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VCE Chemistry ¾
AOS 1 Revision I [0.10]
Workshop

Error Logbook: IMPORTANT

Mistake/Misconception #1		Mistake/Misconception #2	
Question #:	Page #: 2-21	Question #:	Page #: 22
Notes: transesterification GIGA IMPORTANT		Notes: Bond Enthalpy GIGA IMPORTANT	
Mistake/Misconception #3		**Mistake/Misconception #4**	
Question #:	Page #: ?,	Question #:	Page #:
Notes: $H_2O_{(g)} \Rightarrow H_2O_{(l)}$ for thermochemical $\Delta H = -44.0$ kJ/mol		Notes:	

Section A: Transesterification of Biodiesel

Sub-Section: Lipids (Fats & Oils)

Discussion: What are some examples of lipids (fats and oils)?

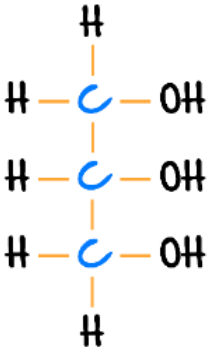
- **Fats:**
  butter, animal fats
- **Oils:**
  Fries, olive, sunflower seed oil

Lipids (Fats & Oils)

- **Definition:** Lipids are fats and oils, and can be found in humans and in food.
- **Alternative Name:** triglyceride.
- **Construct:** From a glycerol molecule along with three fatty acids.

Glycerol

- The structure of glycerol can be found on **page 22 of the databook.**

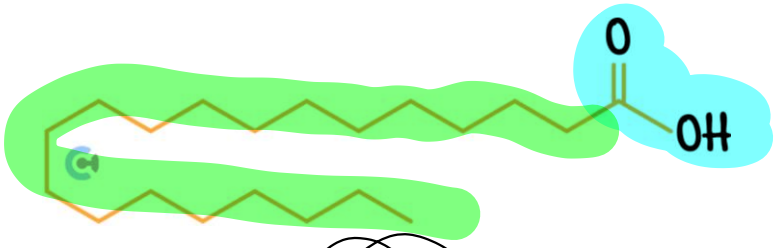


Glycerol

- This name is too long and is simplified to just **glycerol,** $C_3H_8O_3$

Fatty Acids

- **Definition**: Fatty acids are essentially **carboxylic acids** with long carbon chains.
  - They are called fatty acids as they are the building blocks of the fat in our bodies and the food that we eat (cover more of this later).
- Consider arachidic acid:

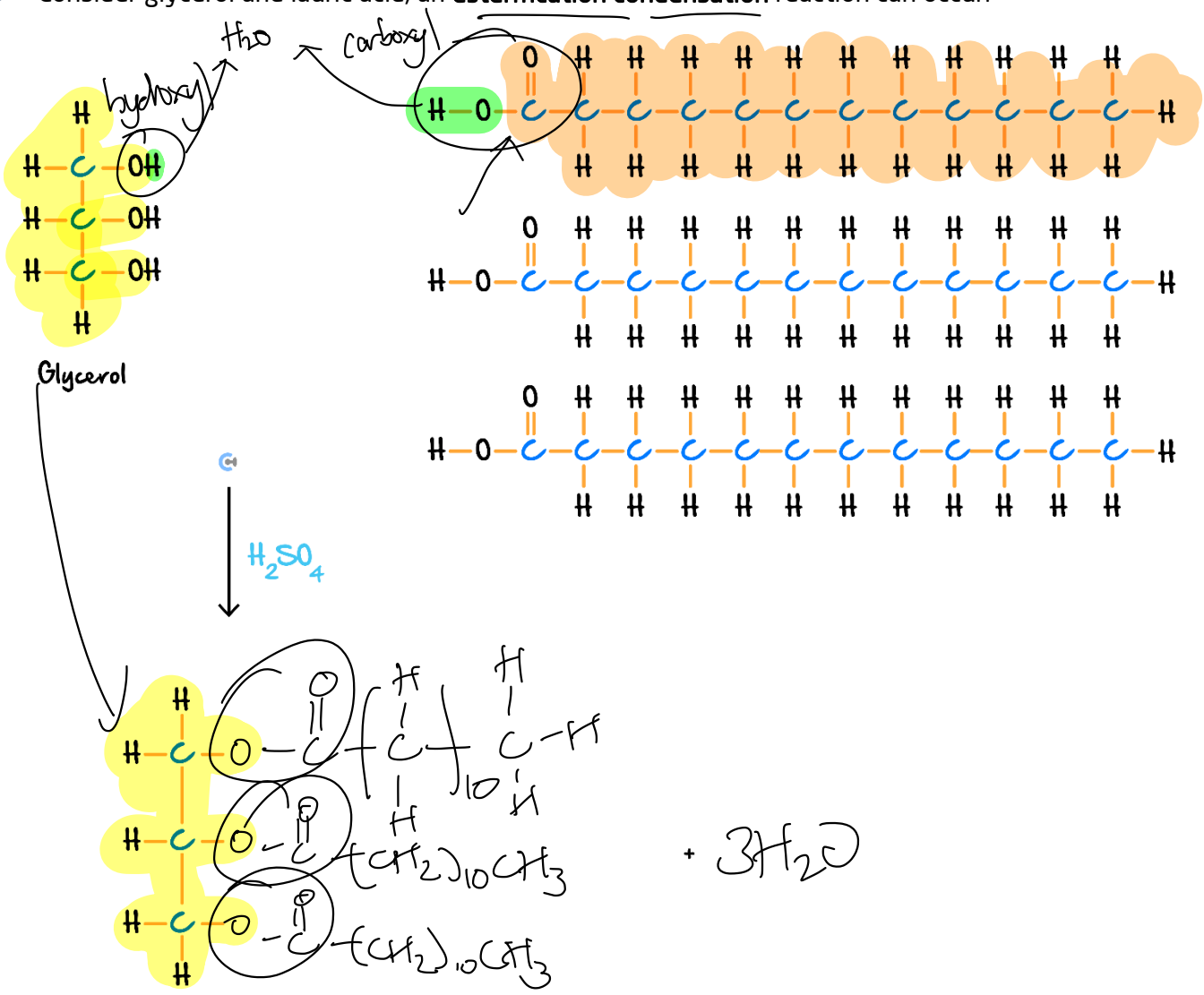


- **Arachidic Acid Polarity:** [Polar] / [Non-Polar]
- **Polarity Reasoning**: While it contains a polar carboxyl group, it is **non-polar overall** due to its **long carbon chain**.
- **Data Book:** Page 18.

Space for Personal Notes

Exploration: Formation of Lipids/Triglycerides / fats & oils

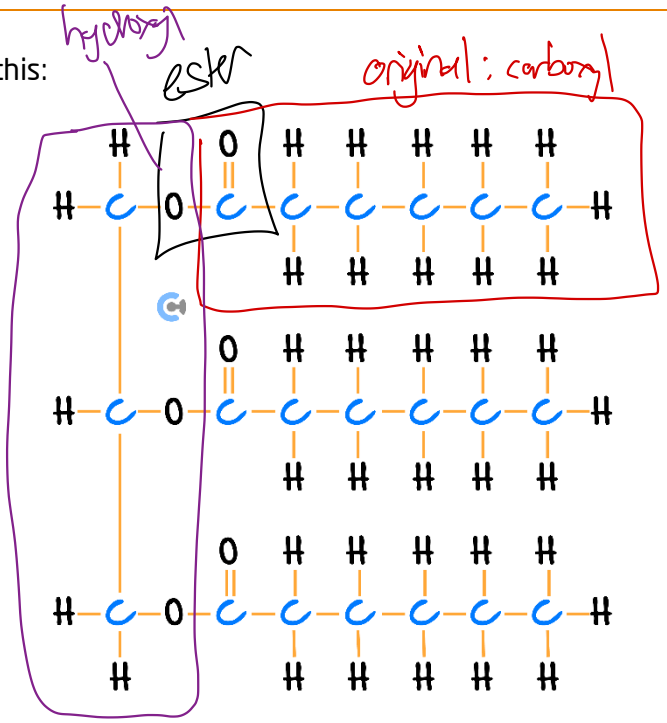
- Consider glycerol and lauric acid, an **esterification condensation** reaction can occur.



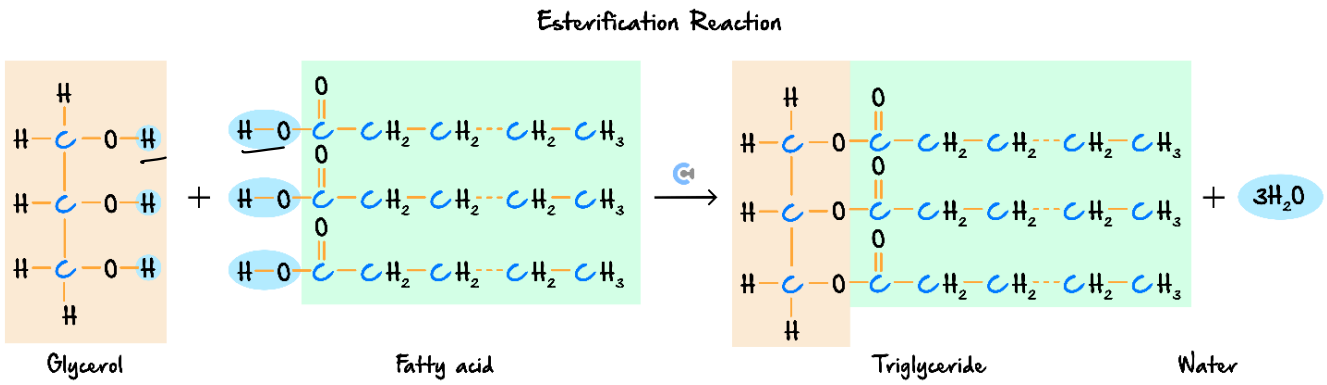
- **Linkage:**

Name	Number of Linkages
ester linkage	3

- Triglycerides look like this:



- **Overall Equation:**



NOTE: We see that the lipid which forms is also known as a triglyceride, which essentially consists of the glycerol backbone, whereby three esters are connected to the glycerol backbone.

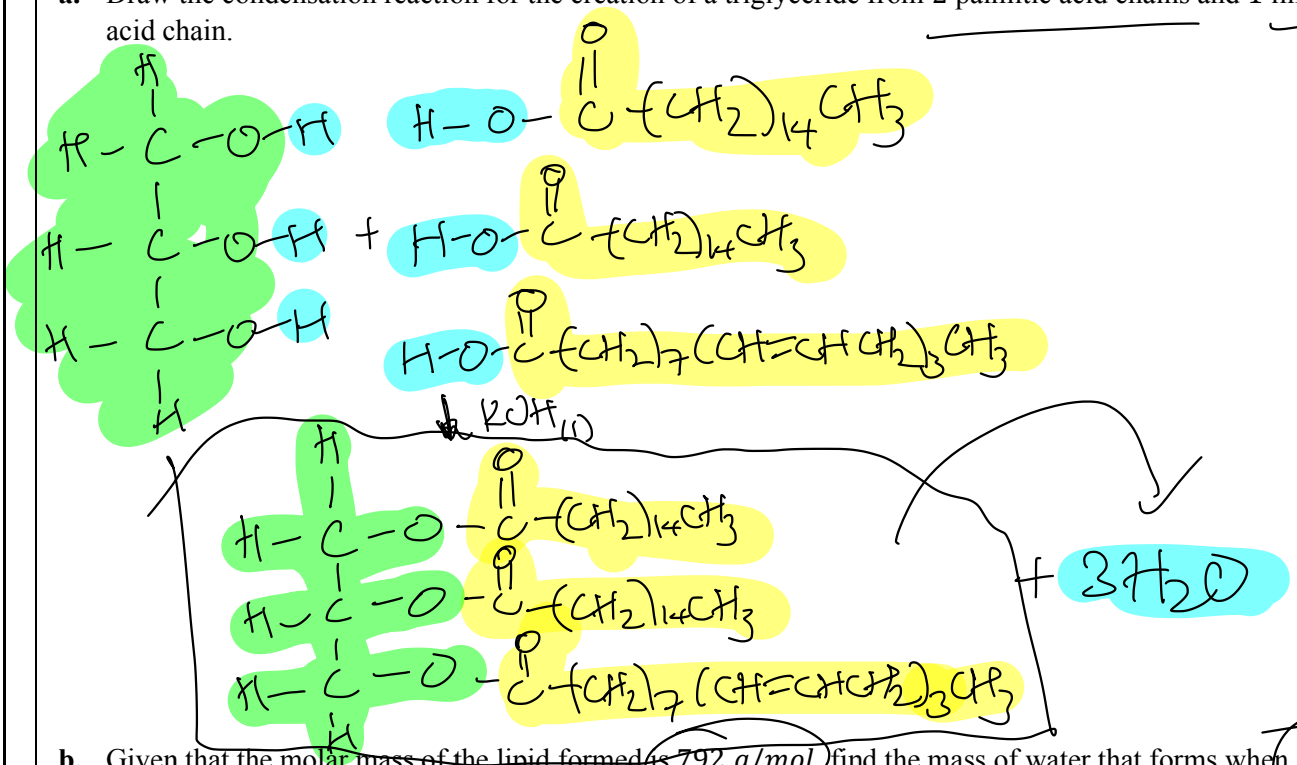
Space for Personal Notes

Let's look at a question together!

