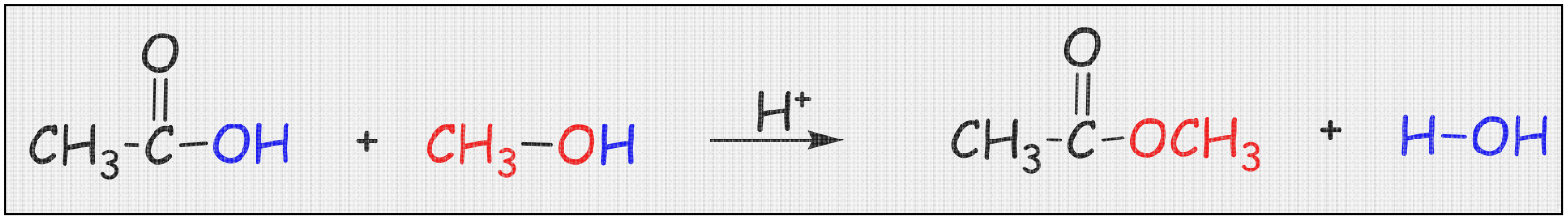
Esterification

A condensation between a carboxylic acid and an alcohol

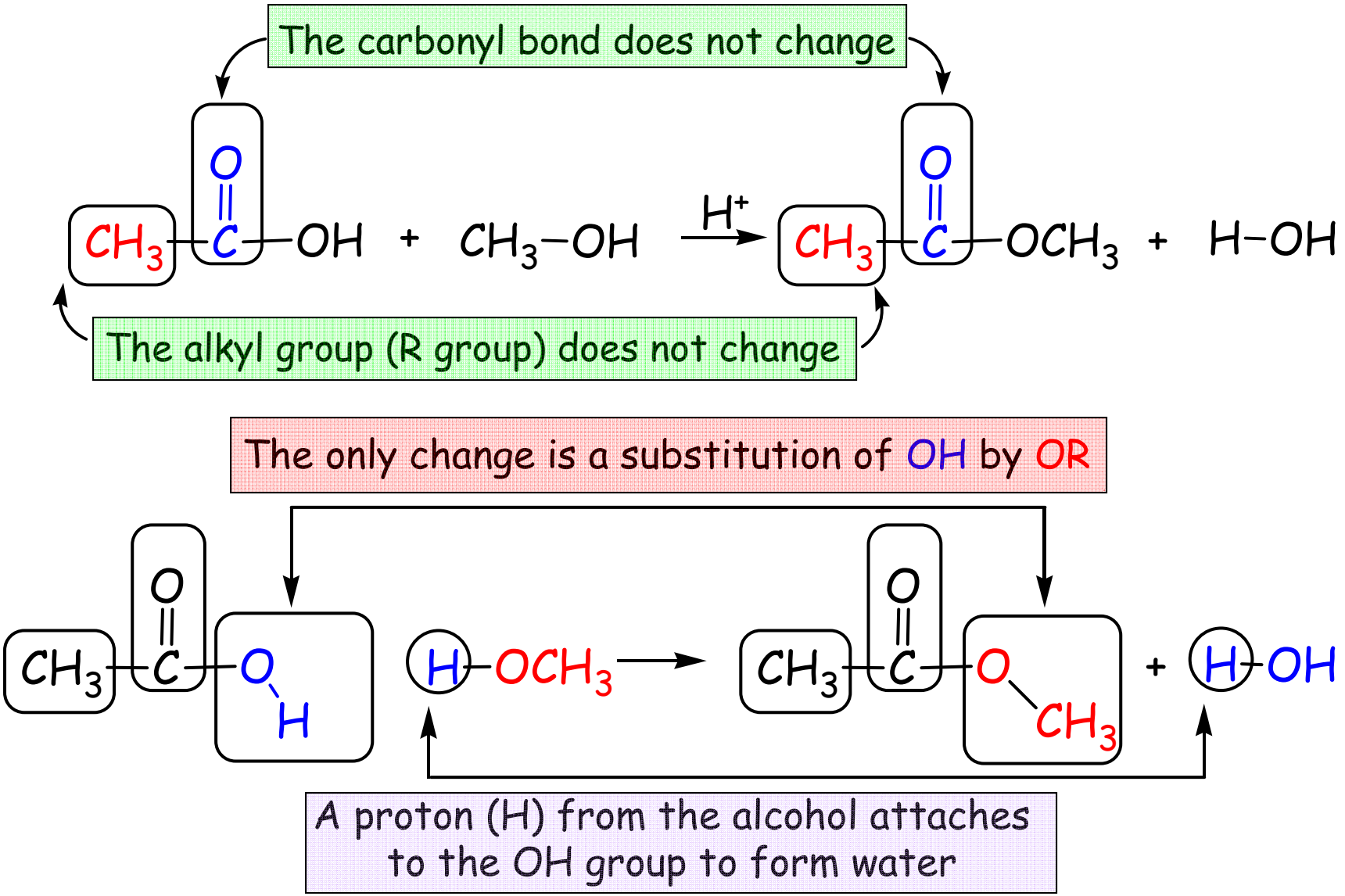


- The carboxylic acid condenses with the alcohol; water is formed in the process.

- The alkoxy group (from the alcohol) becomes the OR group in the product ester.

- The OH group (from the acid) and the H atom from the alcohol produce the by-product, water.

