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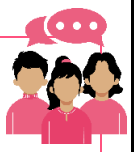
VCE Chemistry ¾
Transesterification of Biodiesel [1.0]
Workbook

Outline:

Section A: Lipids (Fats & Oils)



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

- **Fats**:

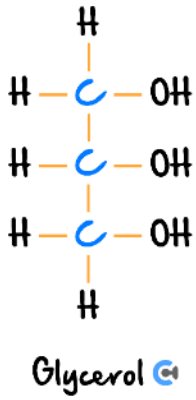
- **Oils**:

Lipids (Fats & Oils)

- **Definition**: Lipids are fats and oils, and can be found in humans and in food.
- Lipids come under the category of being _____.
- Triglycerides (lipids) are constructed from a _____ molecule along with three _____.

Glycerol

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



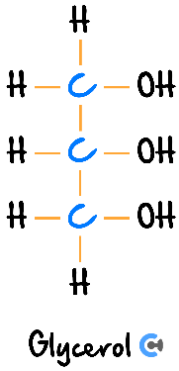
Glycerol

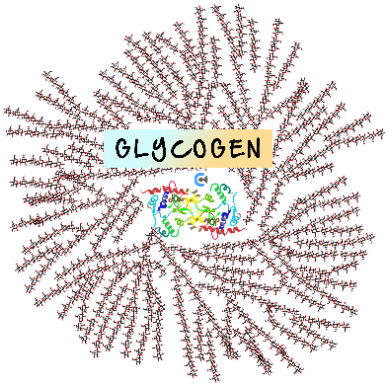
- **IUPAC name of Glycerol:**

- This name is too long, and is simplified to just **glycerol,** C_3H_8O.

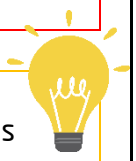
Misconception

"Glycerol and Glycogen are the same thing."





TRUTH: Glycerol is an alcohol whereas glycogen is a polysaccharide made from glucose monomers.



TIP: Glycerol has the suffix '-ol' which indicates that it contains an alcohol functional group whereas glycogen does not end with '-ol' and thus, is not an alcohol.

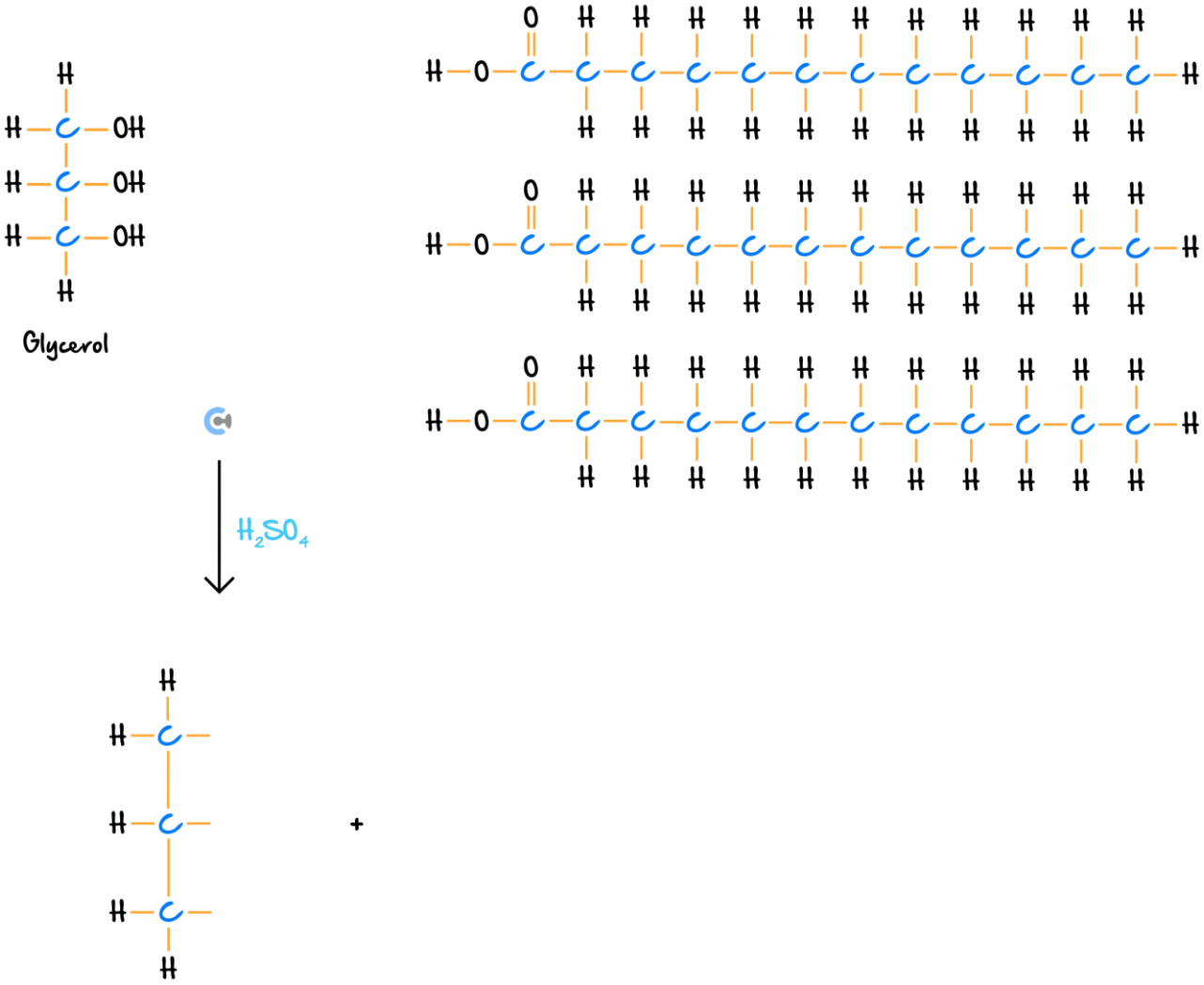
Fatty Acids

- **Definition**: Fatty acids are essentially **carboxylic acids** with _____ 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).
- If we have a look at a fatty acid such as arachidic acid:

