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VCE Chemistry ½

Functional Groups in Organic Chemistry [2.7]

Homework Solutions

Admin Info & Homework Outline:

Student Name	
Questions You Need Help For	
Compulsory Questions	Pg 02 - Pg 17
Supplementary Questions	Pg 18 - Pg 31

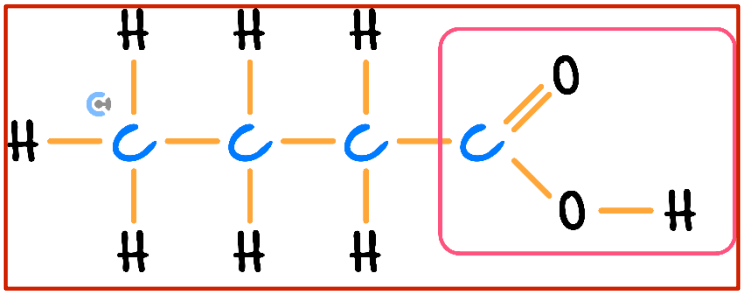
Section A: Compulsory Questions (65.5 Marks)

Sub-Section [2.7.1]: Apply IUPAC Conventions to Identify, Draw & Write IUPAC Names of Straight-Chained & Branched Carboxylic Acids

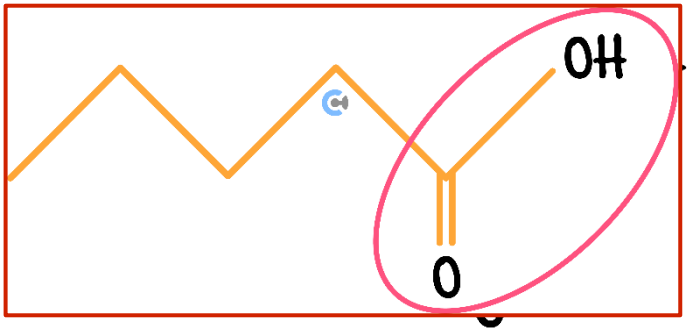
Question 1 (12.5 marks)

a. Identify the carboxyl group in each of the organic compounds below. If there is no carboxyl group present, draw an 'X' through the compound.

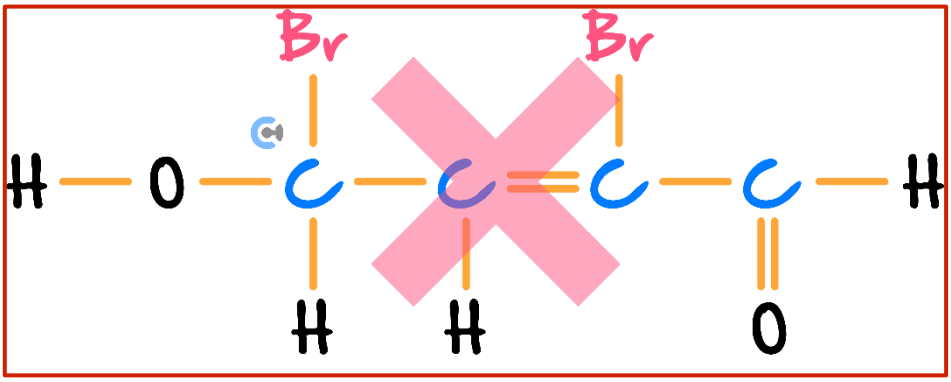
i. (0.5 marks)



ii. (0.5 marks)

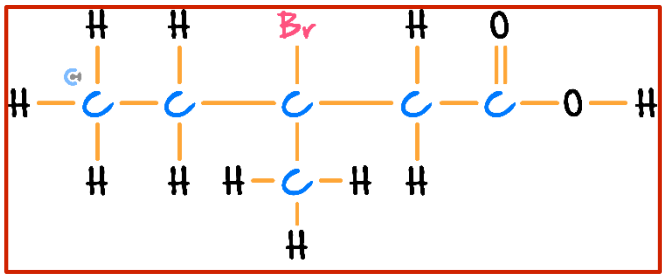


iii. (0.5 marks)

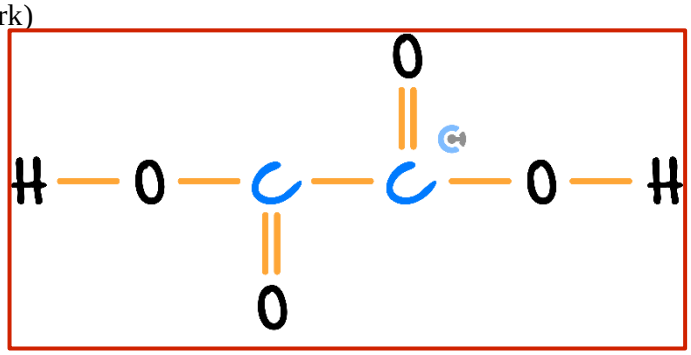


b. Draw the structural formula for each of the organic compounds below.

i. 3-bromo-3-methylpentanoic acid. (1 mark)

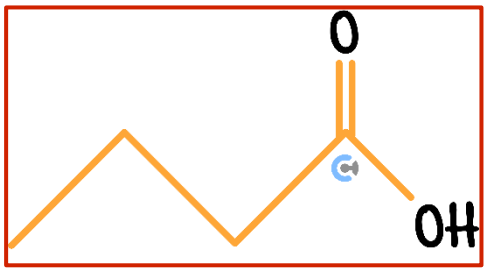


ii. Ethanedioic acid. (1 mark)