Esterification



Esterification

Different alcohols produce different esters …

1 CH_3COOH + $CH_3CH_2O{-}H$ → $CH_3COOCH_2CH_3$ + $H{-}OH$

Acetic acid — Ethanol — ethyl ester of acetic acid

2 CH_3COOH + $CH_3CH_2CH_2O{-}H$ → $CH_3COOCH_2CH_2CH_3$ + $H{-}OH$

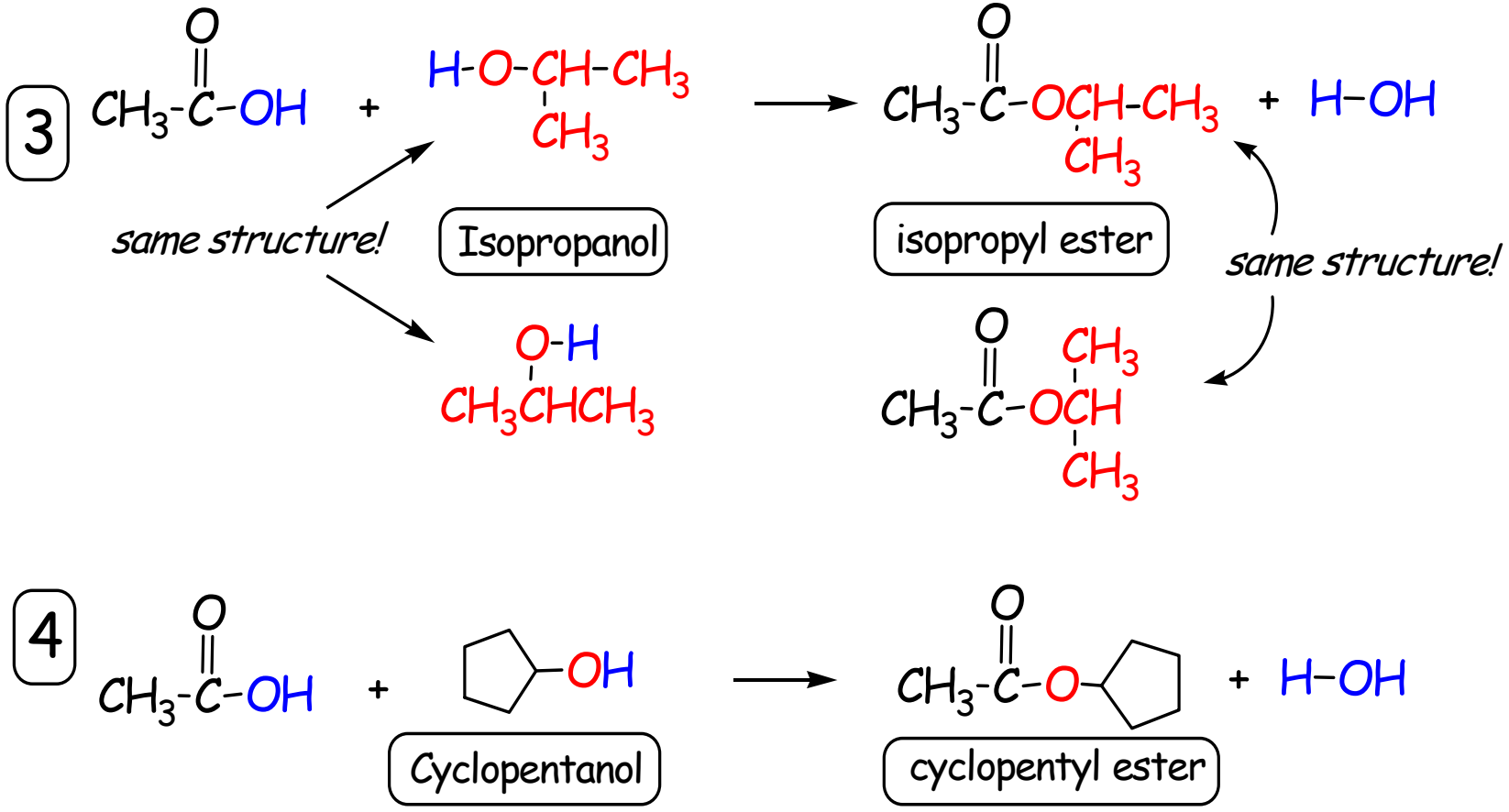
Propanol — propyl ester of acetic acid

… but only the alkoxy groups are different.

The alkyl group (CH_3) remains the same.

Esterification

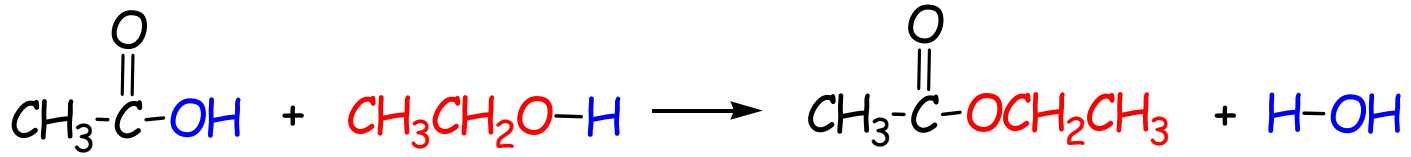
Two more alcohols produce two more esters; again, only the alkoxy groups are different.

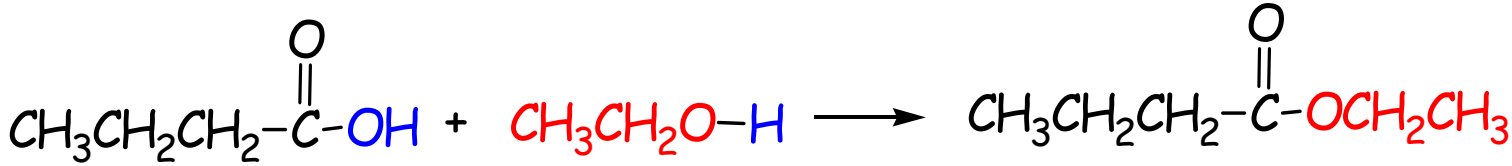


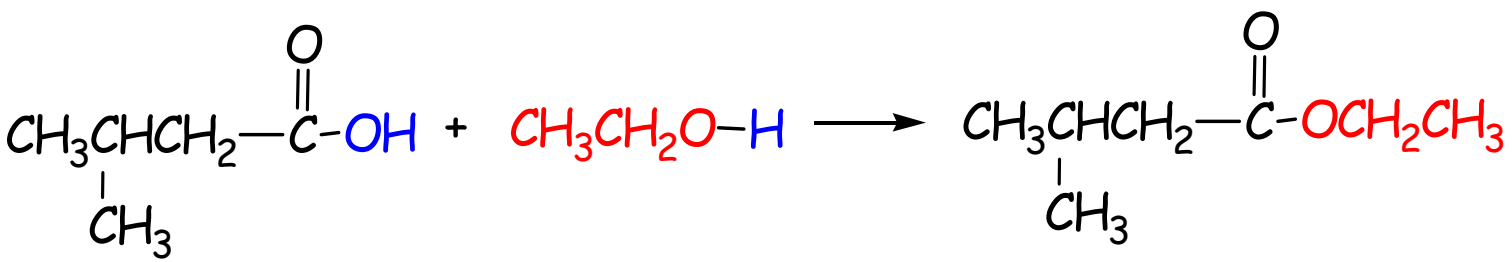
All four esters are acetic acid esters, also called acetate esters.