TIP: When drawing reactions with lipids, draw the hydroxyl groups facing each other.

Question 1 Walkthrough.

a. Draw the condensation reaction for the creation of a triglyceride from 2 palmitic acid chains and 1 linolenic acid chain.



b. Given that the molar mass of the lipid formed is 792 g/mol, find the mass of water that forms when 5.25 g of the lipid is formed.

$n(\text{lipid}) = \frac{m}{M} = \frac{5.25}{792} = 0.00663\ mol$

$n(H_2O) = 3n(\text{lipid}) = 0.0199\ mol$

$m(H_2O) = n \times M = 0.0199 \times 18 = 0.358\ g$

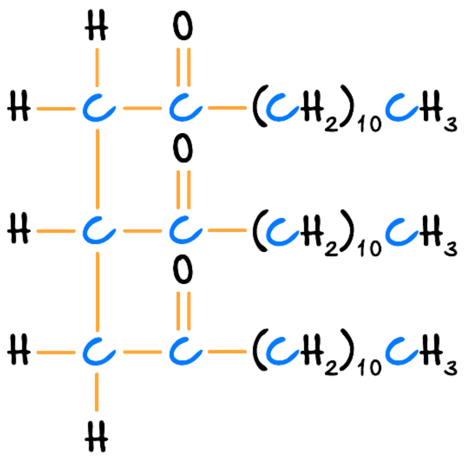
NOTE: Don't forget that 3 H_2O waters are the by-product, as there are three ester linkages formed.

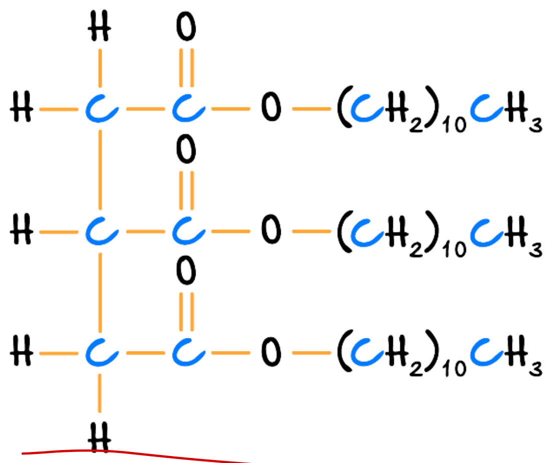
ALSO NOTE: Don't forget that the sulphuric acid (H_2SO_4) catalyst is still required!

NOTE: When looking for the fatty acids, be sure to look carefully as some of them are spelt similar to each other (e.g., linoleic vs linolenic or palmitic vs palmitoleic).

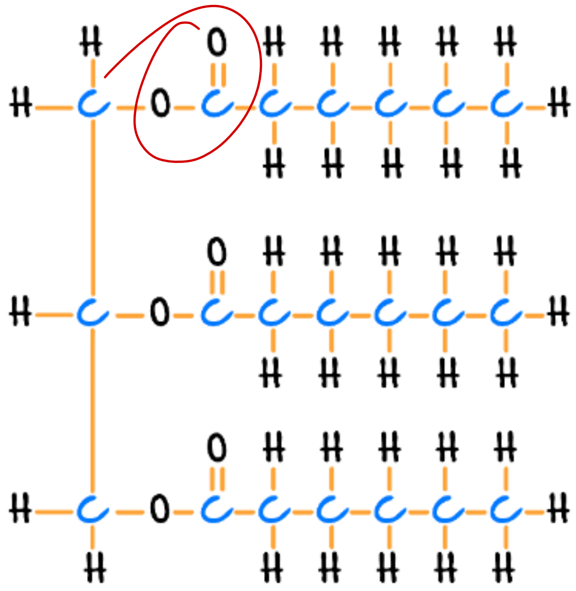
Misconception

" The ester bonds in the triglyceride look like one of the following:"





TRUTH:



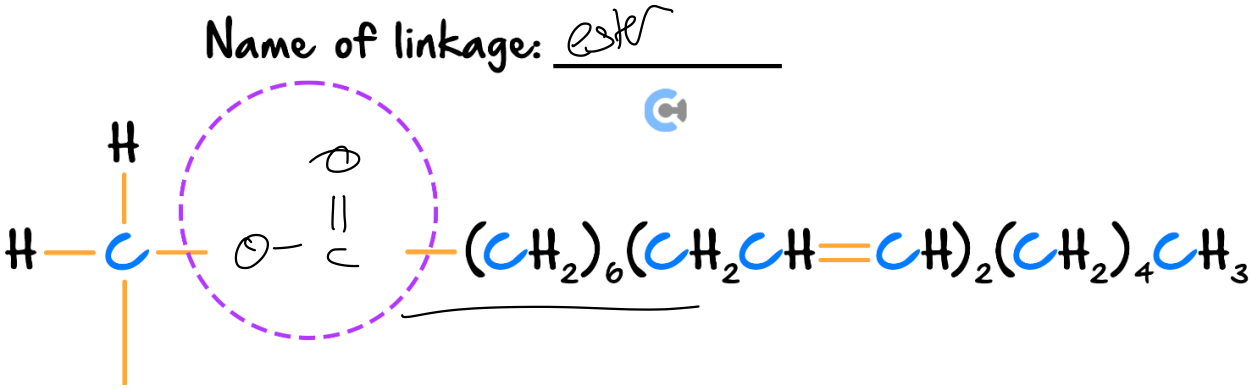
Space for Personal Notes

Your turn!

Question 2

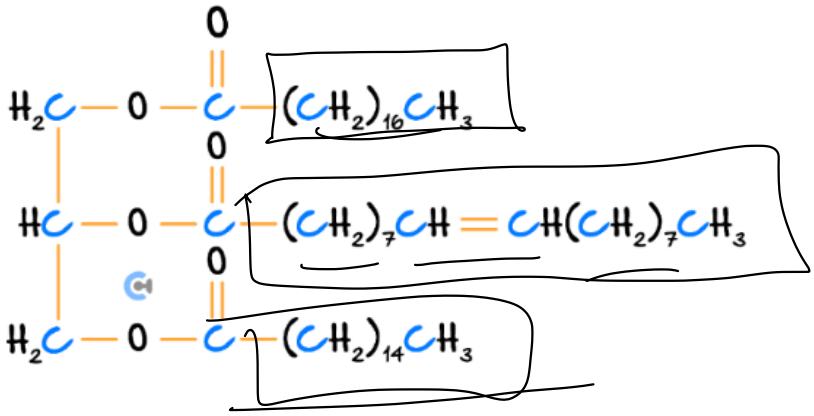
The triglyceride trilinolein is a component of some vegetable oils and has linoleic acid as the only long-chain fatty acid component.

Complete the structure of trilinolein shown below.



Question 3

The structure below is a triglyceride.



The fatty acids used to make this triglyceride are:

A. Arachidic acid, oleic acid and palmitoleic acid.

B. Arachidic acid, linoleic acid and palmitic acid.

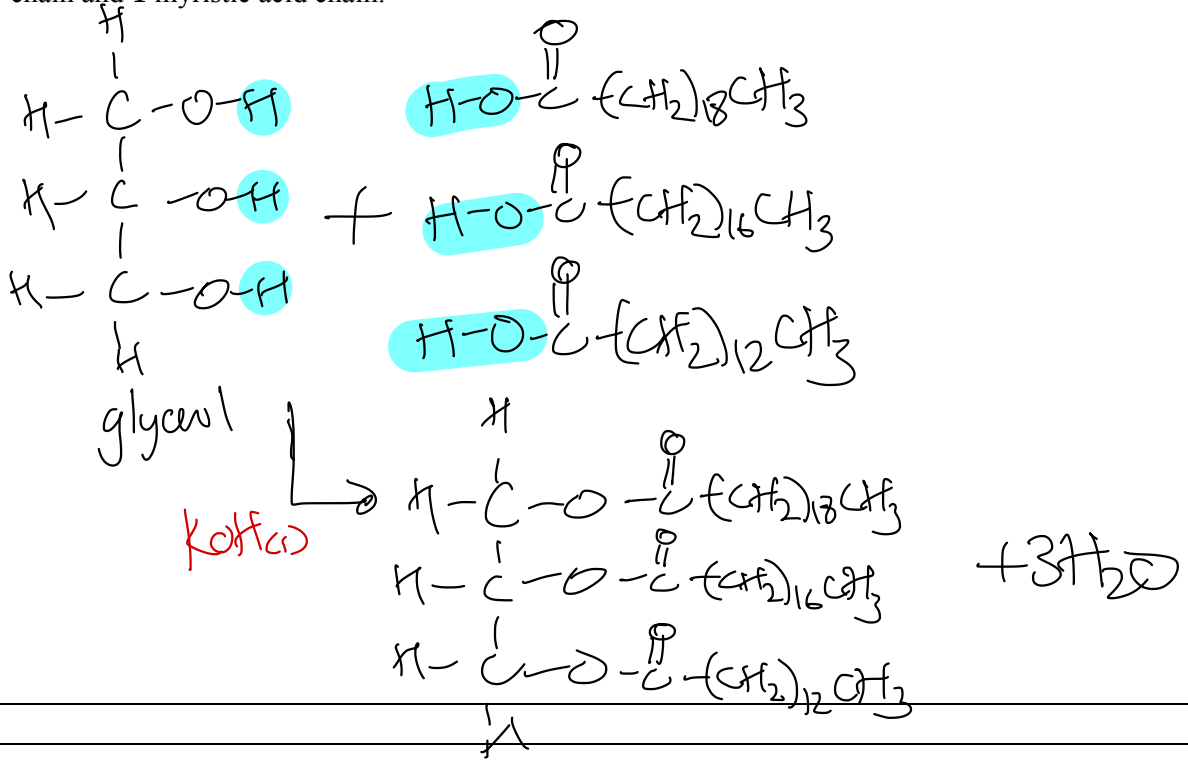
C. Stearic acid, linoleic acid and palmitoleic acid.

D. Stearic acid, oleic acid, and palmitic acid.

Question 4

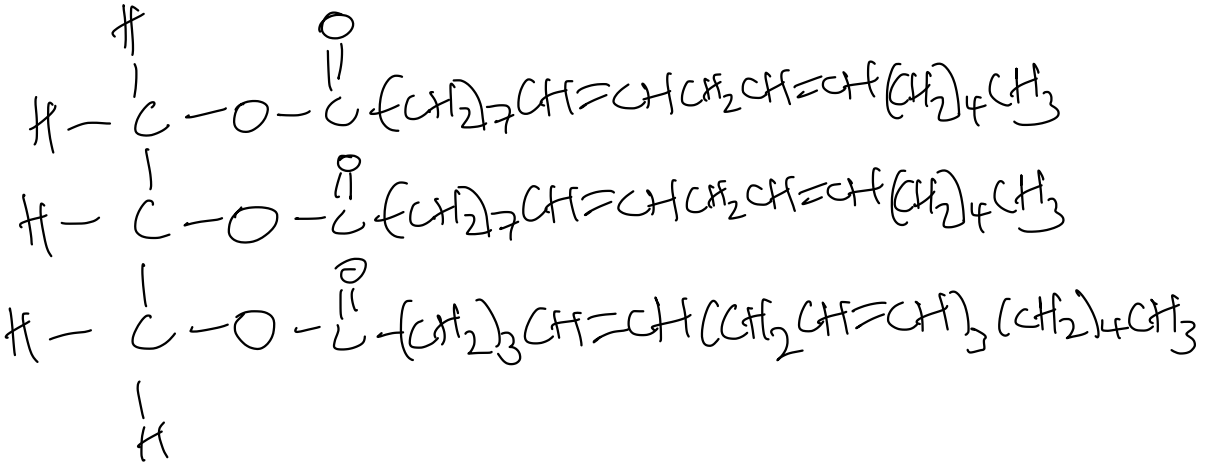
glycerol + 3 fatty acids →

Draw the condensation reaction for the creation of a triglyceride made from 1 arachidic acid chain, 1 stearic acid chain and 1 myristic acid chain.



Question 5

Draw the triglyceride which contains 2 linoleic acid and 1 arachidonic chain.