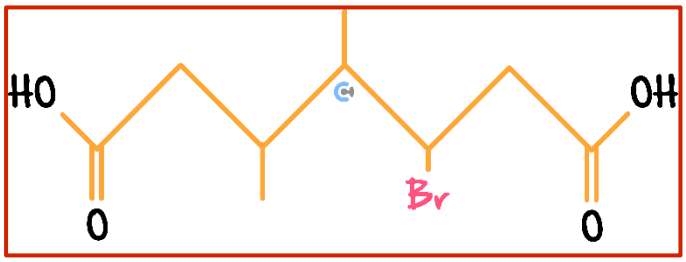


c. Draw the skeletal structure for each of the organic compounds below.

i. Butanoic acid. (1 mark)



ii. 3-bromo-4,5-dimethylheptanedioic acid. (1 mark)



d. Draw the semi-structural formula for each of the organic compounds below.

i. 3,3-dimethylpentanoic acid. (1 mark)

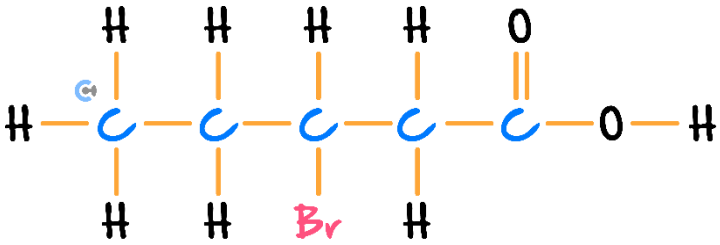
$CH_3CH_2C(CH_3)_2CH_2COOH$

ii. Butanedioic acid. (1 mark)

$HOOCCH_2CH_2COOH$

e. Fill out the table for each of the following molecules.

i. (2 marks)



Name	Semi-structural
3-bromopentanoic acid	$CH_3CH_2CHBrCH_2COOH$

ii. (2 marks)

Name	Semi-structural
Hexanoic acid	$CH_3(CH_2)_4COOH$

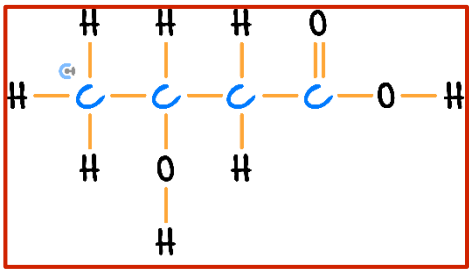
iii. $HOOCCH(CH_3)CH_2CH_2CH_3$. (1 mark)

Name: 2-methylpentanoic acid

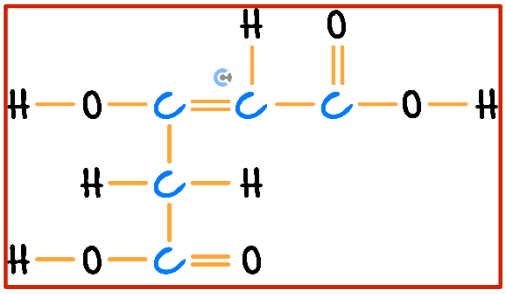
Question 2 (9 marks)

a. Draw the structural formula for each of the organic compounds below.

i. 3-hydroxybutanoic acid. (1 mark)

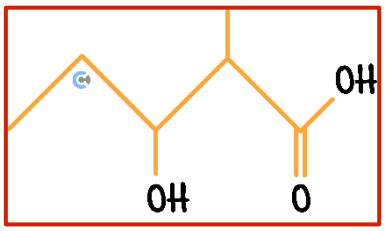


ii. 3-hydroxypent-2-enedoic acid. (1 mark)

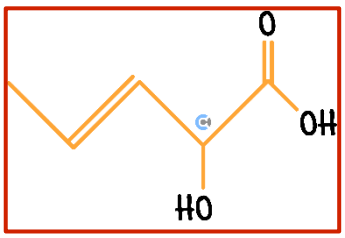


b. Draw the skeletal structure for each of the organic compounds below.

i. 3-hydroxy-2-methylpentanoic acid. (1 mark)



ii. 2-hydroxypent-3-enoic acid. (1 mark)



c. Draw the semi-structural formula for each of the organic compounds below.

i. 2,3-dihydroxybutanoic acid. (1 mark)

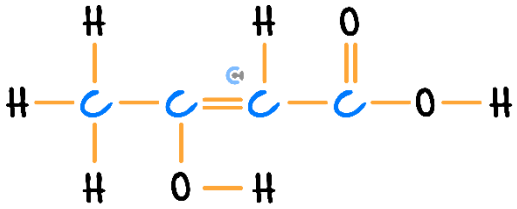
$CH_3CHOHCHOHCOOH$

ii. Hexa-2,4-dienedioic acid. (1 mark)

HOOCCHCHCHCHCOOH

d. Name the following organic compounds.

i. (1 mark)



3-hydroxybut-2-enoic acid

ii. (1 mark)

2-hydroxyhepta-3,5-dienedoic acid

iii. $CH_3CHCOHCH_2CH_2COOH$. (1 mark)