Esterification

Different acids (different alkyl groups) all give ethyl esters if ethanol is used for each reaction:

1 

2 

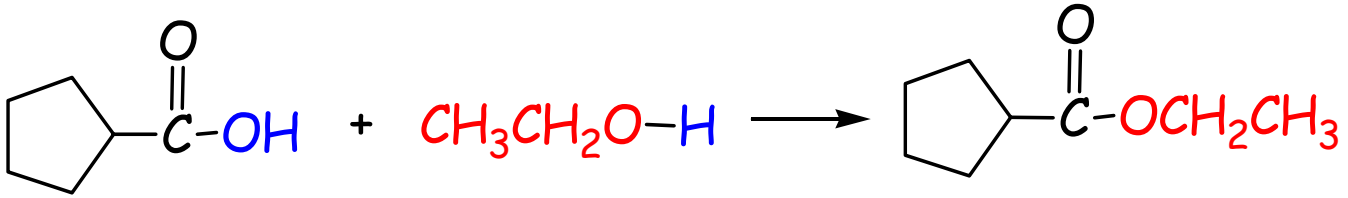
3 

(Water by-product is not shown in these examples.)

Esterification

Two more examples of ethyl esters

4



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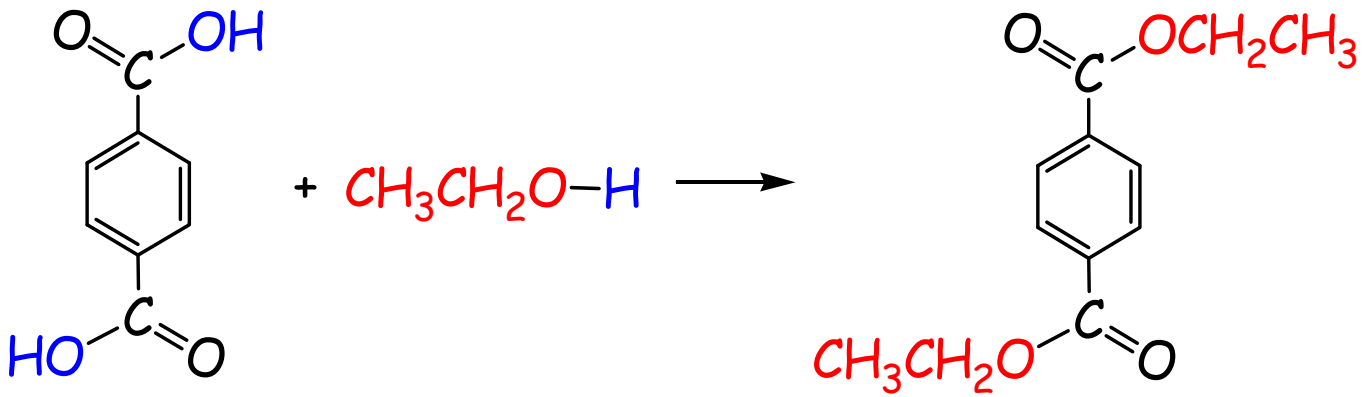
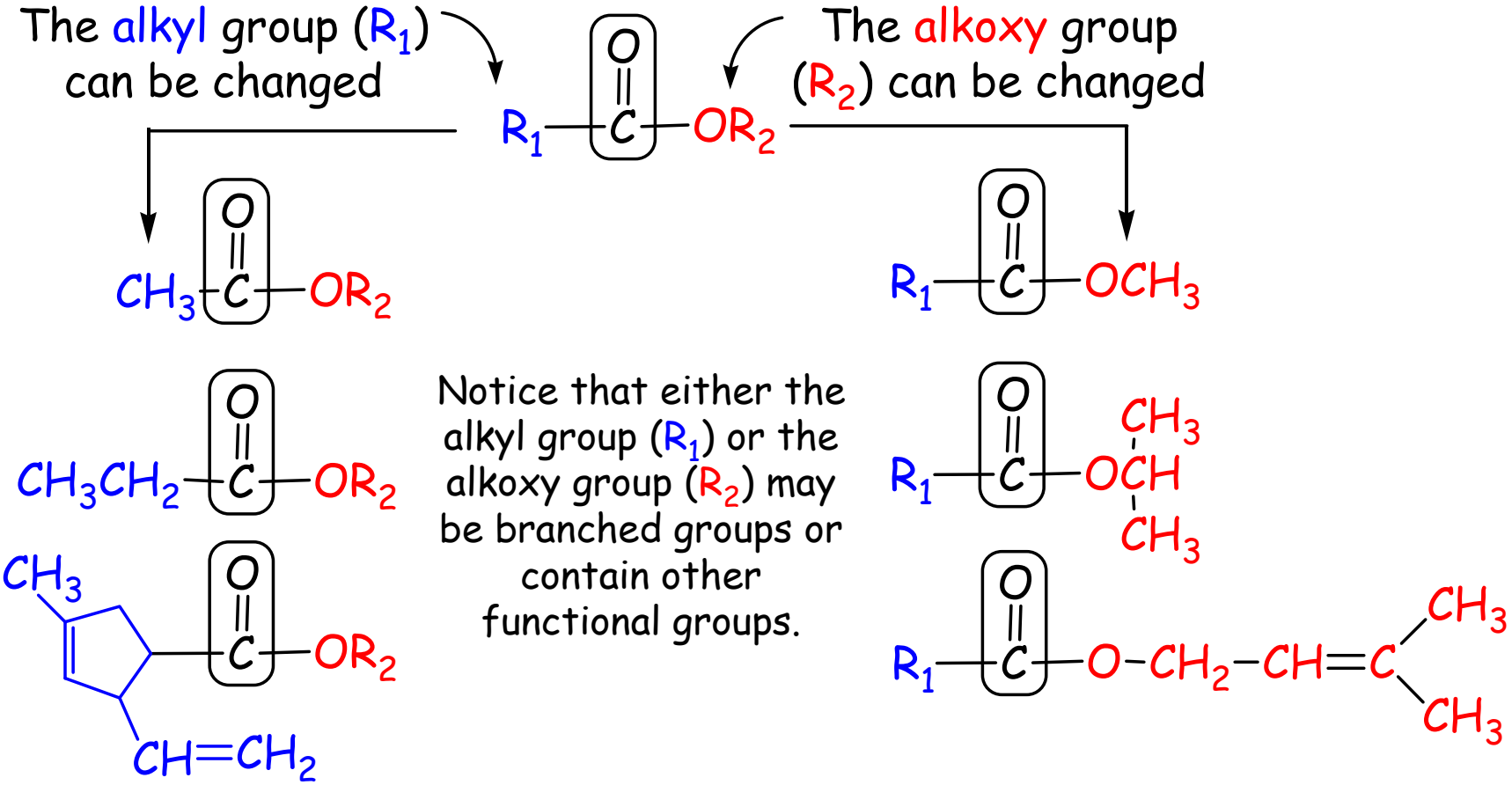