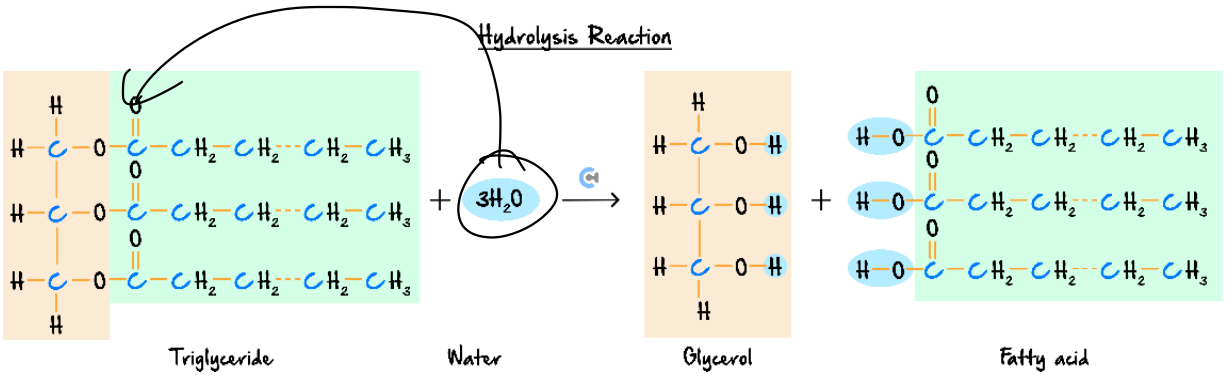


NOTE: Triglycerides can also be broken down from its triglyceride form into its glycerol and three fatty acids backbone – just reverse the process. If $A \rightarrow B$, then $B \rightarrow A$. **(Process reversed.)**

Sub-Section: Hydrolysis of Triglycerides

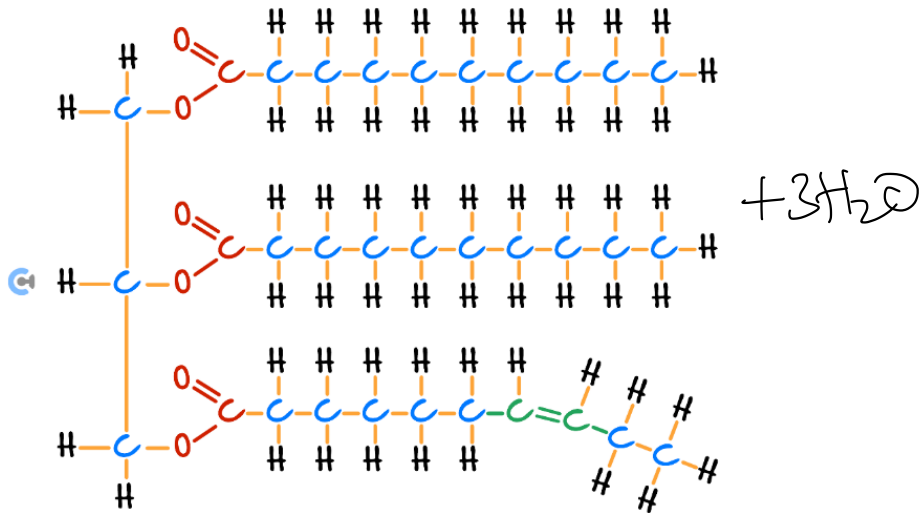
Hydrolysis of Triglycerides

- The opposite **hydrolysis** reaction can occur, whereby water is added to break the triglyceride down.



Exploration: Triglyceride Hydrolysis

- How does the following triglyceride undergo hydrolysis?



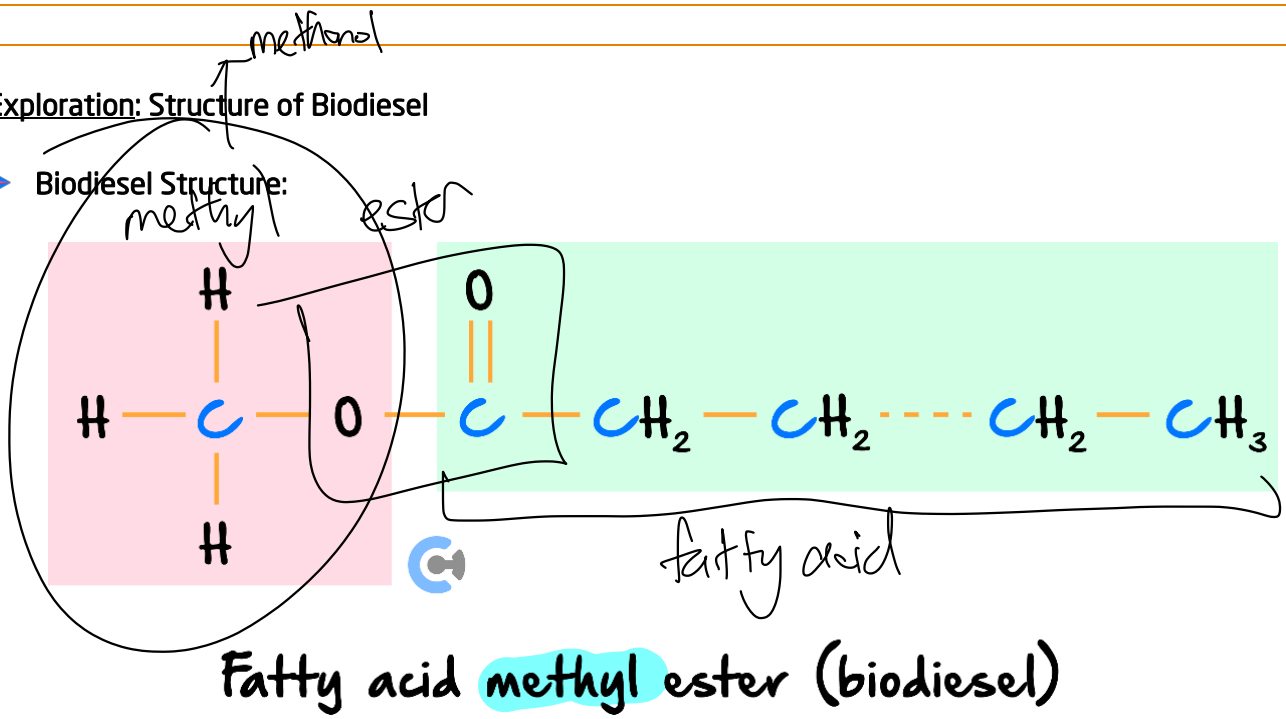
- **Catalyst (Not in Body):** KOH

NOTE: The **acidic** environment of the **stomach** also helps in hydrolysis!

Sub-Section: Formation of Biodiesel

Exploration: Structure of Biodiesel

- **Biodiesel Structure:**



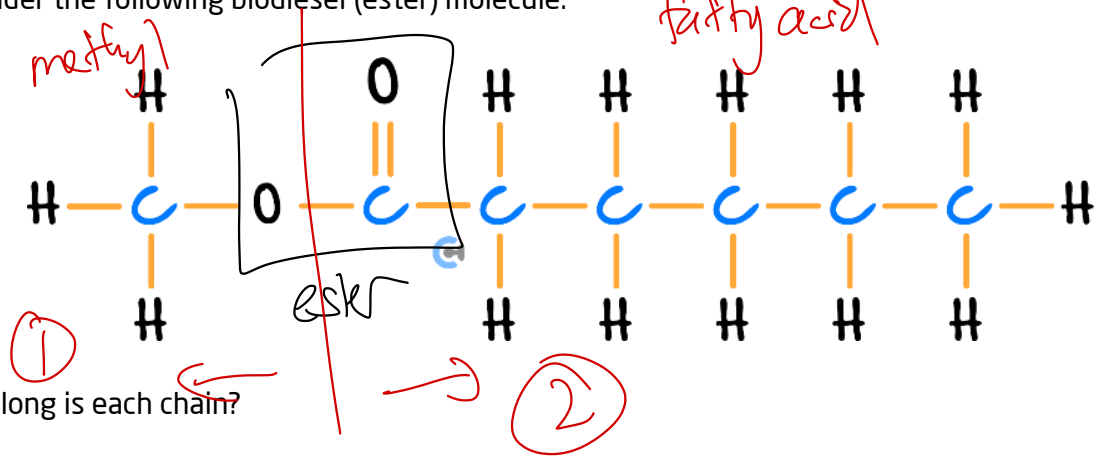
- **Biodiesel Source**: Formed from plant and animal matter!
- **Formation Reaction**: transesterification reaction!

Space for Personal Notes

What is the transesterification reaction?

Exploration: Transesterification Reaction

- Consider the following biodiesel (ester) molecule:



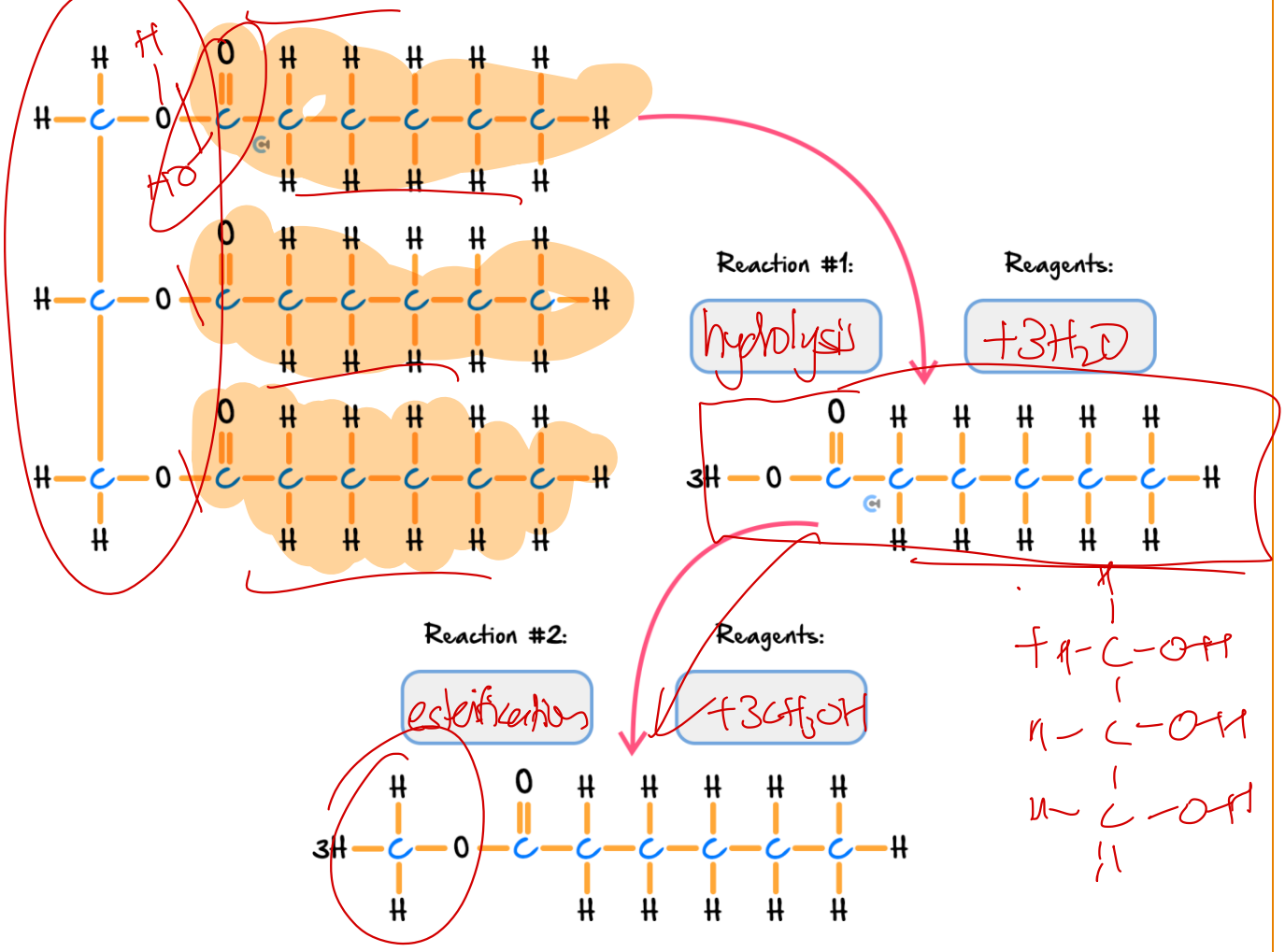
- How long is each chain?

Main Chain	Side Chain
6	1

- What is used to make the above biodiesel?

Carboxylic Acid	Alcohol
hexanoic acid / caproic acid	methanol

- Where do we get **caproic acid** from naturally? _____.