- Is arachidic acid polar or non-polar? [Polar] / [Non-Polar]
- While it contains a polar carboxyl group, it is non-polar overall due to its **long carbon chain**.
- The list of the fatty acids which are tested in VCAA can be found on **page 18 of the databook.**

Exploration: Formation of Lipids/Triglycerides

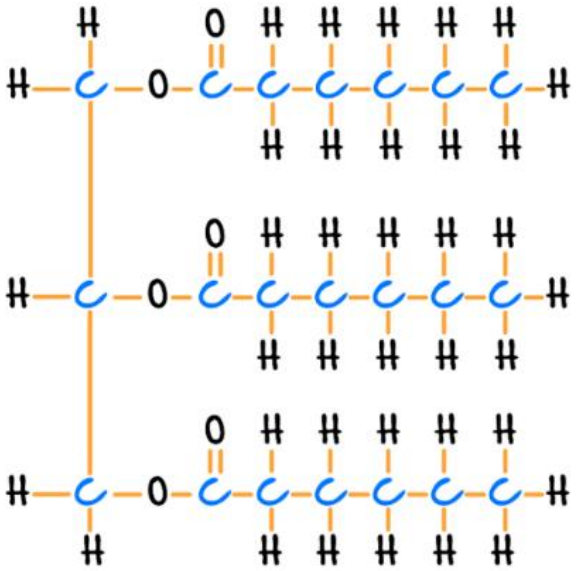
- Consider glycerol and lauric acid, an **esterification condensation** reaction can occur.



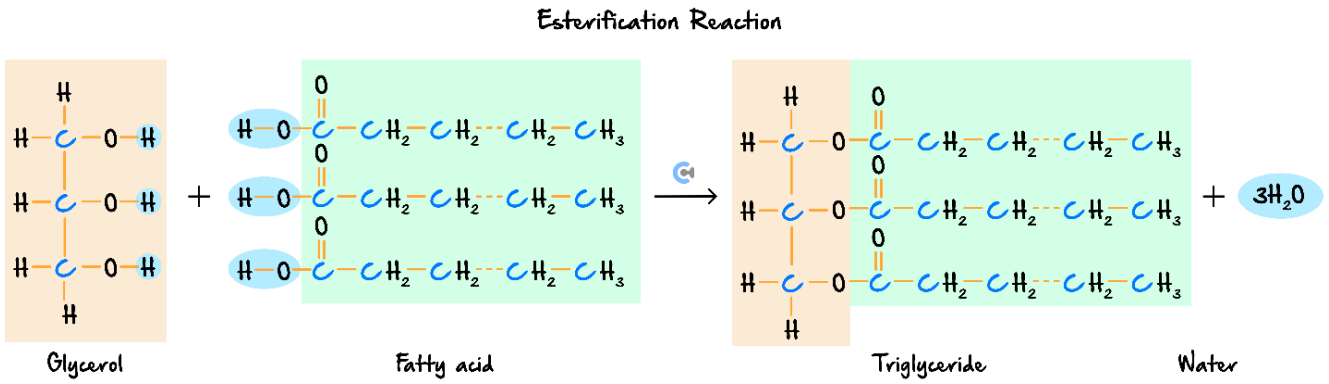
- **Linkage:**

Name	Number of Linkages

- 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.

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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.

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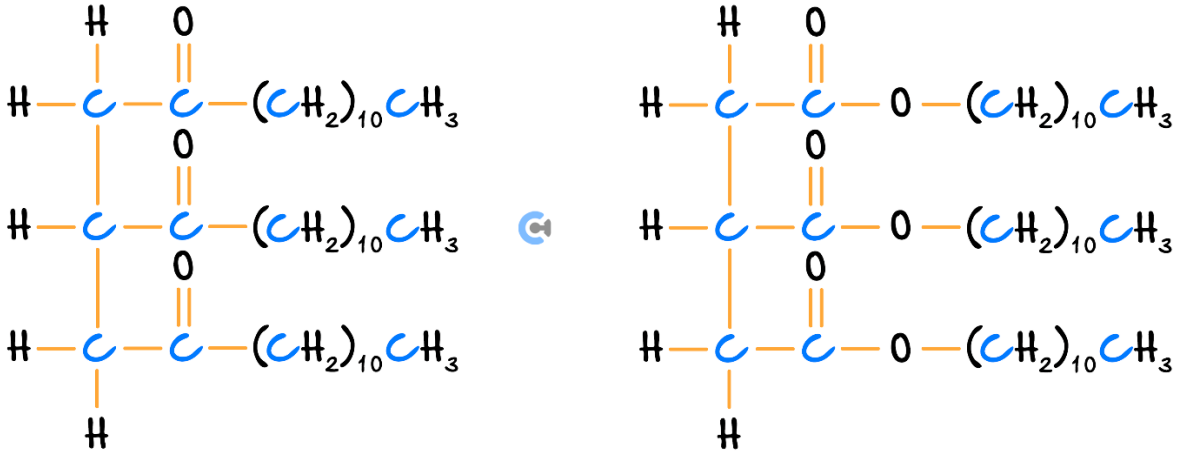
NOTE: Don't forget that _____ waters are the by-product, as there are three ester linkages formed.