Notice the last example: both carboxylic acid groups undergo esterification; two equivalents of water are formed.

Each reaction contains an excess of the alcohol to drive the reactions to completion.

Esterification

Where does the variety of esters come from?

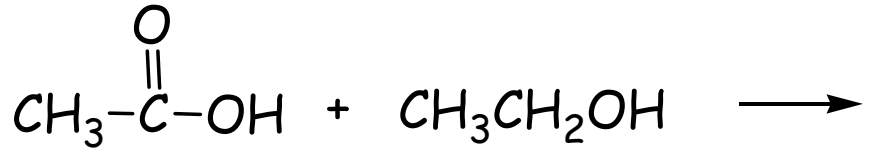


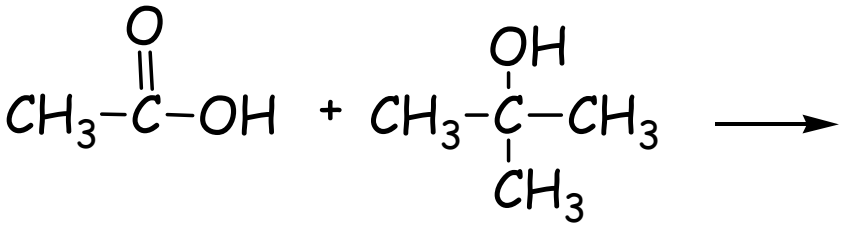
Notice that either the alkyl group (R_1) or the alkoxy group (R_2) may be branched groups or contain other functional groups.

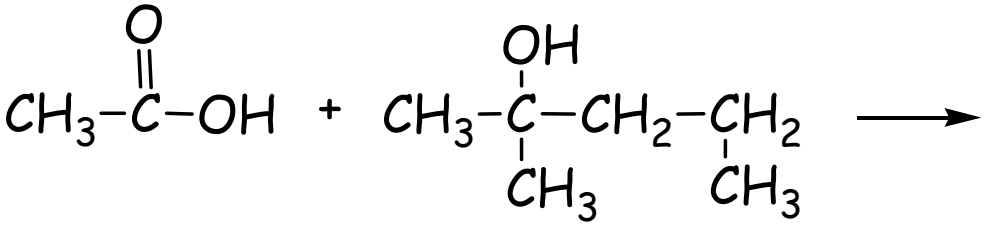
Esterification

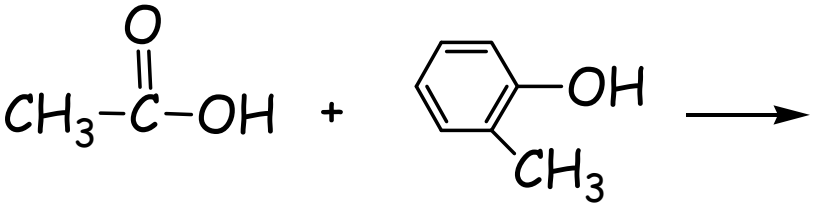
Draw the major organic product (the ester product) from each reaction.

Ignore the by-product (water)