4-hydroxyhex-4-enoic acid

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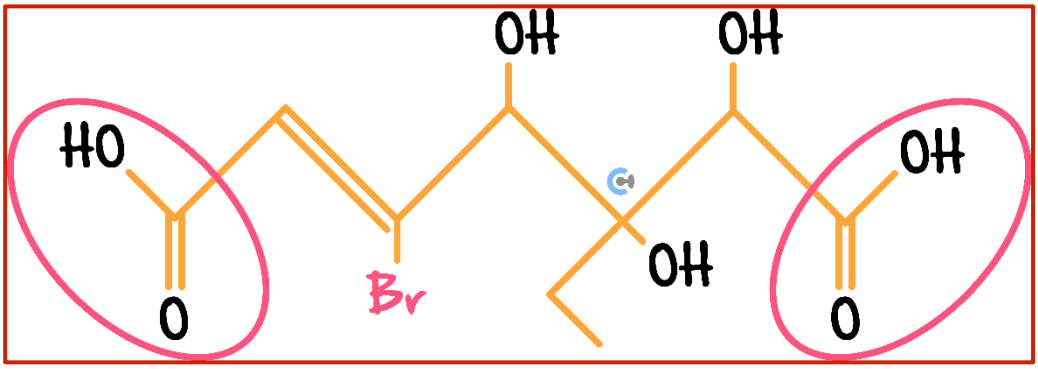
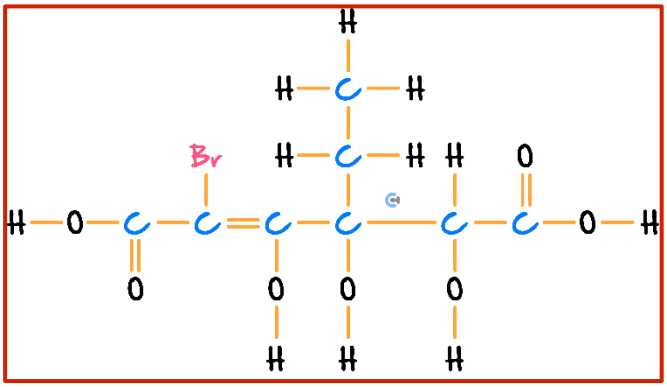
Question 3 (4 marks)

Jaldhi is studying the following organic compound.



a. On the diagram above, circle the carboxyl group(s). (1 mark)

b. Draw the structural formula for the organic compound Jaldhi is studying. (1 mark)



c. Draw the semi-structural formula for the compound. (1 mark)

HOOCCBrCOHCOH(CH_2CH_3)CHOHCOOH

d. Write the IUPAC name for the compound. (1 mark)

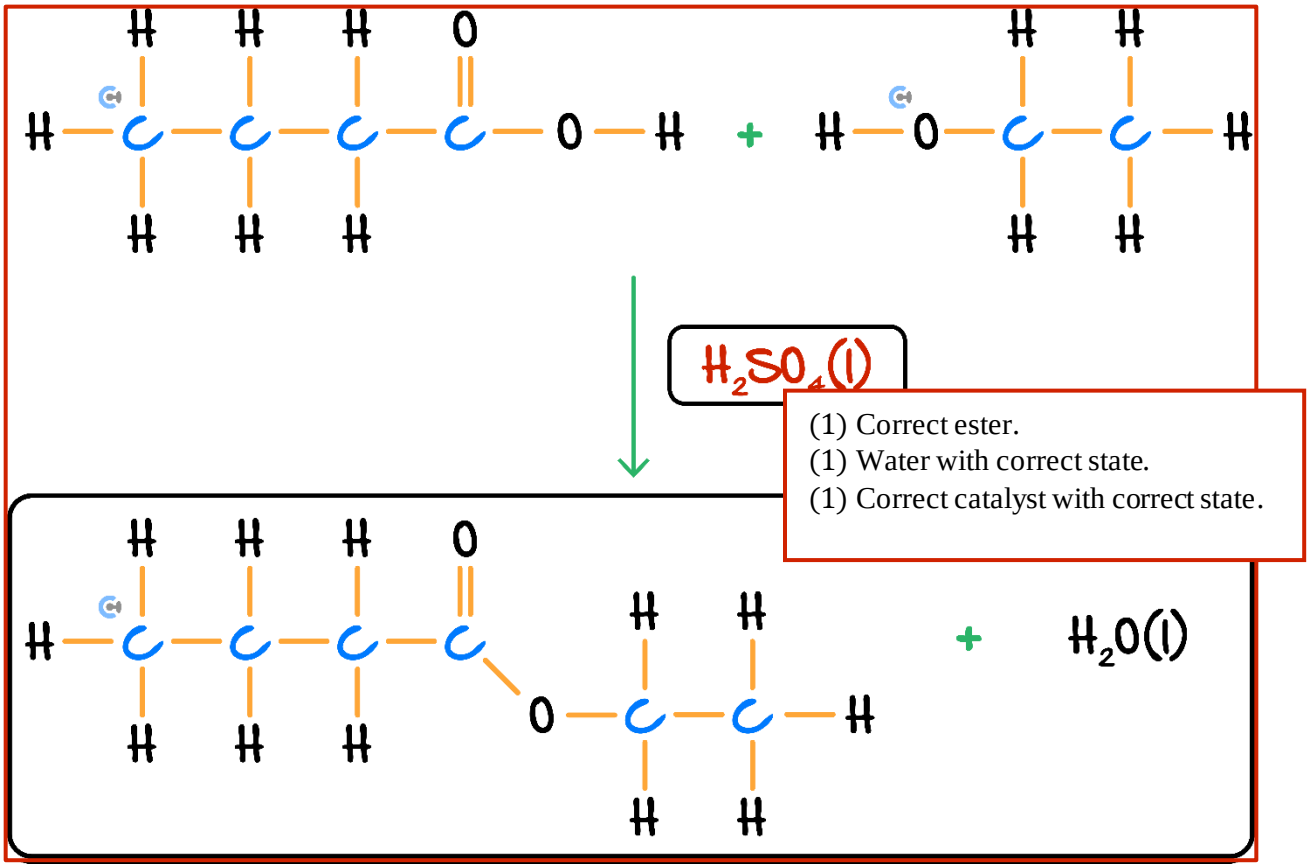
5-bromo-3-ethyl-2,3,4-trihydroxyhex-4-enedioic acid