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

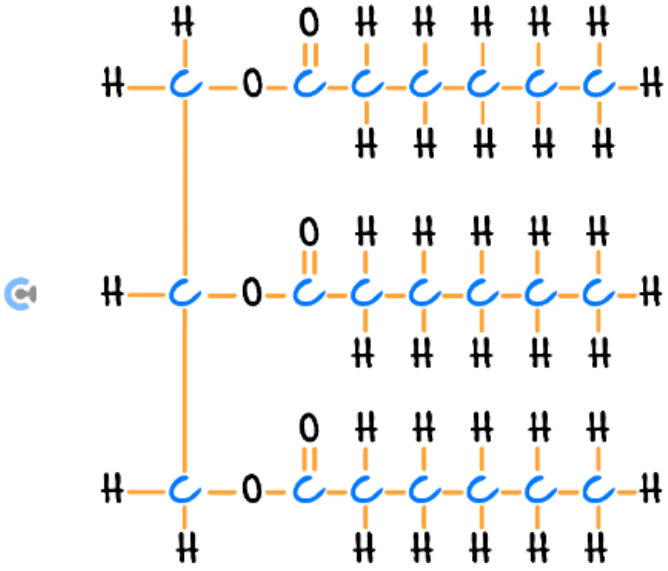
NOTE: When looking for the fatty acids, be sure to look carefully as some of them are spelt similar to each other (e.g., linoleic vs linolenic or palmitic vs palmitoleic).

Misconception

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



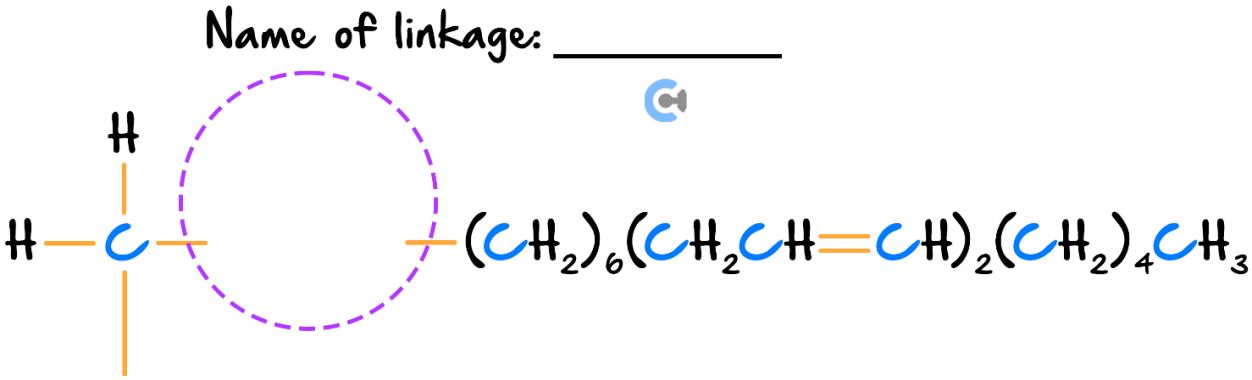
TRUTH:



Question 2

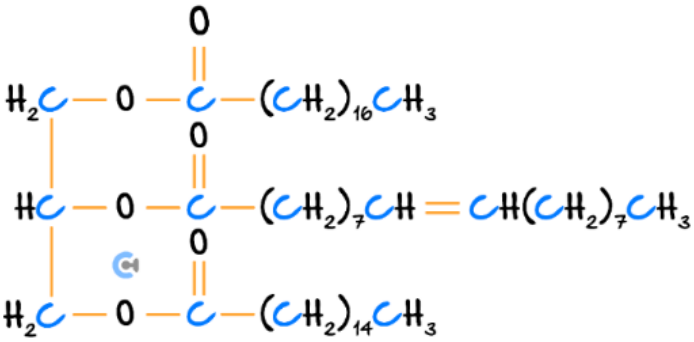
The triglyceride trilinolein is a component of some vegetable oils and has linoleic acid as the only long-chain fatty acid component.

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.

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Question 4

a. 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.

b. Given that the molar mass of myristic acid is 228 g/mol, find the mass of myristic acid required to form 2.00 mol of the triglyceride.

_____

_____

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Question 5

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

b. Find the moles of linoleic acid required to form 10.0 g of water.

_____

_____

_____

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.)

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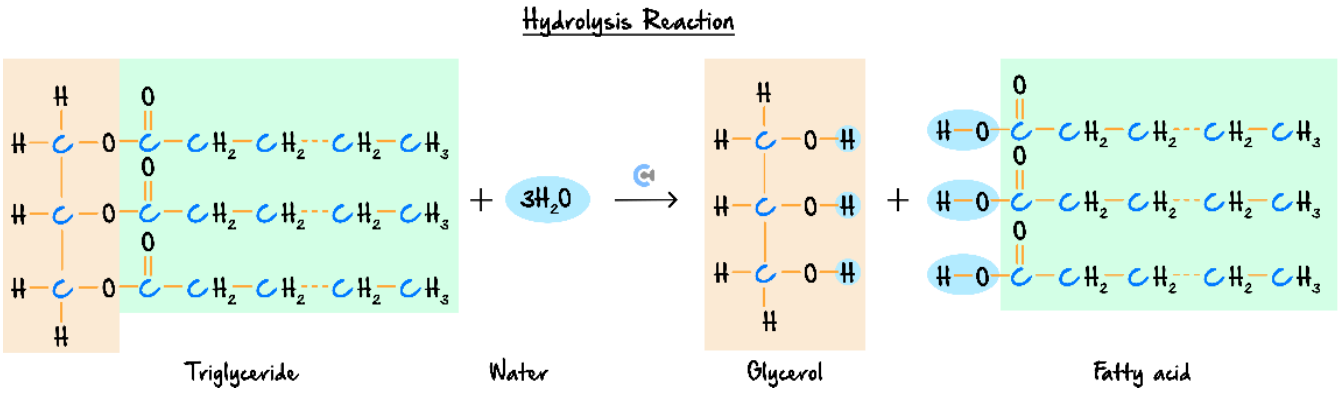
Hydrolysis of Triglycerides