1 

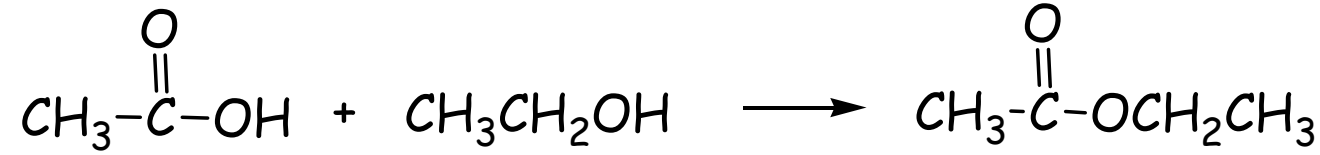
2 

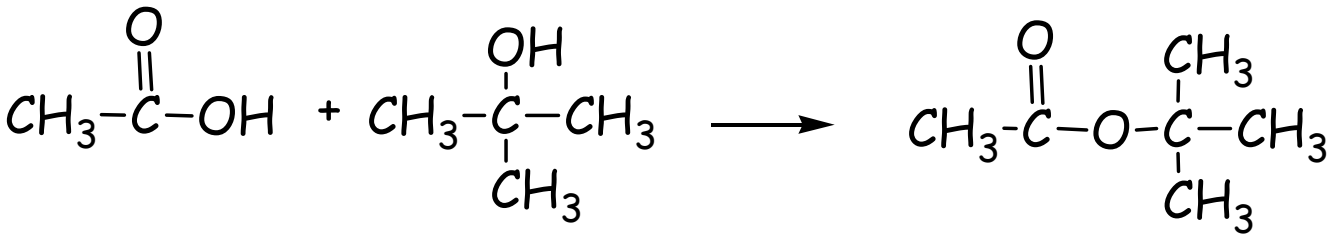
3 

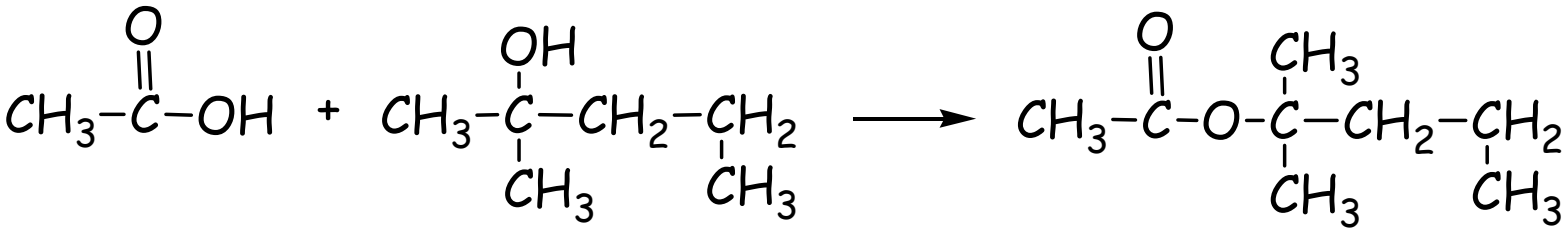
4 

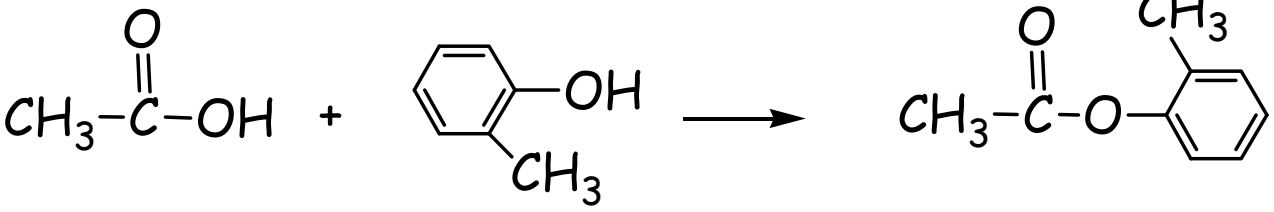
See next slide for answers

Esterification

1 

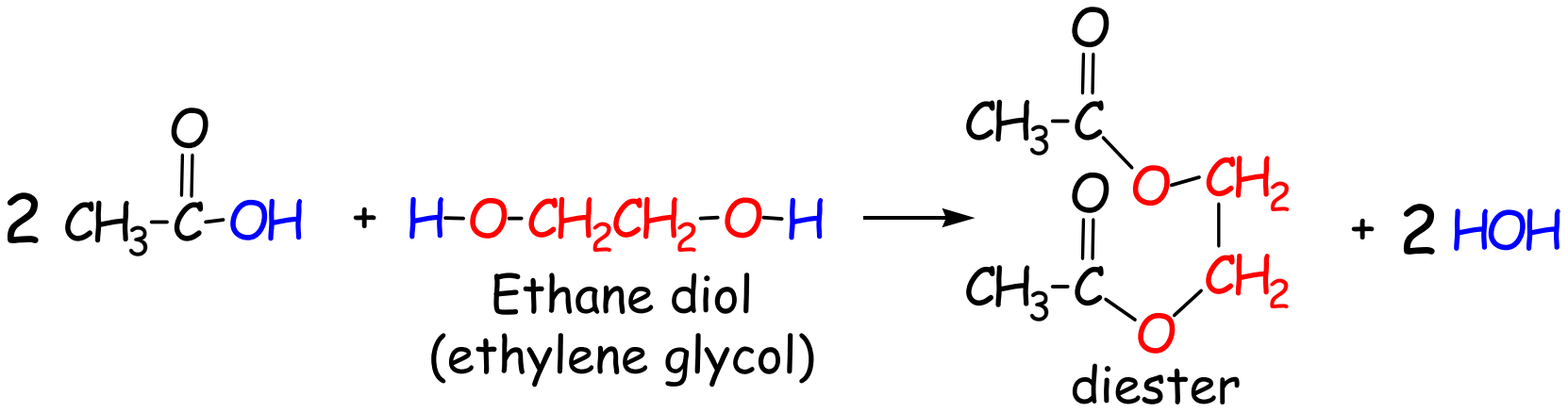
2 

3 

4 

Esterification

Using a diol as the alcohol produces a diester.
Diols are also called glycols.