Sub-Section [2.7.2]: Write Condensation Reactions for the Formation of Esters & Relevant Catalysts/Conditions

Question 4 (4 marks)

Some reactions are being investigated.

a. Complete the reaction below using the structural formula for all organic compounds. States are not required for organic compounds. (3 marks)



(1) Correct ester.
(1) Water with correct state.
(1) Correct catalyst with correct state.

b. State the type of reaction in **part a.** (1 mark)

Condensation reaction (1)

Space for Personal Notes

Question 5 (4 marks)

Write the semi-structural formula for the esterification reaction for the following.

a. Methanoic acid and ethanol. (2 marks)

$$HCOOH(l) + CH_3CH_2OH(l) \rightarrow HCOOCH_2CH_3(l) + H_2O(l)$$

[Include $H_2SO_4(l)$ above the reaction arrow]

(1) – Reaction
(1) – States & catalyst

b. Propan-1-ol and ethanoic acid. (2 marks)

$$CH_3COOH(l) + CH_3CH_2CH_2OH(l) \rightarrow CH_3COOCH_2CH_2CH_3(l) + H_2O(l)$$

[Include $H_2SO_4(l)$ above the reaction arrow]

(1) – reaction
(1) – states & catalyst

Question 6 (7 marks)

a. Complete the reaction below using the semi-structural formula for any organic compounds. States are not required for organic compounds. (2 marks)

$$CH_3CH_2COOH + CH_3CH_2CH_2CH_2OH \xrightarrow{H_2SO_4(l)} CH_3CH_2COOCH_2CH_2CH_2CH_3 + H_2O(l)$$

(1) Correct alcohol & water.
(1) Correct catalyst with correct state.

b. State the type of reaction in **part a.** (1 mark)

Condensation reaction (1)

c. H_2SO_4 is sometimes called a dehydrating agent.

i. Explain the function of H_2SO_4 in terms of esterification reactions. (1 mark)

H_2SO_4 is a catalyst (1).

ii. Identify a safety risk associated with H_2SO_4 solutions used in esterification reactions. (2 marks)

H_2SO_4 must be concentrated for use in esterification reactions (1).
Concentrated acids may cause chemical burns if spilled onto skin. (2)

d. Name the ester formed in **part a.** (1 mark)

Butyl propanoate (1).

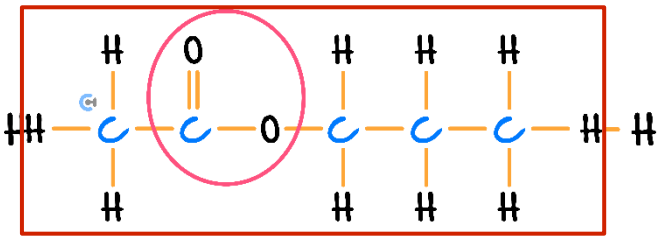
Space for Personal Notes

Sub-Section [2.7.3]: Apply IUPAC Conventions to Identify, Draw & Write IUPAC Names of Straight-Chained Esters

Question 7 (3 marks)

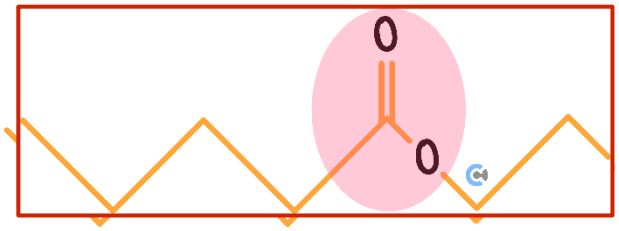
Circle the ester groups in each of the following organic compounds.

a. (1 mark)



b. (1 mark)

c. (1 mark)



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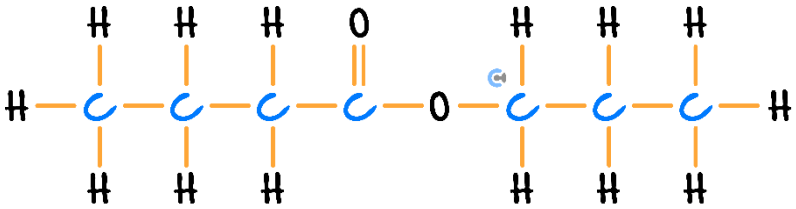
Question 8 (4 marks)

Identify the carboxylic acid and the alcohol that are reacted to form the following esters.

a. (1 mark)

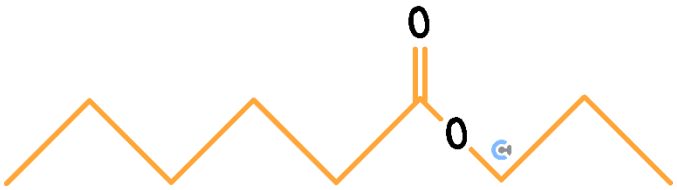


Butanoic acid - Propanol

b. $CH_3CH_2COOCH_2CH_3$. (1 mark)

Propanoic acid - Ethanol

c. (1 mark)



Hexanoic acid - Propanol

d. Hexyl pentanoate. (1 mark)