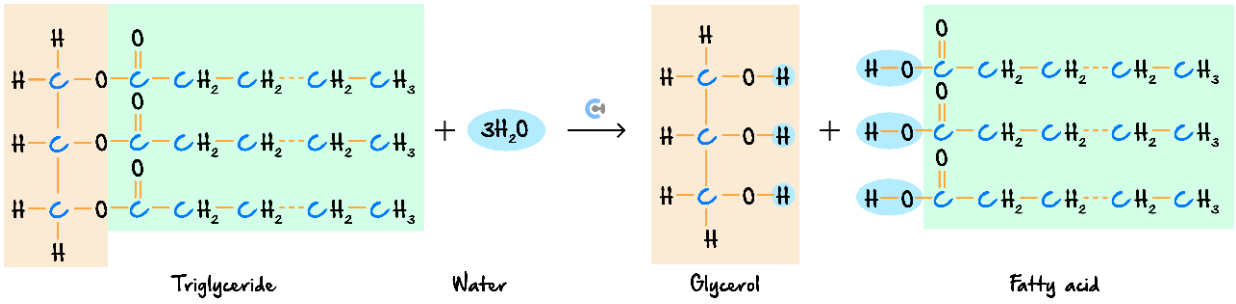
Space for Personal Notes

Transesterification Reaction Overall

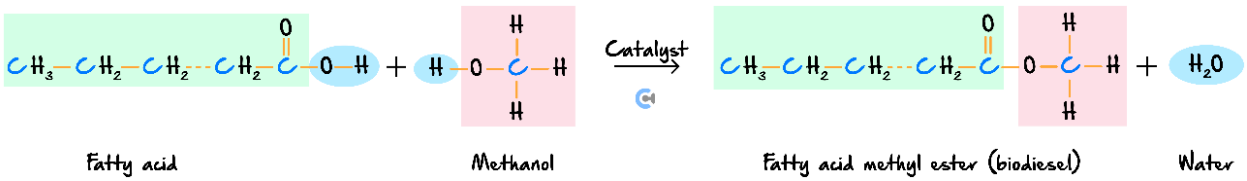
- **Biodiesel Formation:**

- Transesterification reactions consist of **two** reactions put together:
  - hydrolysis of triglyceride.
  - esterification.

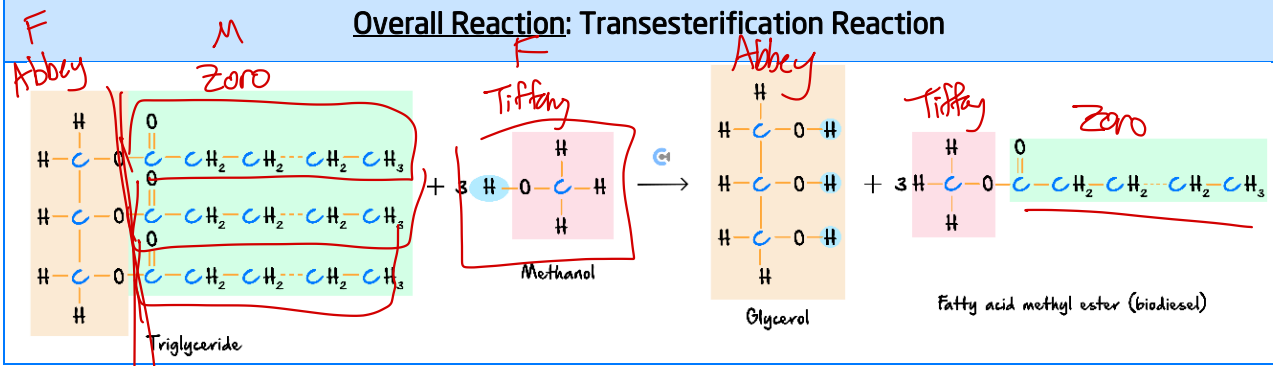
Reaction #1: Hydrolysis of Triglyceride



Reaction #2: Esterification of Fatty Acid and Methanol



Overall Reaction: Transesterification Reaction

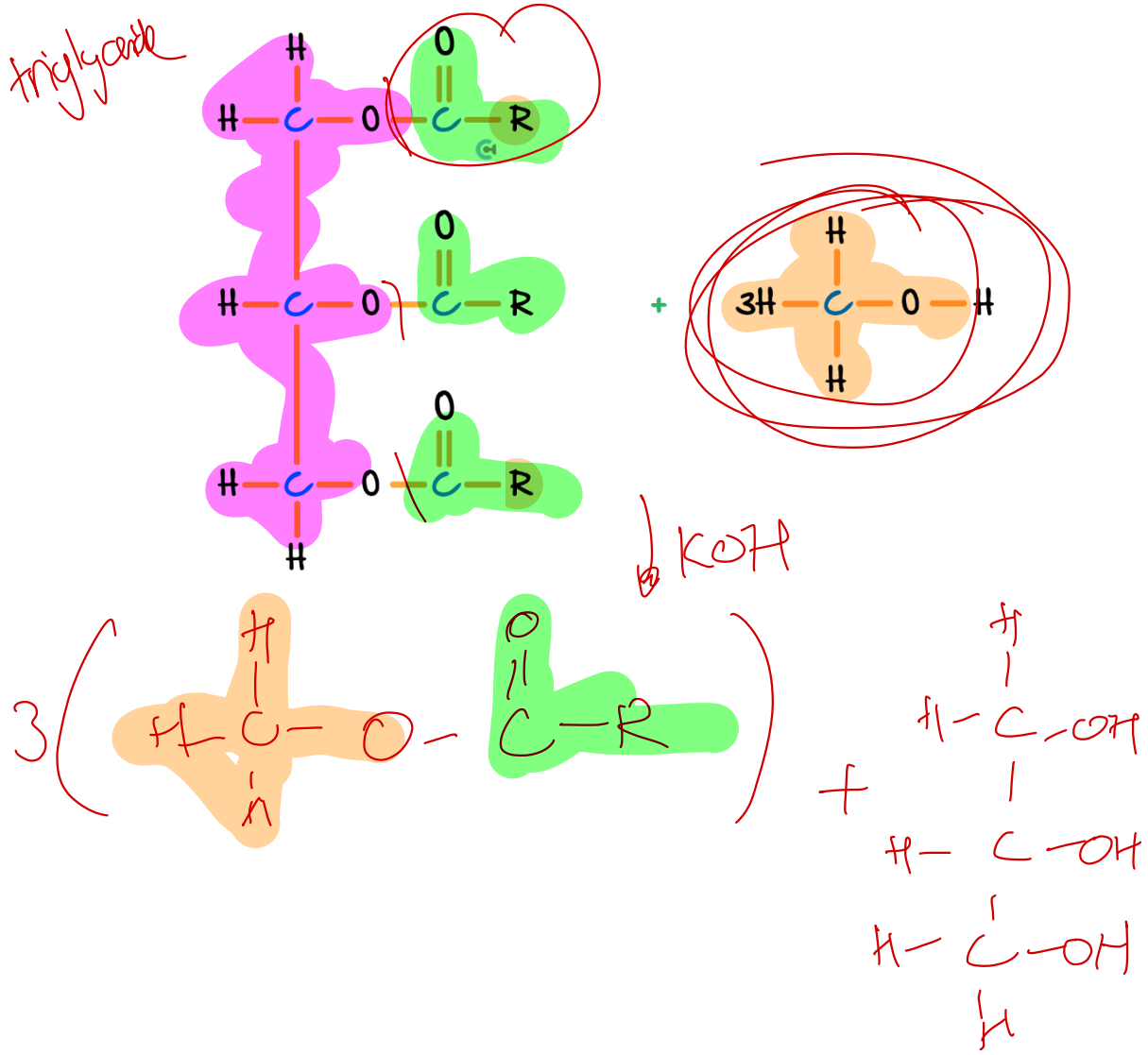


- **Catalysts/Conditions:** KOH.

How does the actual transesterification reaction look like?

Exploration: General Transesterification Reaction

- Consider the general structure of a triglyceride which reacts with methanol.

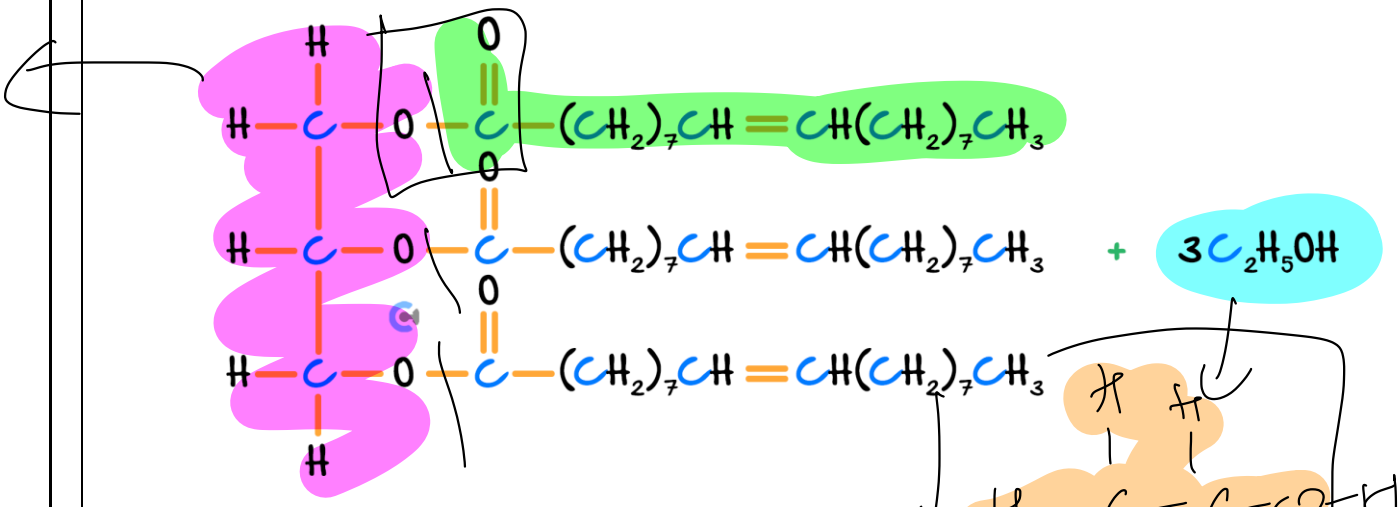


Space for Personal Notes

Let's have a look at a question together!

Question 6 Walkthrough.

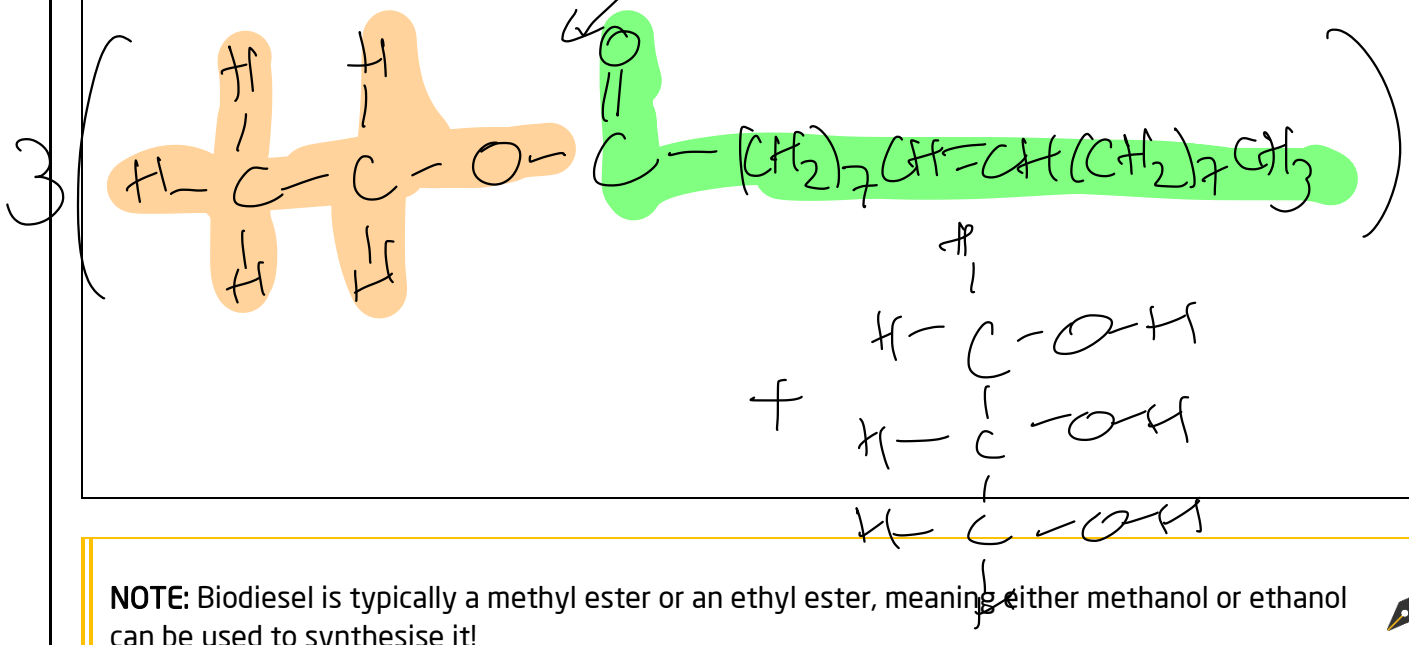
The following triglyceride and ethanol are mixed together.



a. Identify the fatty acids that the triglyceride is comprised of.

oleic acid

b. Draw the products when the following two molecules are mixed.