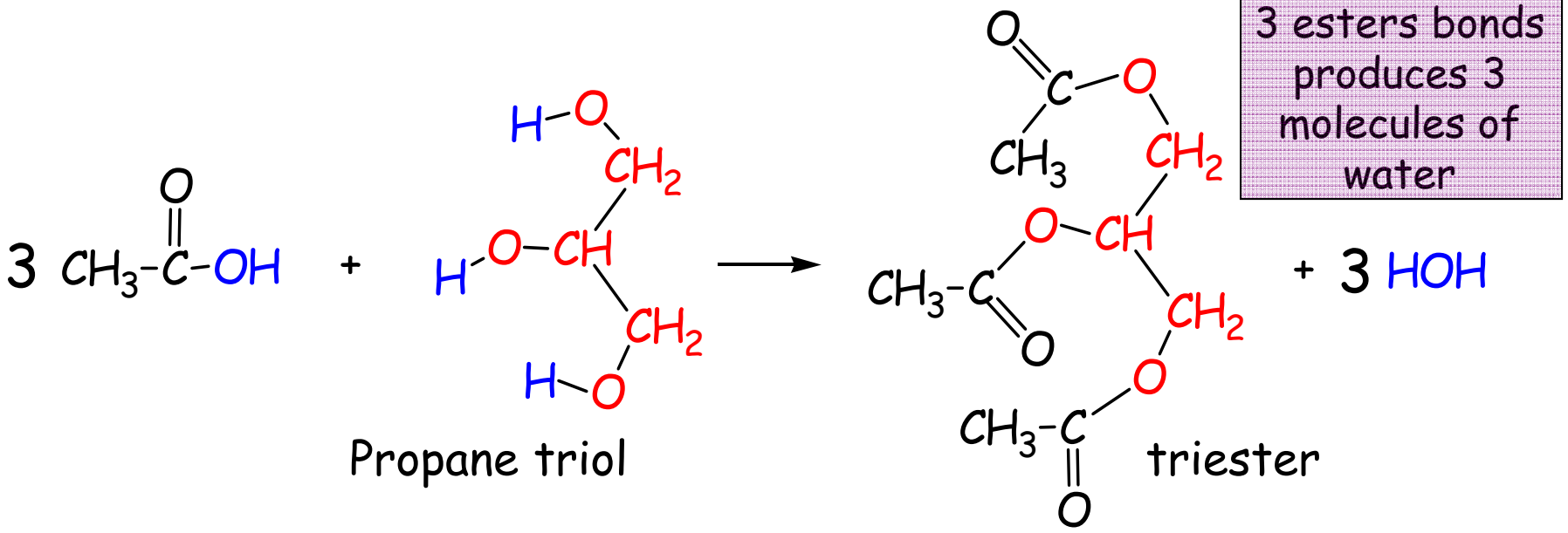


One molecule of water is formed for each ester bond formed.

Two equivalents of ester condense with one equivalent of the diol.
However, excess diol is used to drive the reaction to completion.

Esterification

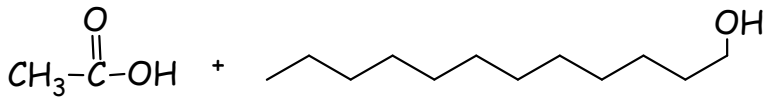
Using a triol as the alcohol produces a triester.
Triols are also called glycols.

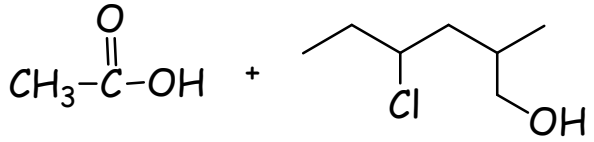


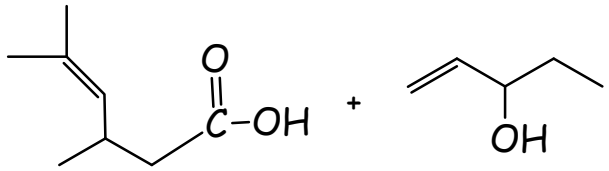
3 esters bonds produces 3 molecules of water

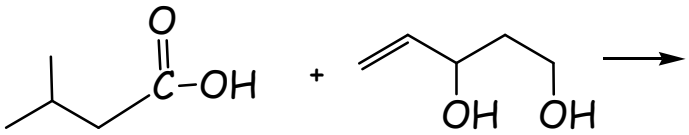
Three equivalents of ester condense with one equivalent of the triol.
However, excess triol is used to drive the reaction to completion.

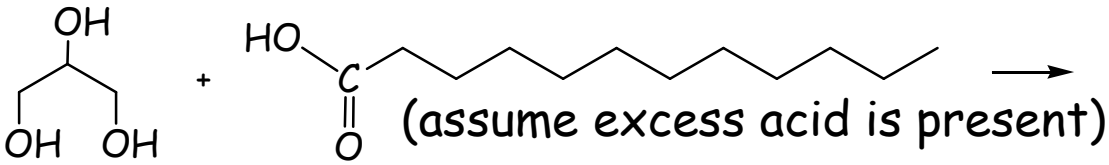
Esterification

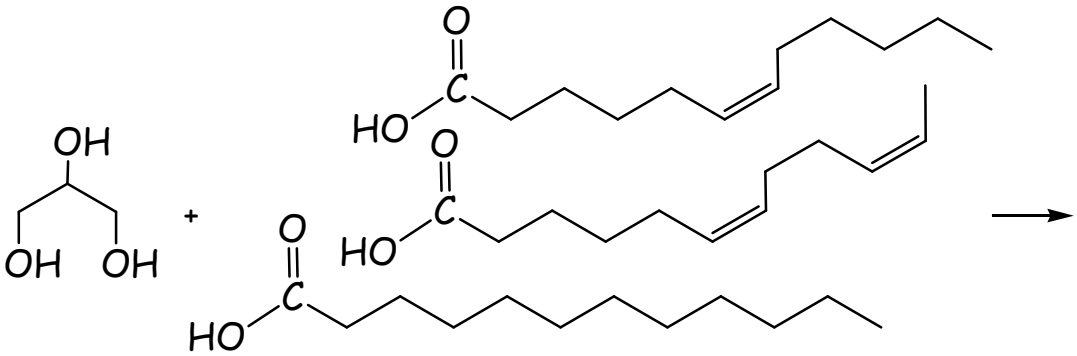
1 

2 

3 

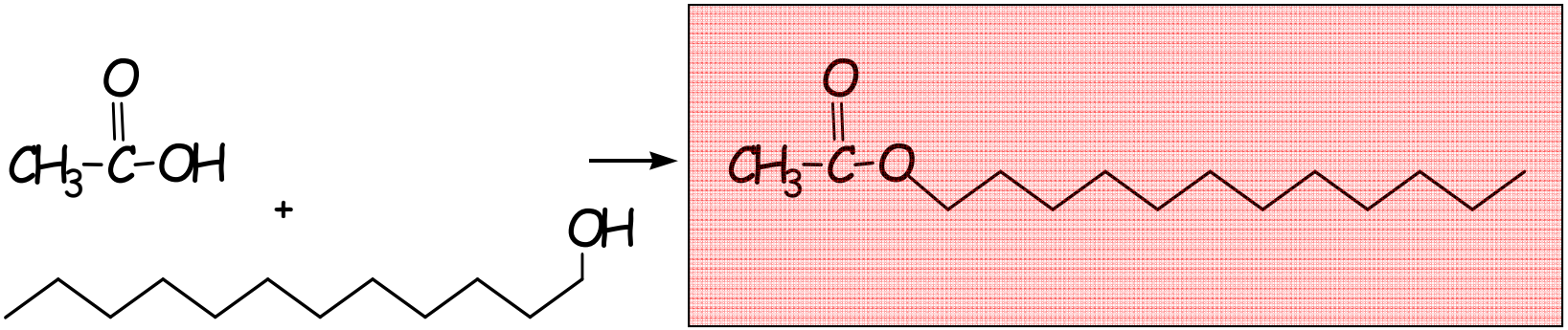
4 

5 
(assume excess acid is present)