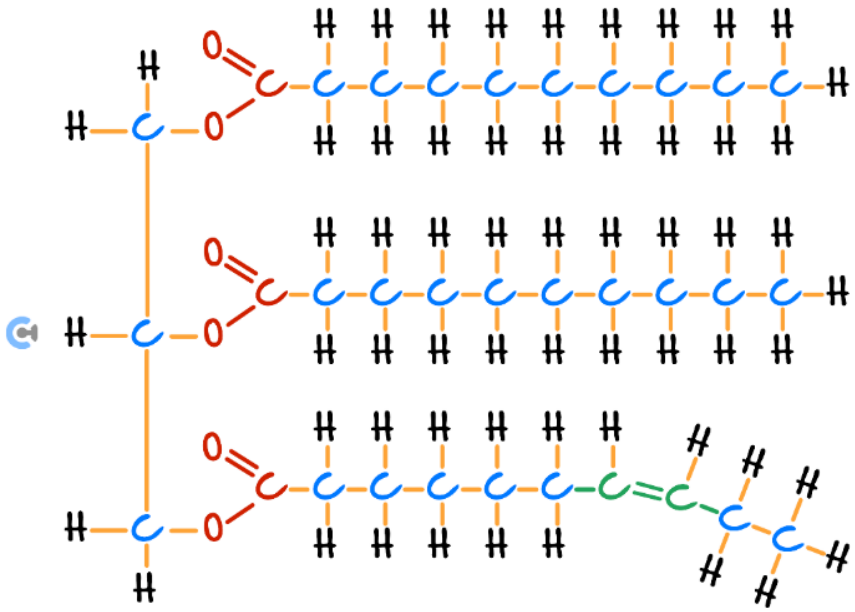
- The opposite **hydrolysis** reaction can occur, whereby water is added to break the triglyceride down.



- **Catalyst:**

Exploration: Triglyceride Hydrolysis

- How does the following triglyceride undergo hydrolysis?



- Catalyst (In the Body):

- Catalyst (Not in Body):

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

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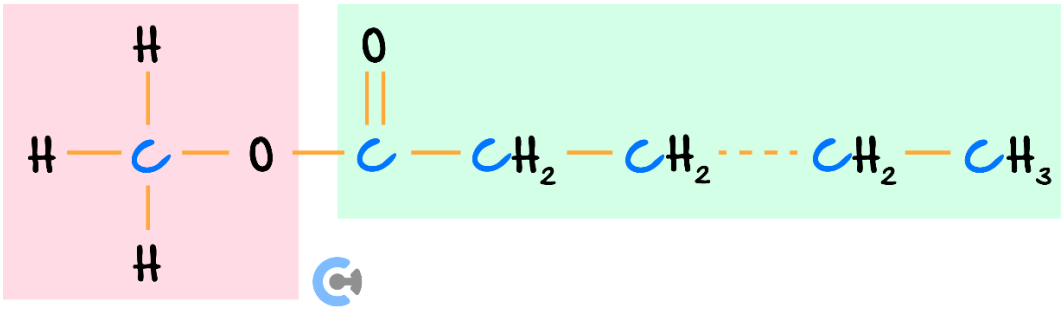
Sub-Section: Formation of Biodiesel

Exploration: Structure of Biodiesel

- Biodiesel has the following structure:



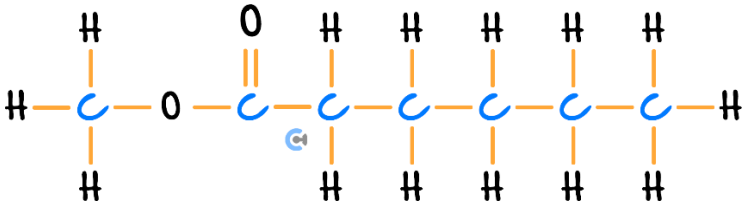
Fatty acid methyl ester (biodiesel)

- Biodiesel is formed from plant and animal matter!
- They are formed from _____ reactions!

What is the transesterification reaction?

Exploration: Transesterification Reaction

- Consider the following biodiesel (ester) molecule:



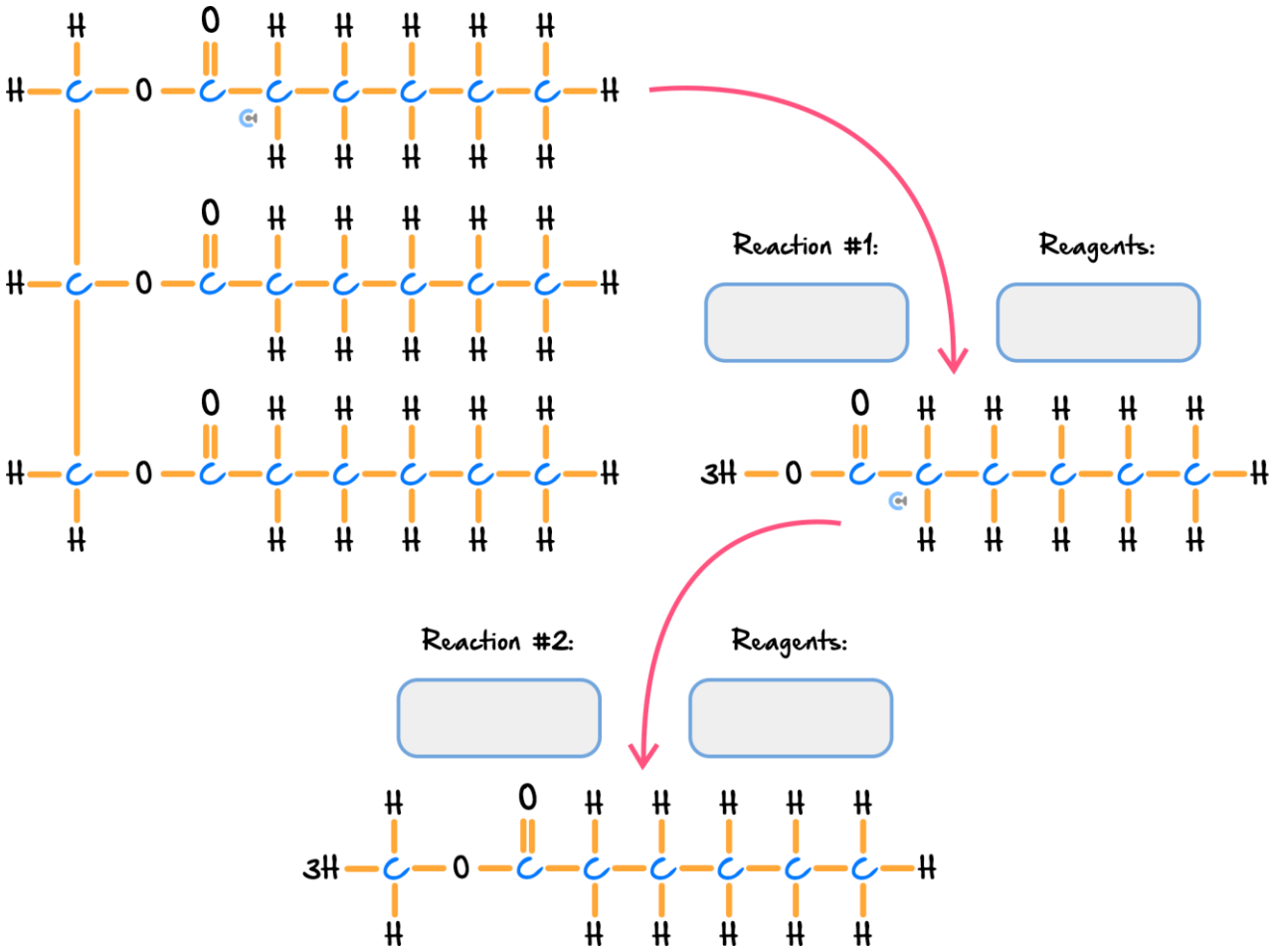
- How long is each chain?

Main Chain	Side Chain

- What is used to make the above biodiesel?

Carboxylic Acid	Alcohol

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



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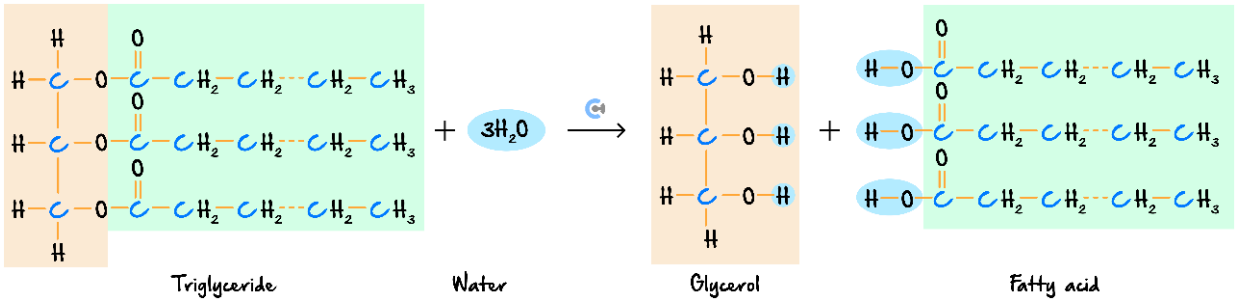
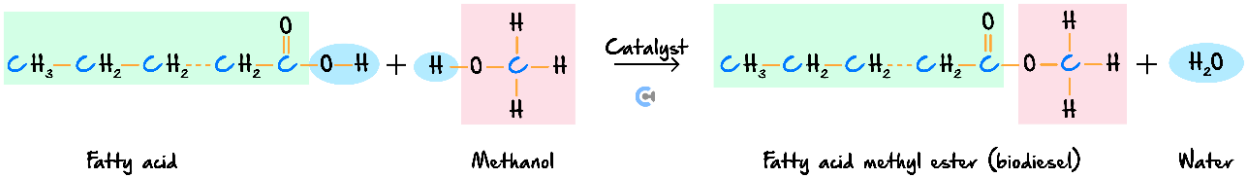
Key Takeaways

- ☑ The following process can be used to obtain the biodiesel:
- ☑ Transesterification reactions consists of **two** reactions put together.
  - _____.
  - _____.