NOTE: Biodiesel is typically a methyl ester or an ethyl ester, meaning either methanol or ethanol can be used to synthesise it!

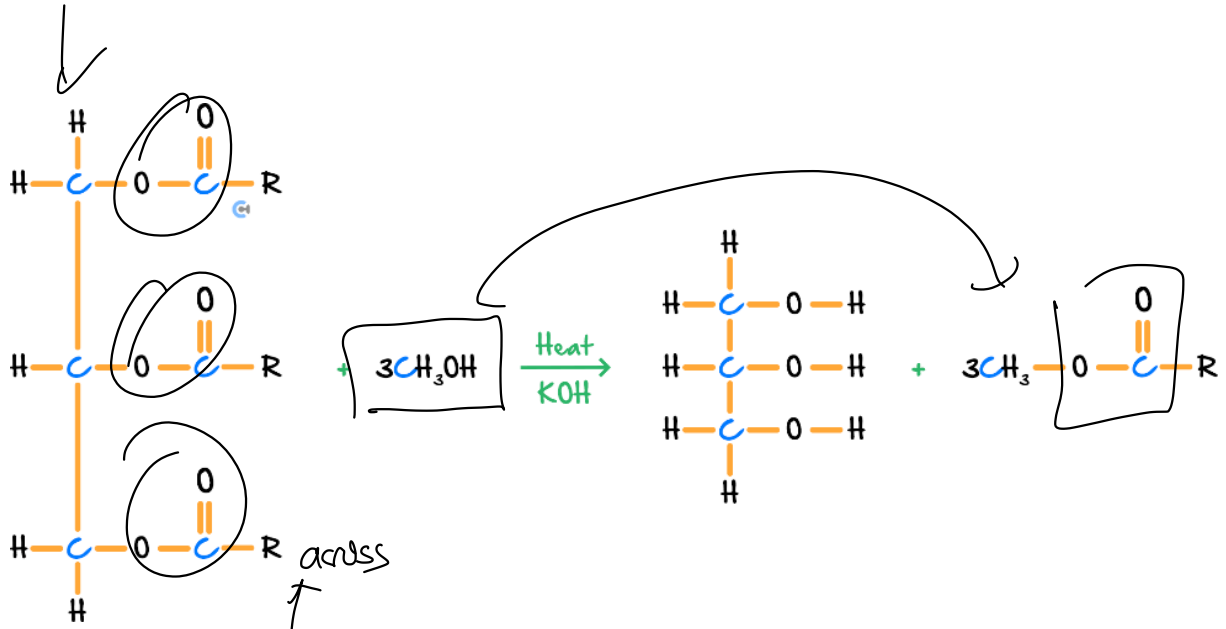
ALSO NOTE: Glycerol is produced as a by-product!

First, try distinguishing between reactions!

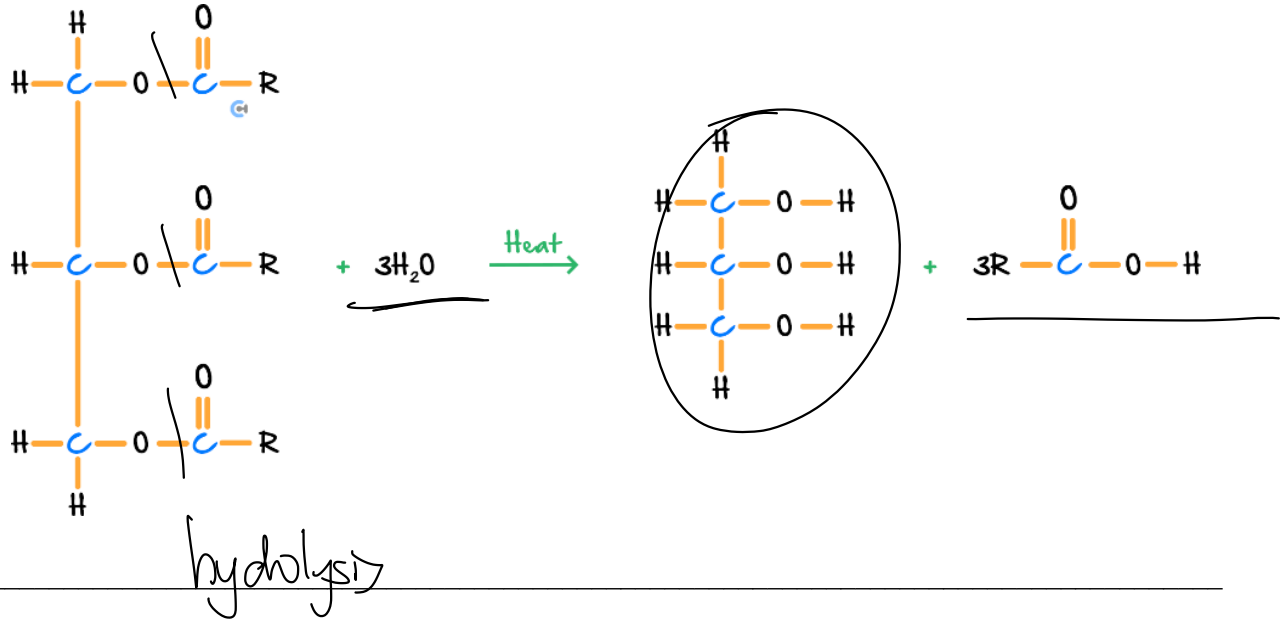
Question 7

Identify the type of reaction which takes place in each of the following processes:

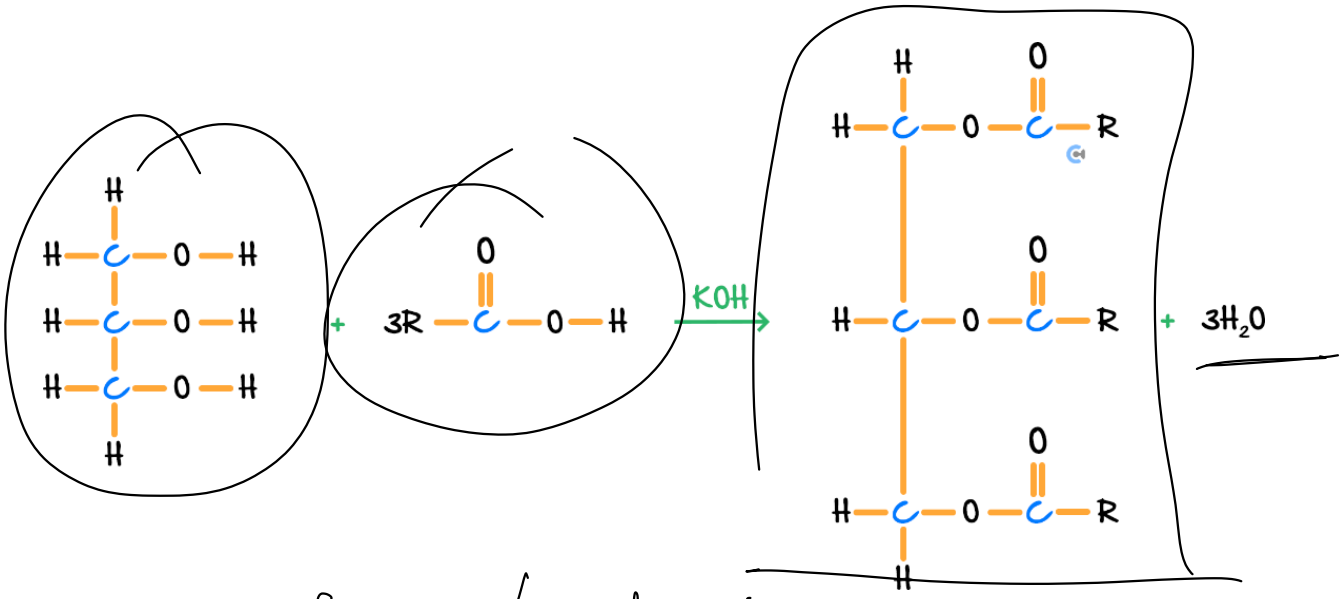
a.



b.

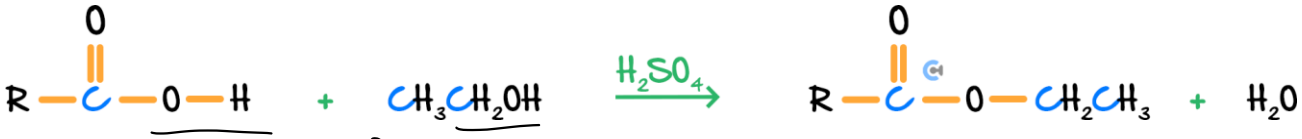


c.



esterification / condensation

d.



esterification

NOTE: For esterification reactions, either $KOH/NaOH$ or $H_2SO_4(l)$ can be used, but usually **$KOH/NaOH$** is used for the production of **biodiesel**, whereas **$H_2SO_4(l)$** is used for **'regular' esterification** reactions!

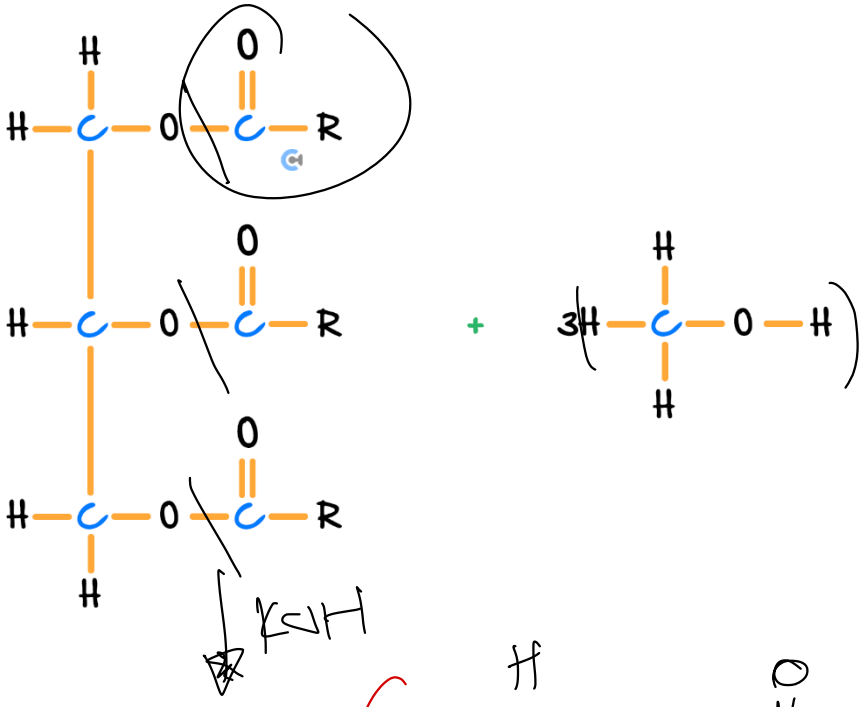
Space for Personal Notes

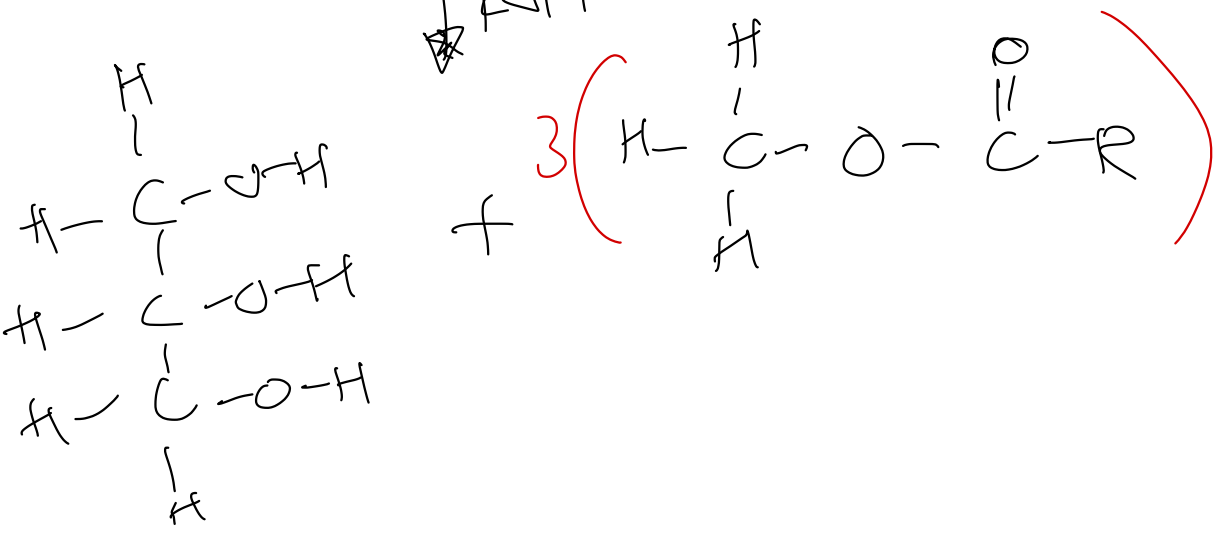
Your turn!