6 

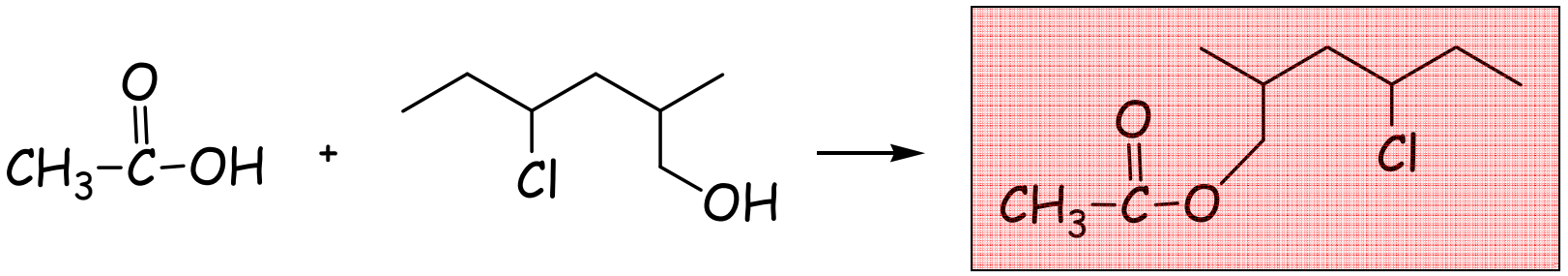
Draw the major organic product. Assume acid catalysis for each reaction. Ignore water.

Esterification problem # 1



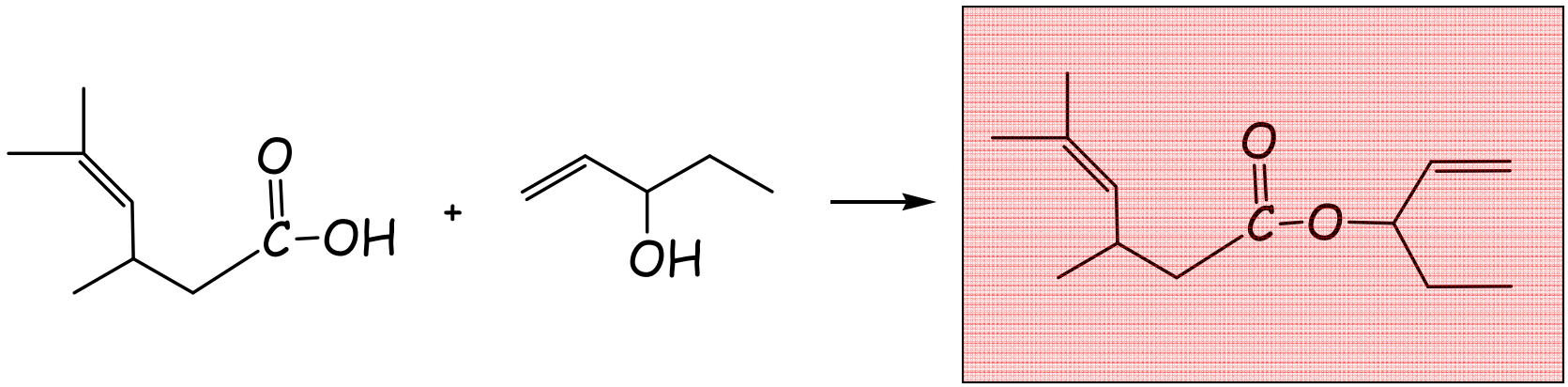
Verify that you have 12 carbon atoms in both the alcohol and the alkoxy group

Esterification problem # 2



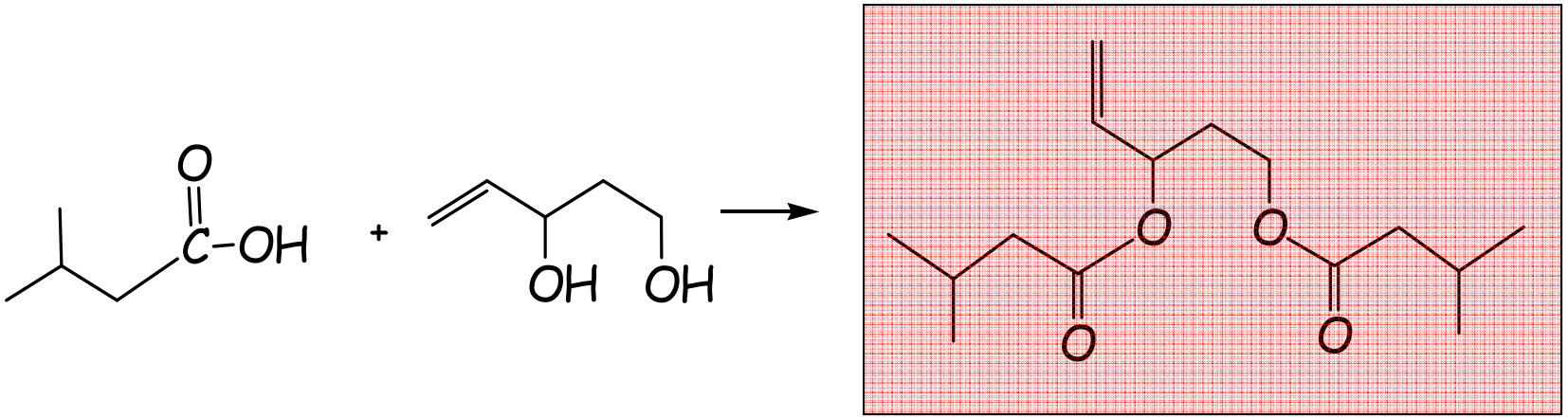
Verify that you have 7 carbon atoms in both the alcohol and the alkoxy group