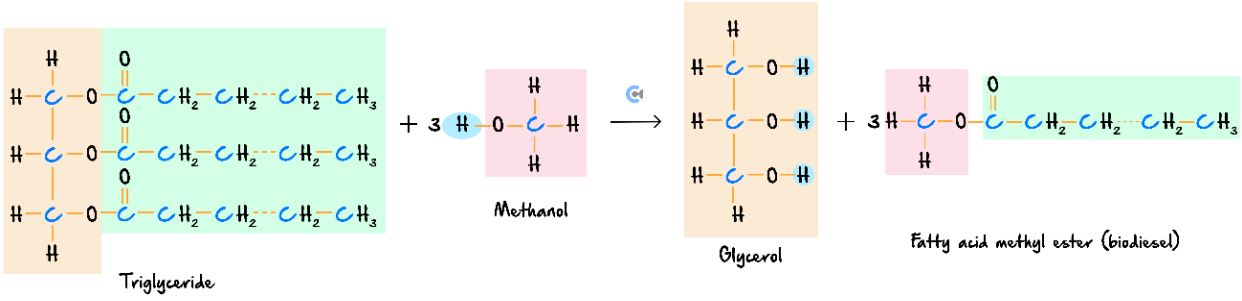
Reaction #1: Hydrolysis of Triglyceride



Reaction #2: Esterification of Fatty Acid and Methanol



Overall Reaction: Transesterification Reaction

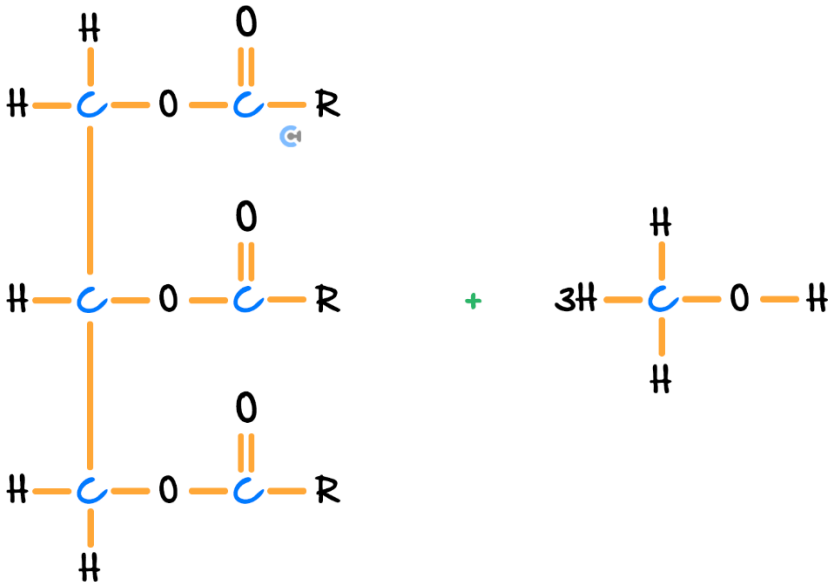


☑ Catalysts/Conditions:

How does the actual transesterification reaction look like?

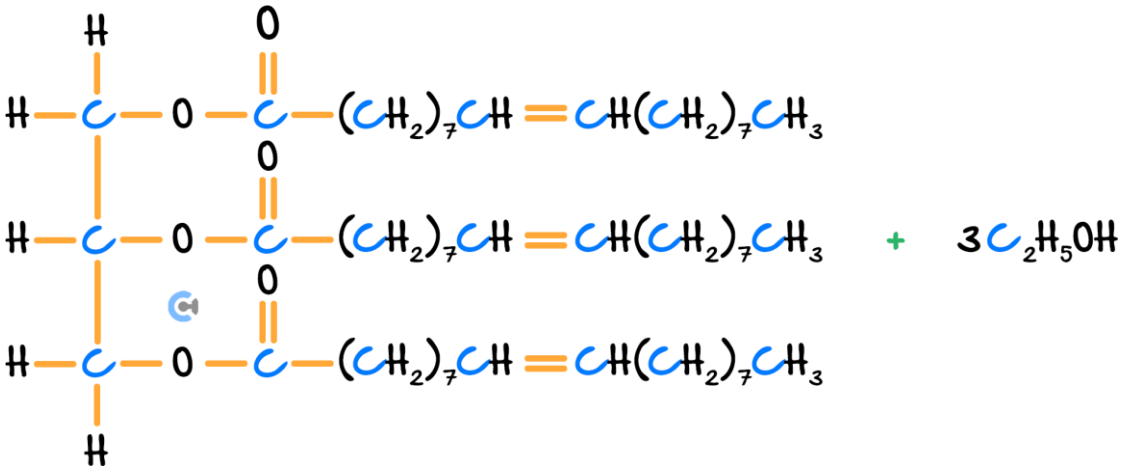
Exploration: General Transesterification Reaction

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



Question 6 Walkthrough.

The following triglyceride and ethanol are mixed together.



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

_____

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!

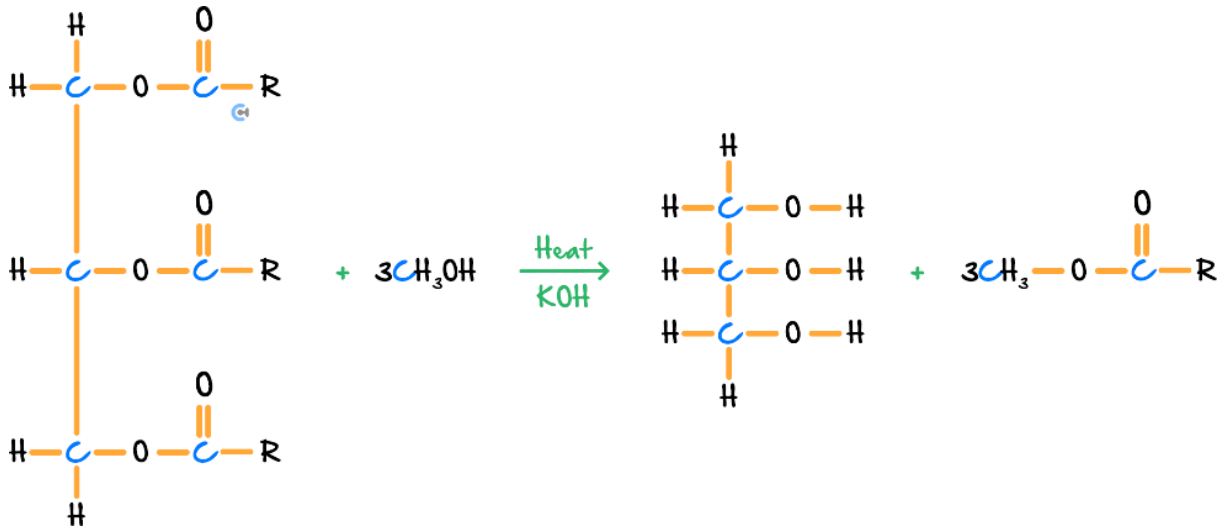
ALSO NOTE: Glycerol is produced as a by-product!

