through the electrolyte?

H^+ ions

g) Using a suitable catalyst methanol can be synthesised from CO_2 and H_2 gases according to the equation below.

$CO_2(g) + 3H_2(g) \rightarrow CH_3OH(l) + H_2O(l)$.

Submarines can use methanol fuel cells to generate electricity to power the motors while submerged. Although submarines run on electric power when submerged they still have diesel engines on board to drive electric generators. Submarines require silent operation to remain concealed and electric power from fuel cells enable this quiet operation.

i. CO_2 can be recycled from the combustion of methanol in the fuel cell. Hydrogen gas must be generated by other means in order synthesise methanol fuel. Suggest a way the hydrogen gas can be generated whilst the submarine is at sea.

Diesel engines can be used to generate electrical energy to electrolyse water into hydrogen and oxygen

ii. Can the submarine use its diesel engines to generate electrical energy to power the motors while submerged in deep water? Explain your answer.

No! A supply of oxygen and removal of exhaust needs to be catered for. This is impossible underwater.

iii. Is methanol, generated in this way, considered a renewable fuel? Explain your answer.

As long as the methanol can be generated at a rate that means it will never be depleted then it is renewable. Hydrogen from the electrolysis of water can be quickly formed while CO_2 can readily be supplied from the exhaust of the fuel cell.