Question 8

Triglycerides can be used to form biodiesel.

a. Complete the equation below, which produces a methyl ester biodiesel from the following triglyceride.



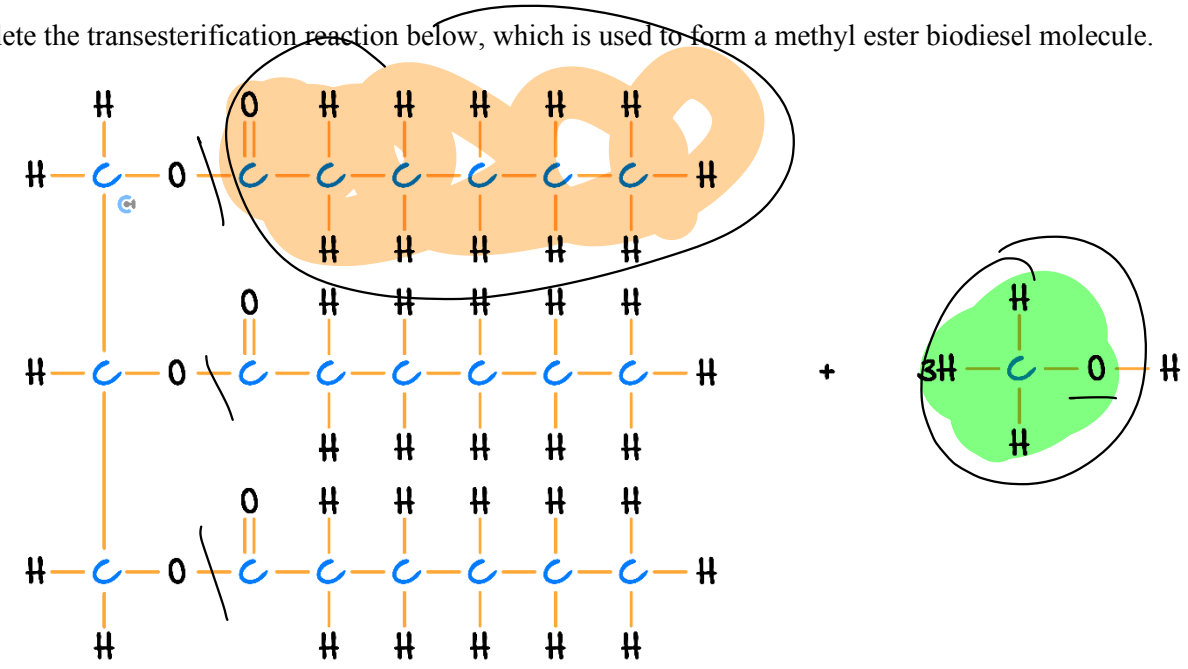


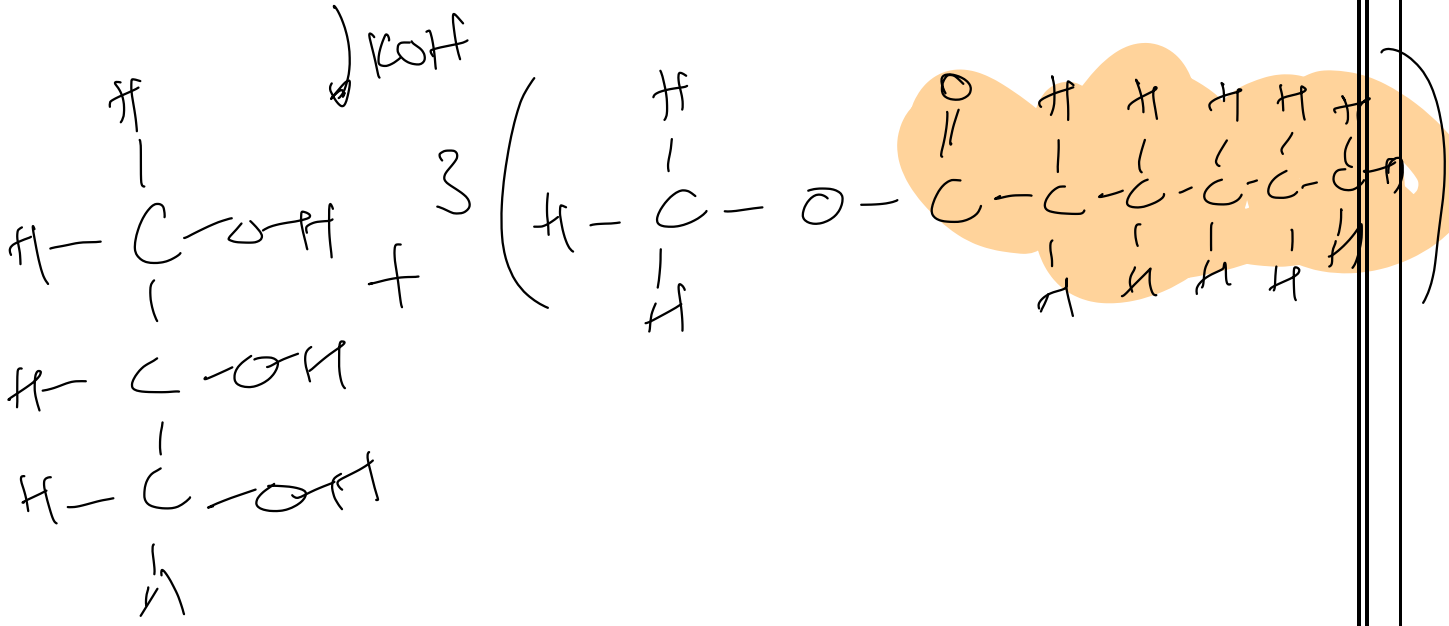
b. Identify the type of reaction which takes place.

transesterification

Question 9

Complete the transesterification reaction below, which is used to form a methyl ester biodiesel molecule.





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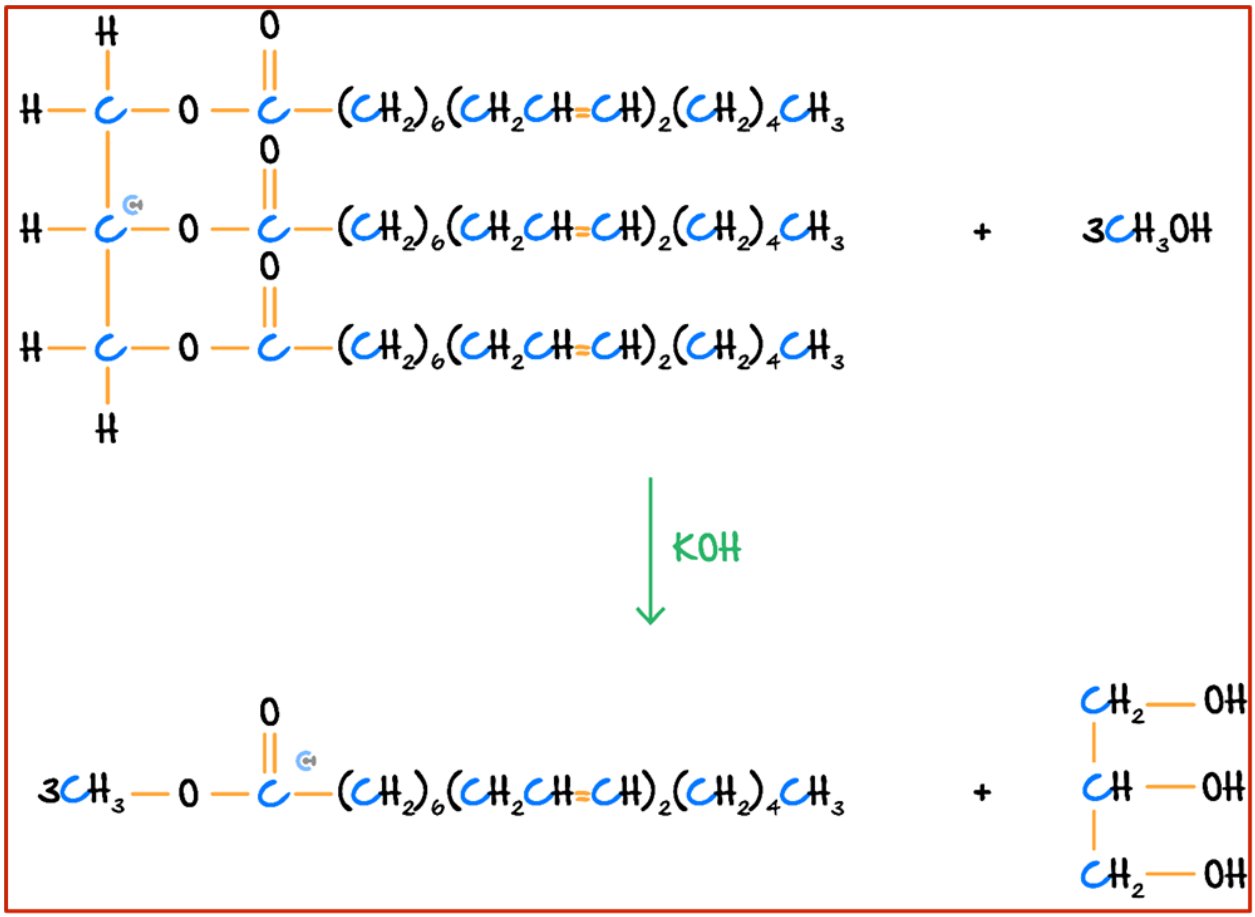
Question 10 Additional Question.

Draw the transesterification reaction for the following triglyceride, which is used to form a methyl ester biodiesel molecule.



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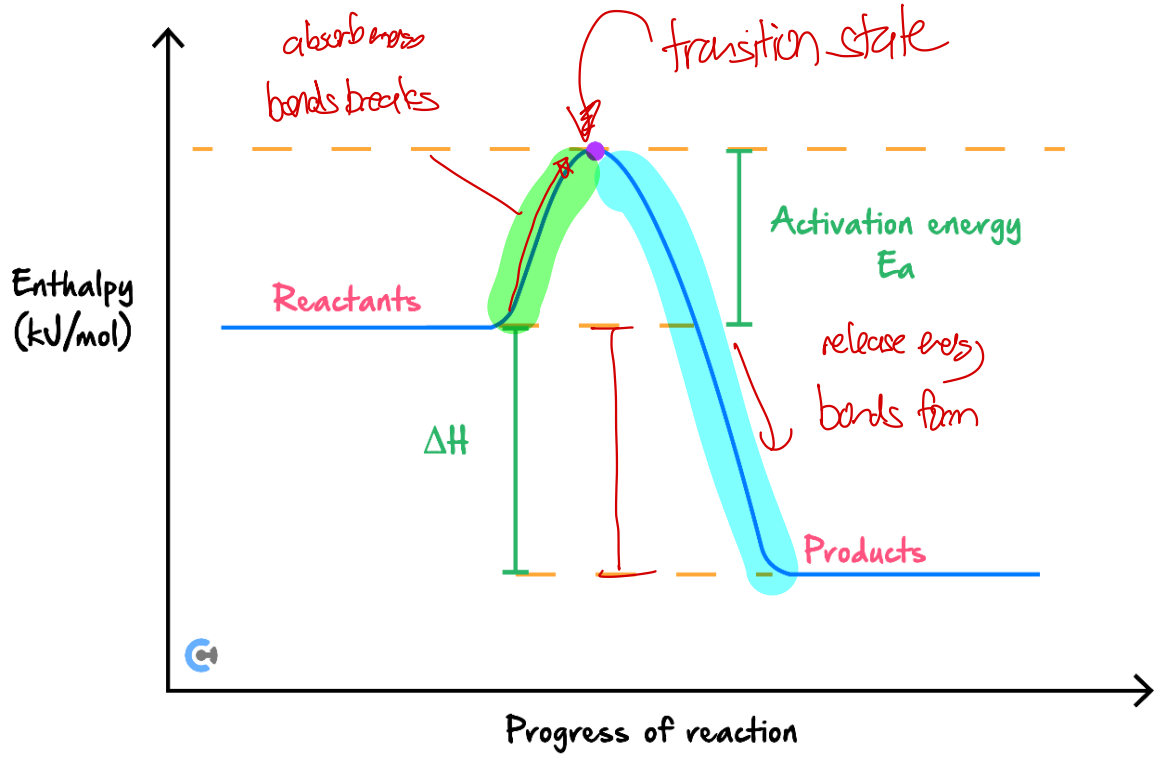
Section B: Average Bond Enthalpies (15 Marks)

Context

- The average bond enthalpies at 25°C are provided on **page 9 of the databook**.