Pentanoic acid - Hexanol

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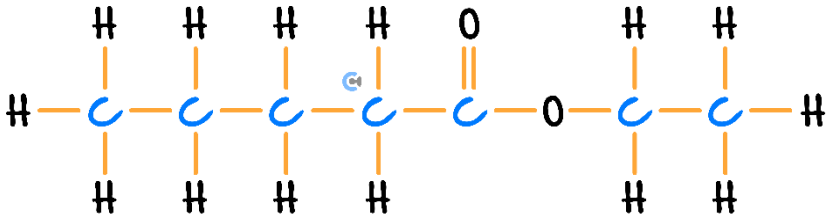
Question 9 (5 marks)

a. State the IUPAC name for each of the following compounds.

i. (1 mark)

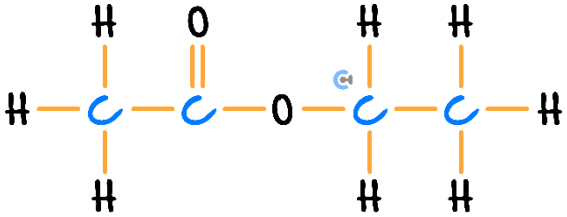


Ethyl pentanoate

ii. $CH_3CH_2CH_2COOCH_2CH_2CH_2CH_2CH_2CH_3$. (1 mark)

Heptyl butanoate

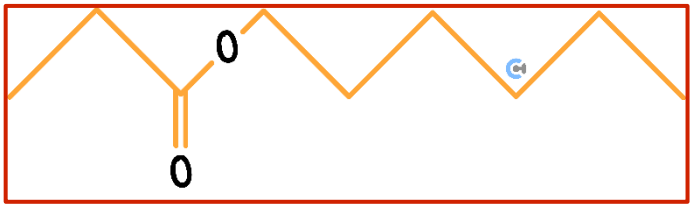
iii. (1 mark)



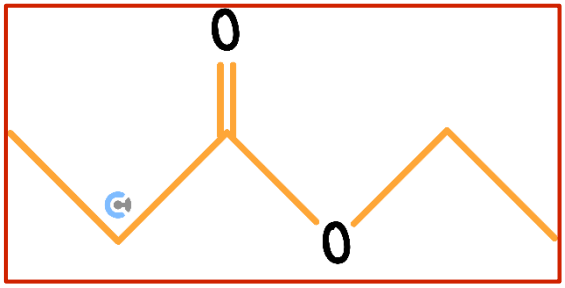
Ethyl ethanoate

b. For the following, draw the skeletal formulas.

i. Hexyl propanoate. (1 mark)



ii. Ethyl propanoate. (1 mark)



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Sub-Section: The 'Final Boss'

Question 10 (13 marks)

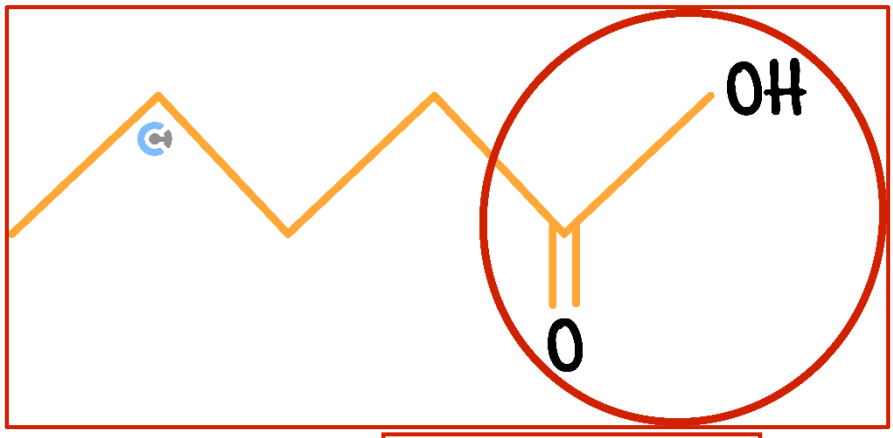
Aaron is working with some organic compounds on Ester Sunday. He decides he would like to synthesise an ester with 7 carbon atoms for the occasion.

a. Aaron is going to use the ethanol in a bottle of vodka (which was gifted to him) to synthesise his ester.

i. Explain why Aaron cannot use vinegar (which is composed of ethanoic acid) to synthesise his ester. (2 marks)

Ethanoic acid has two carbon atoms. The esterification reaction between ethanoic acid and ethanol would produce an ester with four carbons (1), which is not what Aaron desires (2).

ii. Draw the skeletal structure of a potential carboxylic acid Aaron could use. Circle the carboxyl group on your drawing. (2 marks)



(1) skeletal structure
(2) circled carboxyl group

b. Aaron decides to react hexanoic acid with ethanol to synthesise his ester.

i. Using semi-structural formula, write the equation for the esterification reaction between hexanoic acid and ethanol. States are not required for organic compounds. (3 marks)

$$CH_3CH_2OH + CH_3CH_2CH_2CH_2CH_2COOH \xrightarrow{H_2SO_4(l)} CH_3CH_2CH_2CH_2CH_2COOCH_2CH_3 + H_2O(l)$$

(1) reactants
(2) products (water with state)
(3) catalyst with correct state

ii. What type of reaction is Aaron using to synthesise his ester? (1 mark)

Condensation reaction (1)

iii. State the IUPAC name of the ester produced by the reaction in **part b. i.** (1 mark)

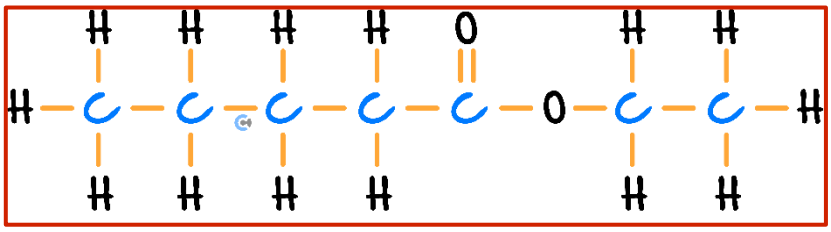
Ethyl hexanoate (1)

iv. With reference to relevant molecular formulae, explain why Aaron should not use hexanoic acid to synthesise the ester he desires. (2 marks)