Esterification problem # 3



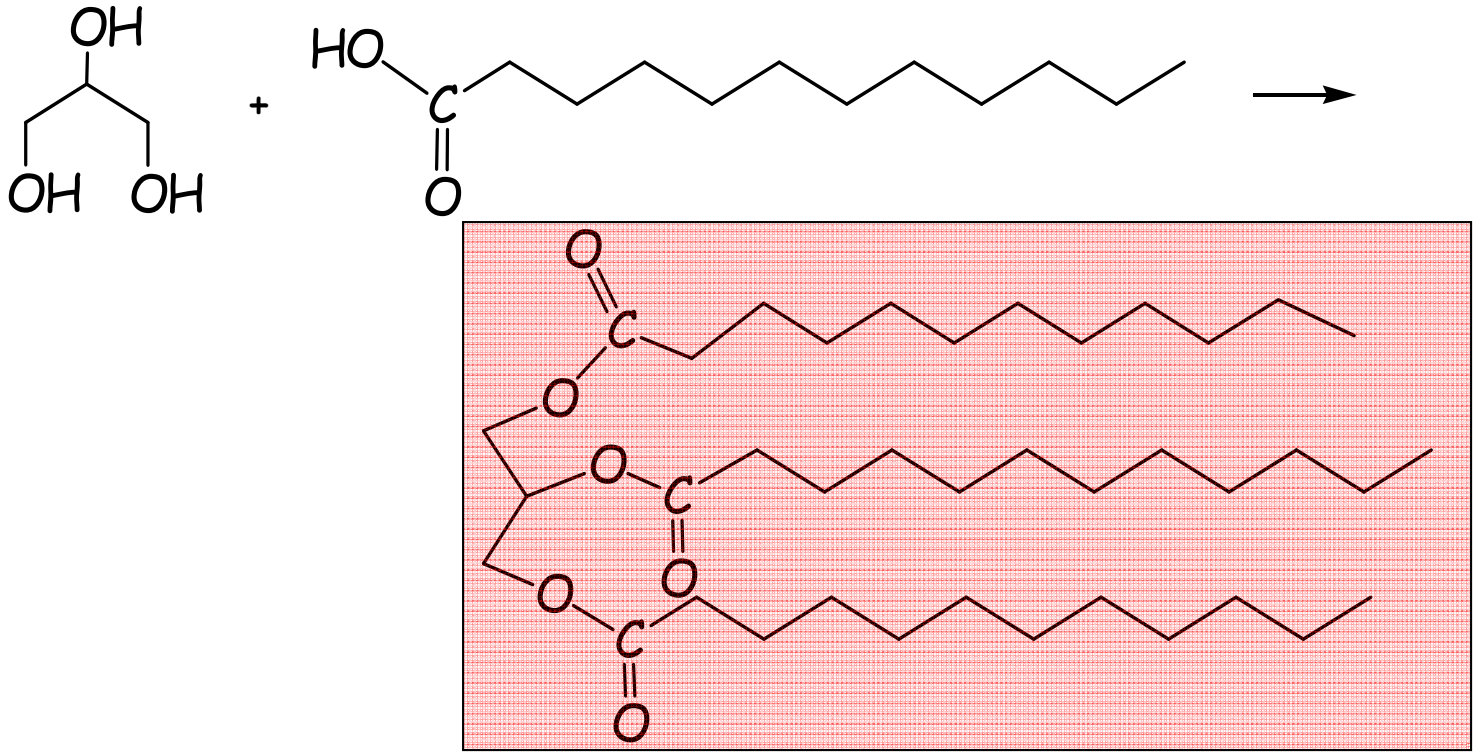
Verify that you have 7 carbon atoms in the alkyl group and 5 carbons in the alkoxy group

Esterification problem # 4



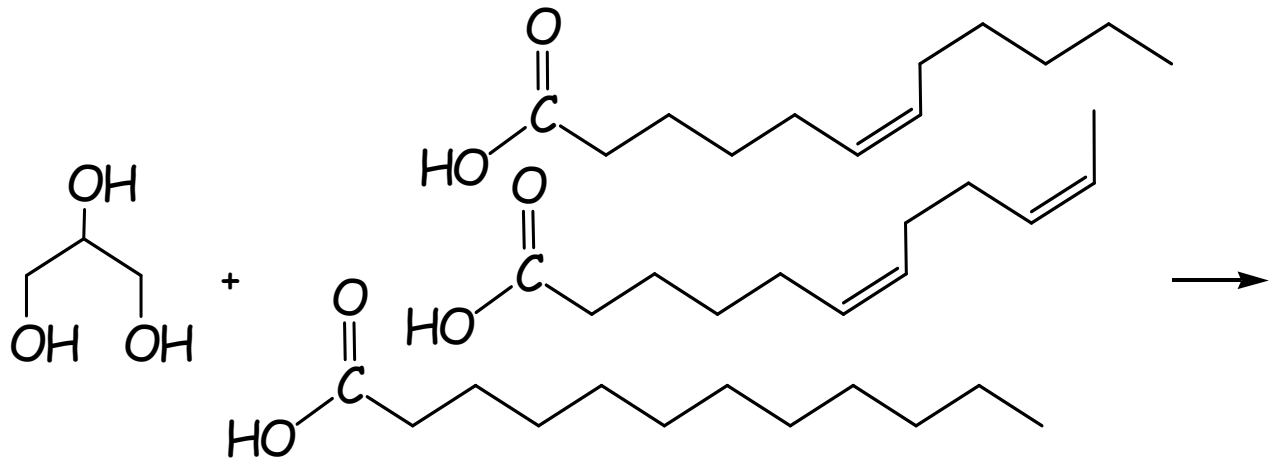
Remember there is free rotation around single bonds:
the alkene functional group is rotated "up" in the product

Esterification problem # 5



Including the carbonyl carbon, there are
12 carbon atoms in each alkyl group

Esterification problem # 6



Including the carbonyl carbons, there are 12 carbons in each alkyl group. All double bonds are cis.