Exploration: Average Bond Enthalpies and Energy Profile Diagram

- Consider an energy profile diagram:
  - What is the tip of the energy profile diagram called? *(Label Above.)*
  - What happens from reactants to tip? *(Label Above.)*
  - What happens from the tip to the products? *(Label Above.)*



- What is the ΔH Formula? *(Circle Below.)*

$$\Delta H = \text{energy of bonds formed} - \text{energy of bonds broken}$$

or

ΔH = break − form

Breaking/Forming Bonds During Reaction

Breaking Bonds	Forming Bonds
Energy is [absorbed] / [released].	Energy is [absorbed] / [released].
Enthalpy Sign: [positive] / [negative].	Enthalpy Sign: [positive] / [negative].

- **Formula:**

$$\Delta H = \text{energy of bonds broken} - \text{energy of bonds formed}$$

Space for Personal Notes

Let's look at a question together!

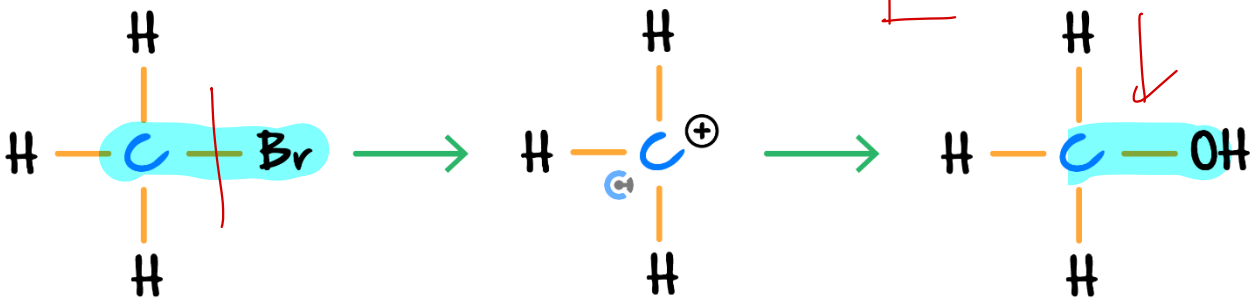
Question 11 (3 marks) **Walkthrough.**

Bromomethane can undergo a reaction with potassium hydroxide to produce methanol. There are two steps in this reaction.

Step 1: The bond between the C and Br is broken, and

Step 2: A new bond between the C and OH is formed.

break C–Br form C–O



Use **item 10** of the Data Book to determine the theoretical ΔH associated with this reaction. (2 marks)

$\Delta H = (C\text{–}Br) - (C\text{–}O) = 285 - 358$

$= -73$ kJ/mol

TIP: Draw the energy profile diagram for the reaction taking place.

NOTE: As the question has written 'OH' already, the bond between O – H does not have to be formed!

Space for Personal Notes

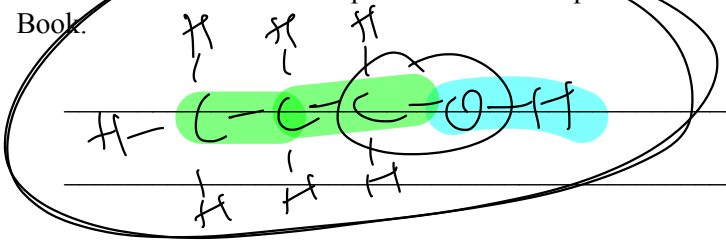
Exploration: Bond Enthalpy Conditions

- Bond Enthalpies are constructed, assuming there are no intermolecular forces.
- **State of Matter with No Intermolecular Forces:** [solid] / [liquid] / [gas].
- **State of Water at SLC:** [solid] / [liquid] / [gas]
- **Result:** Bond enthalpies for water are for gaseous water, and must be converted to liquid!
- How can water gas be converted to water liquid at SLC? latent heat of vaporisation
- $\Delta H_{vap}(H_2O) = +44\ kJ/mol$
- **To convert from gas → liquid process is:** [endothermic] / [exothermic].

Space for Personal Notes liquid → gas endo

Question 12 (4 marks) **Walkthrough.**

Write the thermochemical equation for the complete combustion of propan-1-ol. Use items 10 and 11 of the Data Book.



$C_3H_7OH + \frac{9}{2}O_2 \rightarrow 3CO_2 + 4H_2O \quad \Delta H = -2052\ kJ/mol$

(l) (g) (g) (l)

(g) → (l)

$H_R = O-H + 2\times C-C + 7\times C-H + C-O$

propan-1-ol $463 + 2\times346 + 7\times414 + 358 = 4411\ kJ/mol$

$H_R(O_2) = \frac{9}{2}\times498 = 2241$

$H_R(total) = 4411 + 2241 = 6652$

$H_P = 6\times C=O + 8\times O-H$

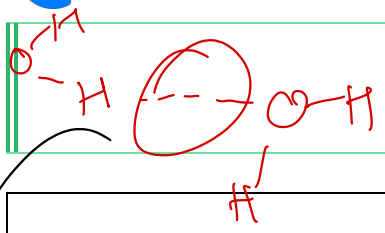
$= 6\times804 + 8\times463 = 8528$

$\Delta H = H_R - H_P = 6652 - 8528 = -1876\ kJ/mol$

$-1876 - 4\times44 = -2052\ kJ/mol$

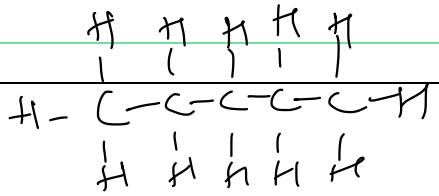
NOTE: The actual heat of combustion of propan-1-ol is $\Delta H = -2021\ kJ/mol$ - the databook values are the 'average bond enthalpy' and do not directly correspond to the actual heat of combustion!

Space for Personal Notes



Your Turn!

C_5H_{12}



Question 13 (4 marks)

Write the thermochemical equation for the complete combustion of pentane. Use items 10 and 11 of the Data Book.

$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O_{(l)}$ $\Delta H = -3524$ kJ/mol

$H_R = 4 \times C-C + 12 \times C-H + 8 \times O=O$ (g) (g) (g)

$= 4 \times 346 + 12 \times 414 + 8 \times 498 = 10336$

$H_P = 10 \times C=O + 12 \times O-H$

$= 10 \times 804 + 12 \times 463 = 13596$

$\Delta H = 10336 - 13596 = -3260$ kJ/mol

$-6 \times 44 = -264$

$-3260 - 264 = -3524$ kJ/mol

7:20

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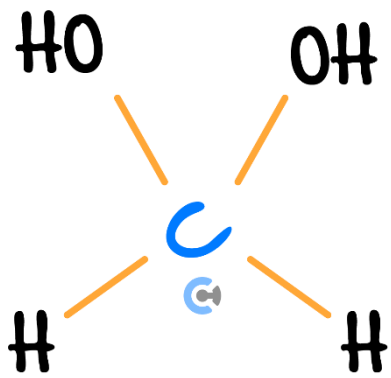
Question 14 (4 marks) **Additional Question**.

Methanediol has the following structure:



Write the thermochemical equation for the complete combustion of methanediol at SLC. Use items 10 and 11 of the Data Book.

$$CH_4O_2(l) + O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \quad \Delta H = -716\ kJ\ mol^{-1}$$

$$H_R = [2C - H + 2C - O + 2O - H] + O = O = (2 \times 346 + 2 \times 358 + 2 \times 463) + 498 = 2832\ kJ/mol$$

$$H_P = 2C = O + 4O - H = 2 \times 804 + 4 \times 463 = 3460 \frac{kJ}{mol}$$

$$\Delta H = H_R - H_P = 2832 - 3460 = -628\ kJ/mol$$

$$\Delta H = -628 - 2 \times \Delta H_{vap}(H_2O) = -628 - 2 \times 44 = -716\ kJ/mol$$

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Section C: Ramping Up (11 Marks) 7:20

INSTRUCTION: 11 Marks. 8 Minutes Writing.

Question 15 (3 marks)

Tick whether the following statements are **true** or **false**.

Statement	True	False
a. Crude oil is obtained through mining/digging up land.		✓
b. Biogas is comprised purely of methane sourced renewably.		✓
c. Biodiesel comes from the lipids of biological organisms.	✓	
d. Natural gas is obtained by drilling under the seabed.		✓
e. Coal is comprised purely of Carbon.		✓
f. Bioethanol requires yeast to ferment carbohydrates found in crops.	✓	

Question 16 (1 mark)

Write the balanced equation to show how humans obtain energy from food.

1. ΔH & exo
2. gas, stoich, exo profile
3. calorimetry

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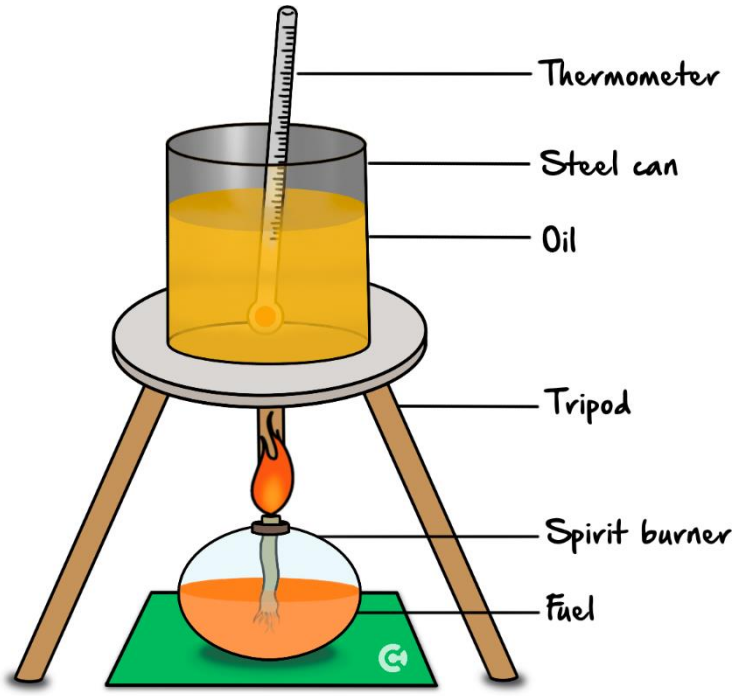
Question 17 (7 marks)

Aditi finds an unknown fuel in her cupboard and immediately gets a burning desire to figure out its identity. To do so, she constructs the following set-up, using oil instead of water.



The information she researched, as well as the data she obtained, is summarised below:

Density of oil	0.703 g/mL
Volume of oil used	250 mL
Specific heat capacity of oil	1.67 $J/g/\mathrm{K}$
ΔT (oil)	10.0°C
The initial mass of the spirit burner	158.80 g
The final mass of the spirit burner	158.59 g

a. Calculate the energy absorbed by the oil, in kJ. (2 marks)

$q = mc\Delta T = 0.703 \times 250 \times 1.67 \times 10.0 = 2.935$ kJ

b. When Aditi found the fuel in her cupboard, she remembers seeing a note saying that 0.11 mol of the fuel produces 0.33 mol of water.

i. After conducting the experiment, if she collects 245 mg of water, calculate the amount of fuel in mol, which must have reacted. (1 mark)

$$n(H_2O) = m/M = 0.245/18.0 = 0.0136\ mol$$
$$n(fuel) = 1/3 \times n(H_2O) = 0.0045\ mol$$

ii. Hence, assuming all of the heat was transferred to the oil, calculate the experimental molar heat of combustion of the fuel. (1 mark)

$\Delta H = q/n = 2.935/0.0045 = -646.9$ kJ/mol

iii. Using your answer to **part b. i.**, and using the information in the table above, calculate the molar mass of the fuel to 2 significant figures. (1 mark)

$M(fuel) = \Delta m/n = (158.80-158.59)/0.0045 = 46$ g/mol

c. The experiment is known to be inaccurate due to heat loss. Propose an appropriate modification to the experiment, which will increase the accuracy of the experiment. Explain your reasoning. (2 marks)

~~Add a lid to the steel can.~~
This will minimise heat loss through the top of the can,
and thus more will be absorbed by the oil and therefore the ΔH calculated will be closer to the true value, leading to a more accurate answer, and thus part c. i.,
will now be commensurate with the fuel being ethanol.