First try distinguishing between reactions!

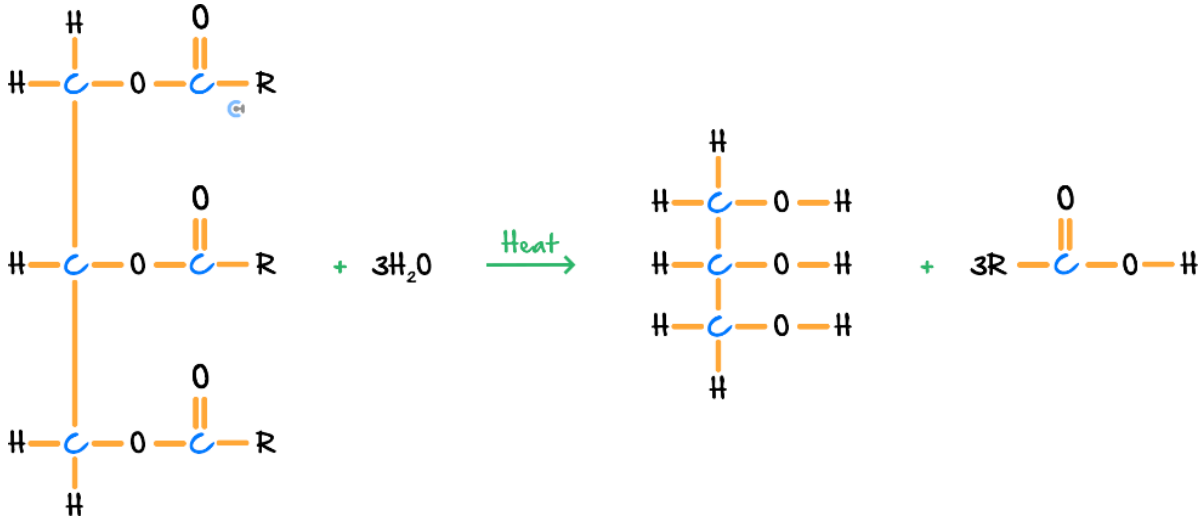
Question 7

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

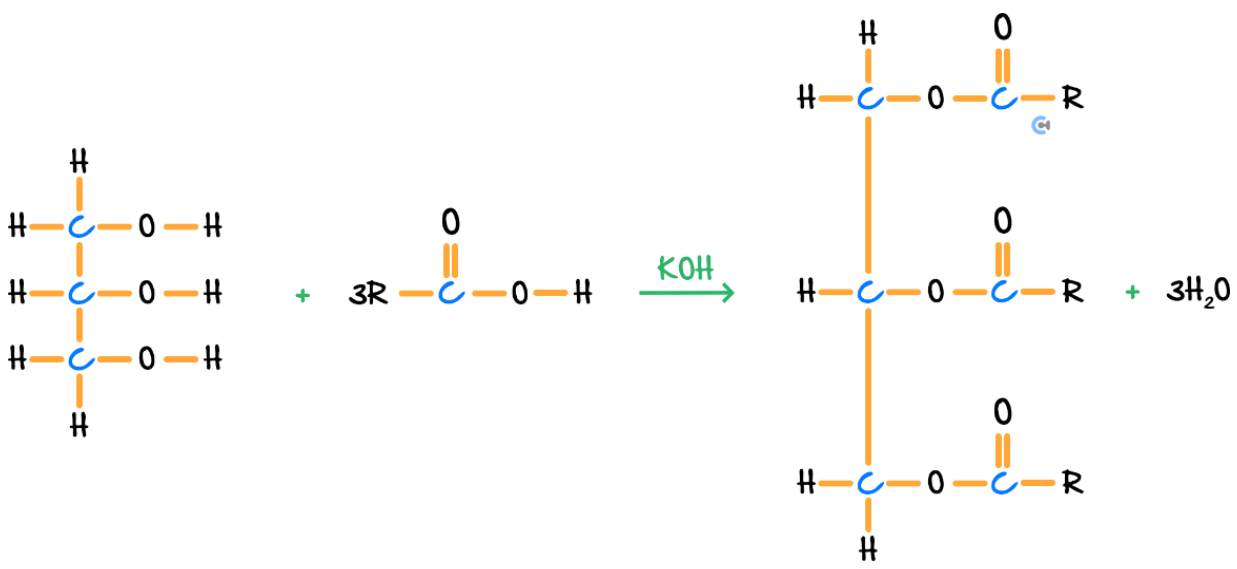
a.