Ethyl hexanoate, the product of the esterification reaction between ethanol and hexanoic acid, has the molecular formula $C_8H_{16}O_2$ (1) as a result of ethanol having the molecular formula C_2H_6O and hexanoic acid having the molecular formula $C_6H_{12}O_2$. Ethyl hexanoate has eight carbon atoms but Aaron only desires an ester with seven carbon atoms (2); therefore, hexanoic acid should not be used.

c. After some trial and error, Aaron synthesises the ester he desires using the ethanol from his bottle of vodka.

i. Draw the structural formula for the ester that Aaron synthesises. (1 mark)



Esters
Table of esters and their smells

ii. Using the table above, describe the smell of the ester Aaron has synthesised. (1 mark)

Aaron's ester has a mix of fruity smells (1)
Note: Accept any valid description.

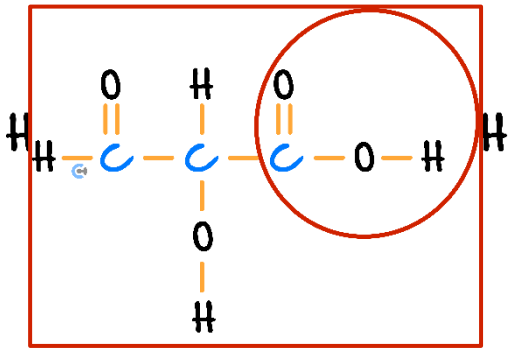
Section B: Supplementary Questions (58 Marks)

Sub-Section [2.7.1]: Apply IUPAC Conventions to Identify, Draw & Write IUPAC Names of Straight-Chained & Branched Carboxylic Acids

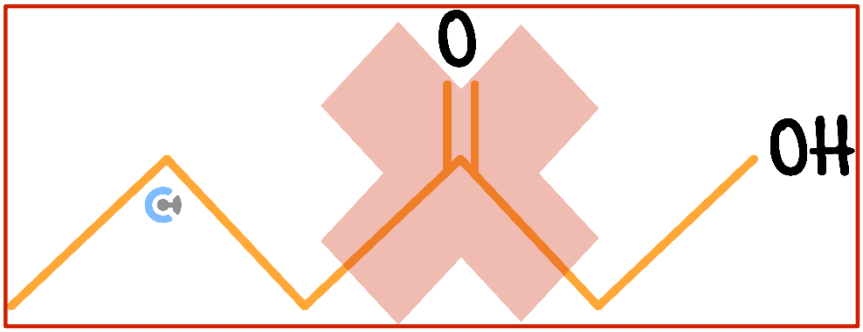
Question 11 (6 marks)

a. Identify the carboxyl group in each of the organic compounds below. If there is no carboxyl group present, draw an 'X' through the compound.

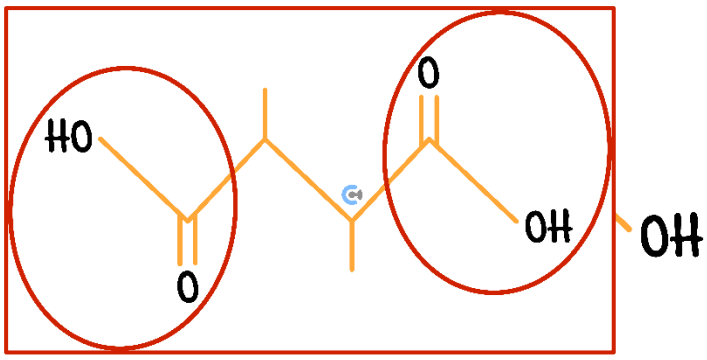
i. (1 mark)



ii. (1 mark)



iii. (1 mark)

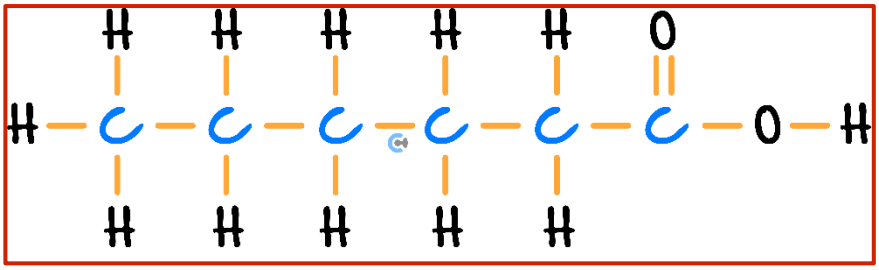


b. Complete the following:

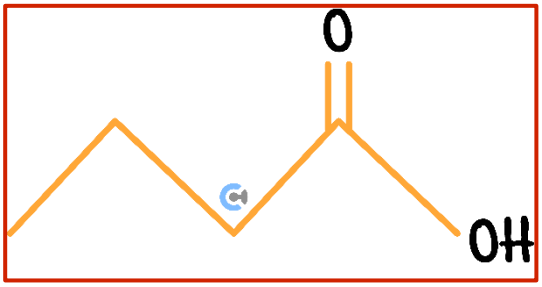
i. Draw the semi-structural formula for ethanoic acid. (1 mark)