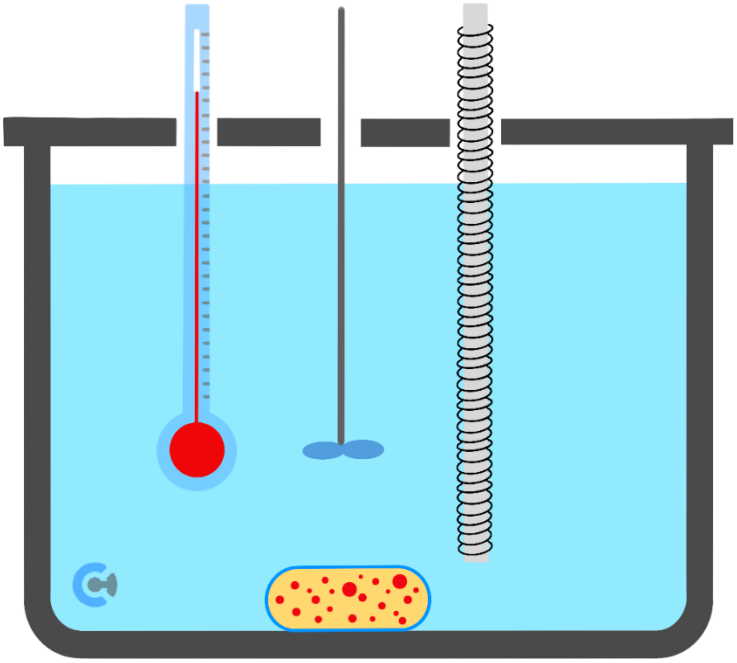
Let's take a BREAK!

Section D: VCAA-Level Questions I (9 Marks)

INSTRUCTION: 9 Marks. 30 Seconds Reading. 8 Minutes Writing.

Question 18 (9 marks)

Elson sets up a calorimeter to determine the energy content of a protein bar. His set-up is Depicted below.



a. Outline two potential reasons why Elson chose to use a calorimeter instead of a spirit burner to determine a protein bar's energy content. (2 marks)

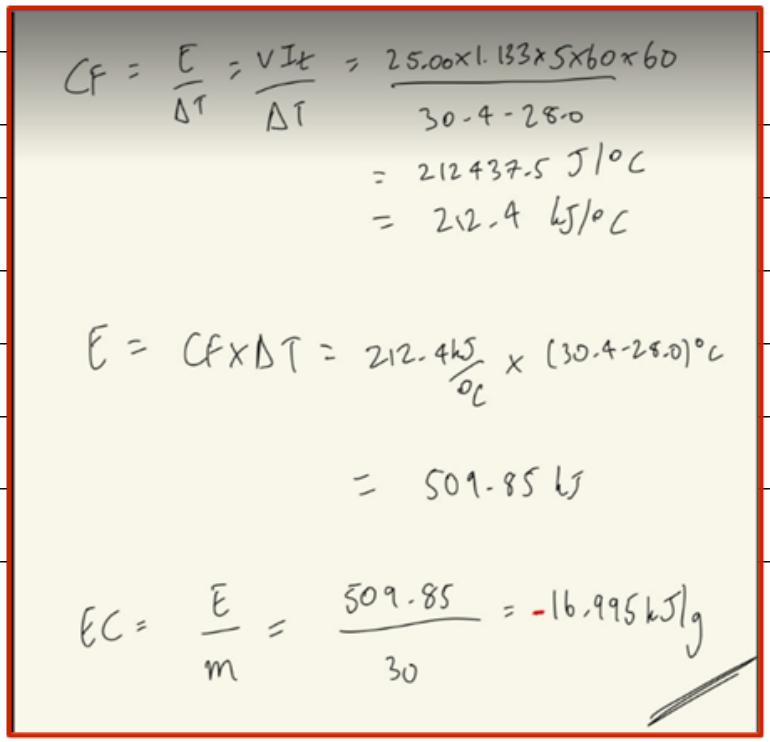
Much more accurate as there is less heat loss due to: Insulation;
Direct reaction within water rather than there being a gap between the fuel and water which adds to heat loss.

And/or easier to set up/safer.

b. Elson then calibrates the calorimeter by passing a current of 25.00 A and a potential difference of 1.133 V through the electric heater for 5 hours, causing the temperature in the thermometer to rise from 28.0°C to 30.4°C.

He then allows the calorimeter to cool, places his 30 g protein bar in the calorimeter, and coincidentally, observes the same temperature rise from 28.0°C to 30.4°C.

Calculate the bar's energy content in kJ/g. (3 marks)



c.

i. If, during calibration, there was heat loss, explain how this would have affected the calibration factor obtained. (1 mark)

Heat loss → not all E was absorbed → lesser ΔT → higher CF as CF = E/ΔT.

ii. If there was heat loss only in the second half of the experiment when the protein bar was reacted, explain how this would have affected the magnitude of the energy content calculated. (1 mark)

Heat loss → not all E was absorbed → lesser ΔT → smaller EC as EC = E/m and E = CF×ΔT.

iii. Hence, justify whether there was heat loss in this calorimeter if the expected energy content is 17 kJ/g given that the bar is mostly protein. (2 marks)

We got the expected value so it is tempting to say no heat loss,
but it is impossible to tell if there was heat loss as both calibration and the second half had the same T_i and T_f therefore same rate of heat loss and as proven in part c. i., and part c. ii.,
the effects cancel one another out (given same T_i and T_f).

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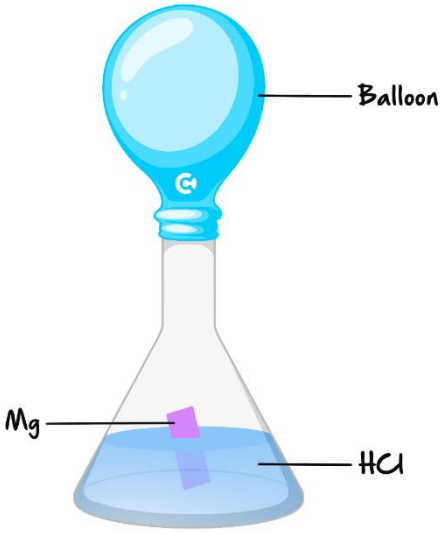
Section E: VCAA-Level Questions II (8 Marks)

INSTRUCTION: 8 Marks. 30 Seconds Reading. 7 Minutes Writing.

Question 19 (8 marks)

A reaction between a magnesium ribbon and hydrochloric acid is shown below and occurs at standard laboratory conditions.



The balloon is designed to trap the hydrogen gas produced.

The reaction which occurs is shown below.

$n = \frac{V}{V_m}$

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

a. When the reaction proceeds, it traps 4.90 L of hydrogen gas at standard laboratory conditions.

i. Calculate the mass of the magnesium strip which was reacted. (2 marks)

$n(H_2) = \frac{V}{V_m} = \frac{4.90L}{24.8L/mol} = 0.1976mol$

$n(Mg) = n(H_2) = 0.1976mol$

$m(Mg) = n \times M = 0.1976 \times 24.3 = 4.80g$

ii. If the reaction released 127 *kJ* of thermal energy, complete the thermochemical equation for the following reaction below. (2 marks)

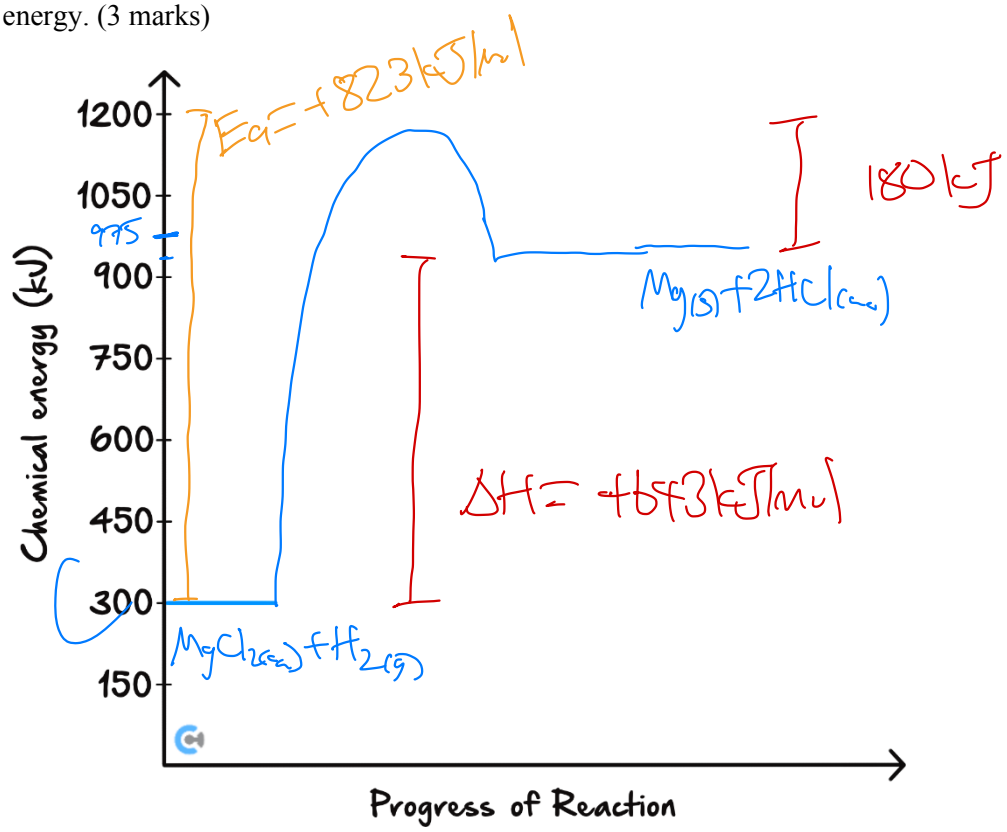
$MgCl_2\,(aq) + H_2(g) \rightarrow Mg(s) + 2HCl\,(aq)$ $\Delta H =$ +643 kJ mol^{-1}

$\Delta H = \frac{q}{n} = \frac{127\,kJ}{0.1976\,mol} = -643\,kJ/mol$

iii. Given that 180 *kJ* are released when forming the products, draw the energy profile diagram for: per mole

$$MgCl_2\,(aq) + H_2(g) \rightarrow Mg(s) + 2HCl\,(aq)$$

Be sure to label the reactants, products, their enthalpies, the change in enthalpy, and the magnitude of the activation energy. (3 marks)



b. Explain why the ΔH value is calculated in **part b. ii.**, does not match the value found in the Data Book for the heat of combustion for hydrogen in Item 13. (1 mark)

different reaction

Section F: Extension Questions (10 Marks)

Question 20 (10 marks)

A comparison between methane produced from waste containers and bioethanol produced from carrots is to be compared.

a. Explain how methane is produced from waste containers and justify why it is renewable. (2 marks)

is biogas ✓

(1) how produced

Methane from waste containers is obtained by anaerobic respiration by bacteria of organic waste, which can be replaced by natural processes within a relatively short time.

(1) renewable

b. Write the equation to show how bioethanol is produced from carrots. (1 mark)

$C_6H_{12}O_{6(aq)} \xrightarrow{\text{yeast}} 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$

c. The energy content from each fuel is also compared.

i. Given that biogas contains 65.0% methane by mass and the remainder carbon dioxide, find the heat of combustion of biogas in kJ/g. (1 mark)

$\Delta H(CH_4) = \frac{890\,kJ}{1\,mol} = \frac{890\,kJ}{16\,g} = 55.6\,kJ/g$

$= 36.2\,kJ/g$

ii. Compare which fuel has a higher heat of combustion in kJ/g, justifying the reasoning for this difference. (2 marks)

$\Delta H(\text{bioethanol}) = 29.7\,kJ/g$

$\Delta H(\text{biogas}) = 36.2\,kJ/g$

biogas has higher heat of combustion, as ethanol is partially oxidised.

d. The density of bioethanol is $0.790\ g/mL$. A container is filled with $3.20\ L$ of bioethanol. The container of bioethanol is combusted to release energy.

$\Delta H = 29.7\ kJ/g$

Calculate the amount of thermal energy released when this bioethanol is combusted. (2 marks)

$m(C_2H_5OH) = d \times V = 0.790\ g/mL \times 3.2\ L = 2528\ g$

$q(C_2H_5OH) = \Delta H \times m = 29.7\ kJ/g \times 2528\ g = 75082\ kJ$

$= 7.51 \times 10^4\ kJ$

e. If the container was filled with biogas at SLC instead, would it release more or less energy? Justify your answer. (2 marks)

Bioethanol. Biogas is a gas & occupies more volume for same amount of fuel. ∴ in the same volume, there would be significantly less biogas present, & thus less energy released when combusted.

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