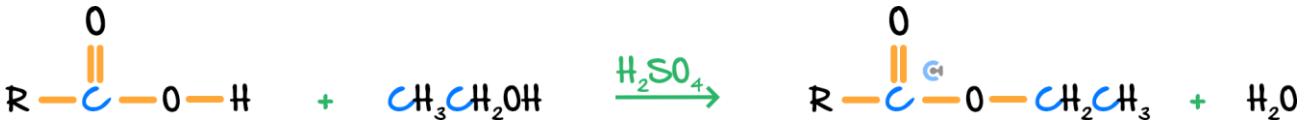
b.



c.



d.



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

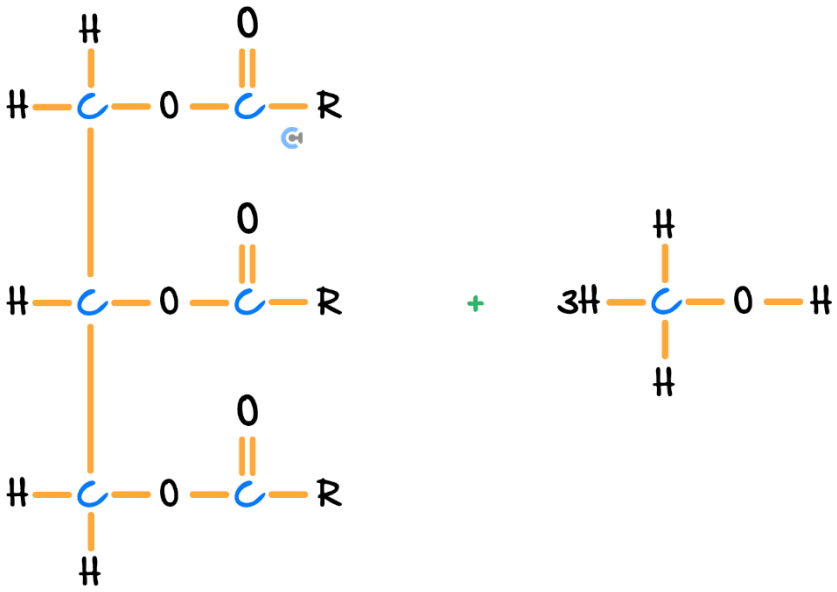
Space for Personal Notes

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.

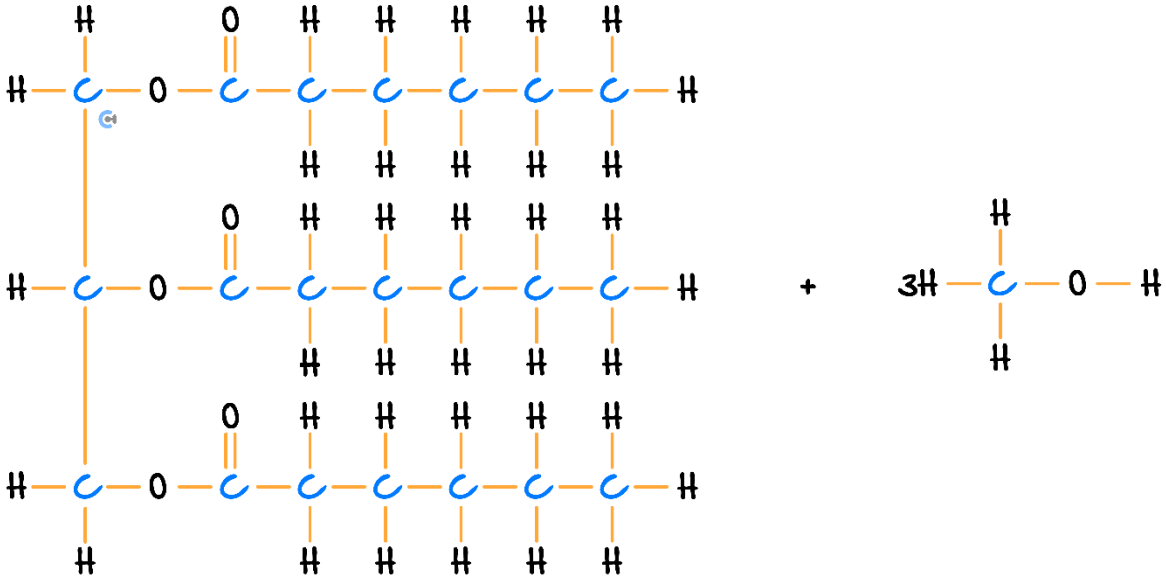


b. Identify the type of reaction which takes place.

_____

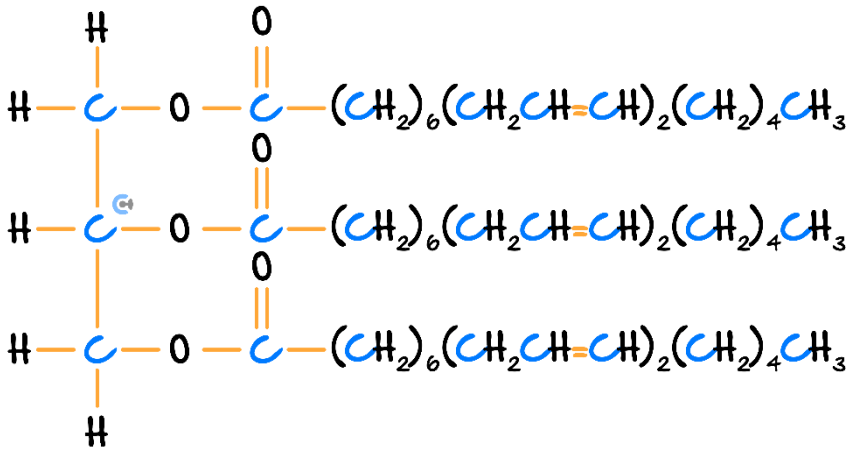
Question 9

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



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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