CH_3COOH

ii. Draw the structural formula of hexanoic acid. (1 mark)



iii. Draw the skeletal structure of butanoic acid. (1 mark)



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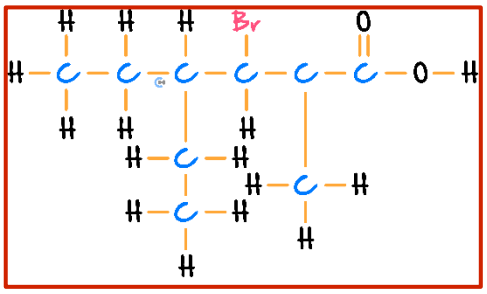
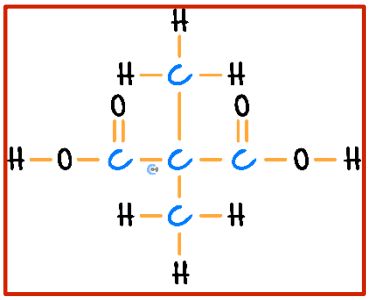
Question 12 (9 marks)

a. Draw the structural formula for each of the organic compounds below.

i. 3-bromo-4-ethyl-2-methylhexanoic acid. (1 mark)

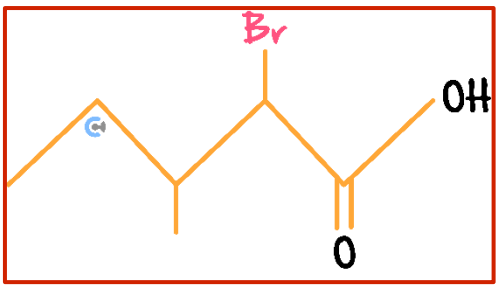


ii. 2,2-dimethylpropanedioic acid. (1 mark)

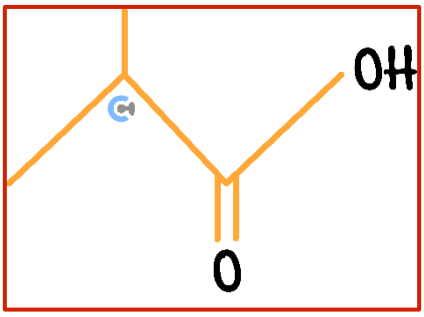


b. Draw the skeletal structure for each of the organic compounds below.

i. 2-bromo-3-methylpentanoic acid. (1 mark)



ii. 2-methylpropanoic acid. (1 mark)



c. Draw the semi-structural formula for each of the organic compounds below.

i. 2-methylbutanoic acid. (1 mark)

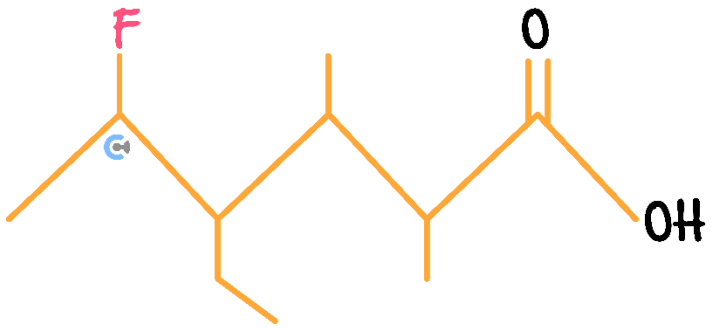
$C_3CH_2CH(CH_3)COOH$

ii. 3-ethyl-4-iodopentanoic acid. (1 mark)

$CH_3CHICH(CH_2CH_3)CH_2COOH$

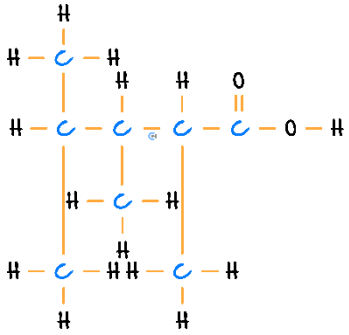
d. Name the following organic compounds:

i. (1 mark)



4-ethyl-5-fluro-2,3-dimethylhexanoic acid

ii. (1 mark)



2,3,4-trimethylpentanoic acid

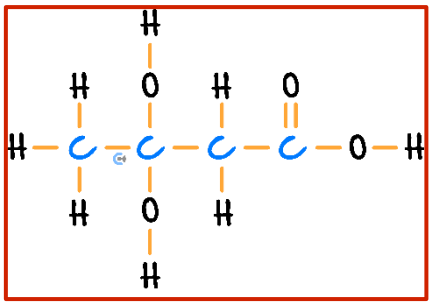
iii. HCOOH. (1 mark)

Methanoic acid

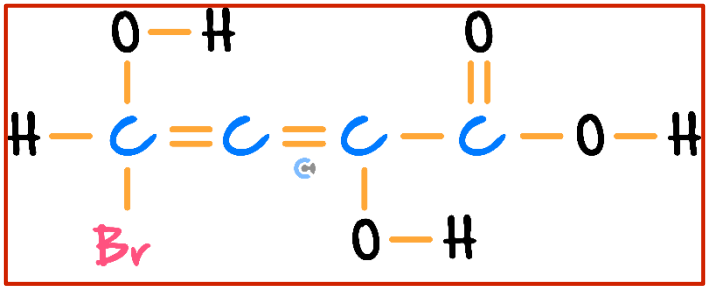
Question 13 (9 marks)

a. Draw the structural formula for each of the organic compounds below.

i. 3,3-dihydroxybutanoic acid. (1 mark)

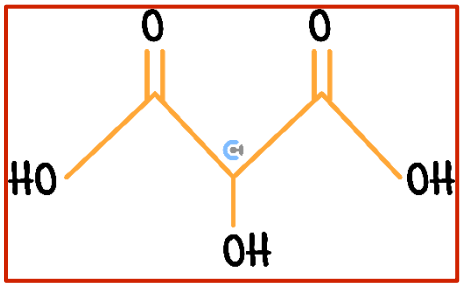


ii. 4-bromo-2,4-dihydroxybuta-2,3-enoic acid. (1 mark)

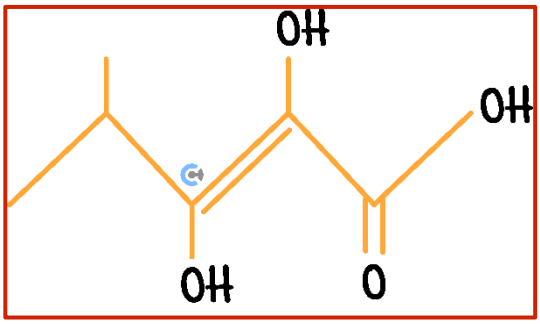


b. Draw the skeletal structure for each of the organic compounds below.

i. 2-hydroxypropanedioic acid. (1 mark)



ii. 2-3-dihydroxy-4-methylpent-2-enoic acid. (1 mark)



c. Draw the semi-structural formula for each of the organic compounds below.

i. But-3-enoic acid. (1 mark)

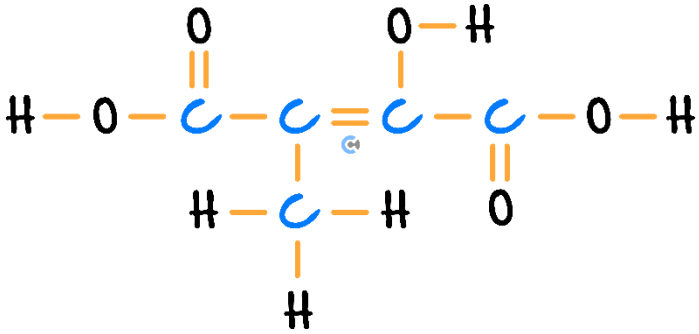
CH_2CHCH_2COOH

ii. 2,2,3,3-tetrahydroxybutanedioic acid. (1 mark)

$HOOCC(OH)_2C(OH)_2COOH$

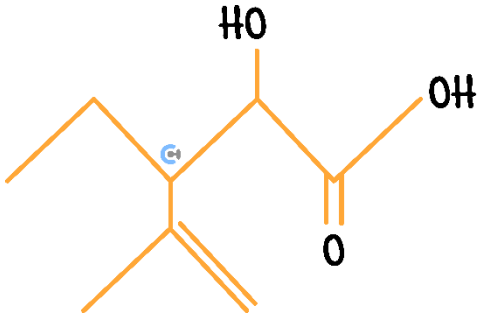
d. Name the following organic compounds.

i. (1 mark)



2-hydroxy-3-methylbut-2-enedioic acid

ii. (1 mark)



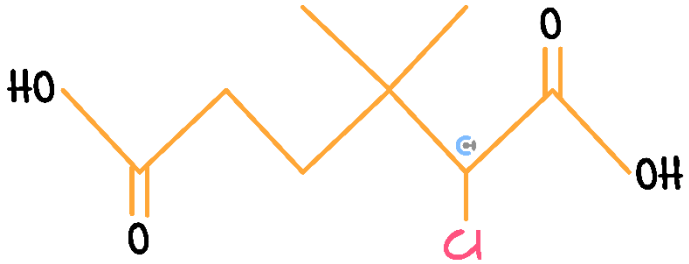
3-ethyl-2-hydroxy-4-methylpent-4-enoic acid

iii. $CH_2CH\big(CH(OH)\big)_3COOH$. (1 mark)

2,3,4-trihydroxyhex-5-enoic acid

Question 14 (3 marks)

Elijah is studying an organic compound. The compound is shown below.



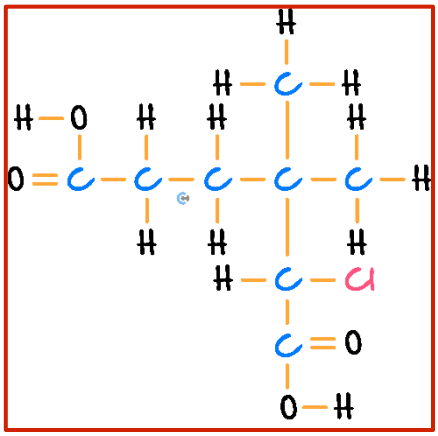
a. Draw the semi-structural formula for this organic compound. (1 mark)

$HOOCCH_2CH_2C(CH_3)_2CHClCOOH$

b. State the IUPAC name for this compound. (1 mark)

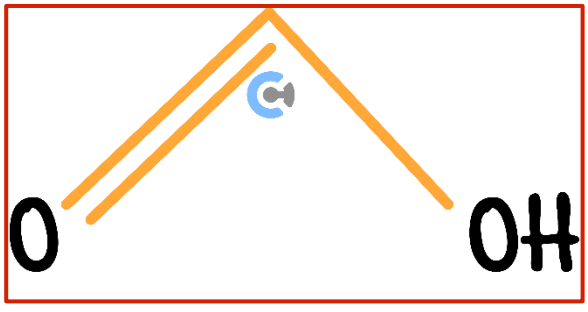
2-chloro-3,3-dimethylhexanedioic acid

c. Draw the structural formula for this organic compound. (1 mark)



Question 15 (1 mark)

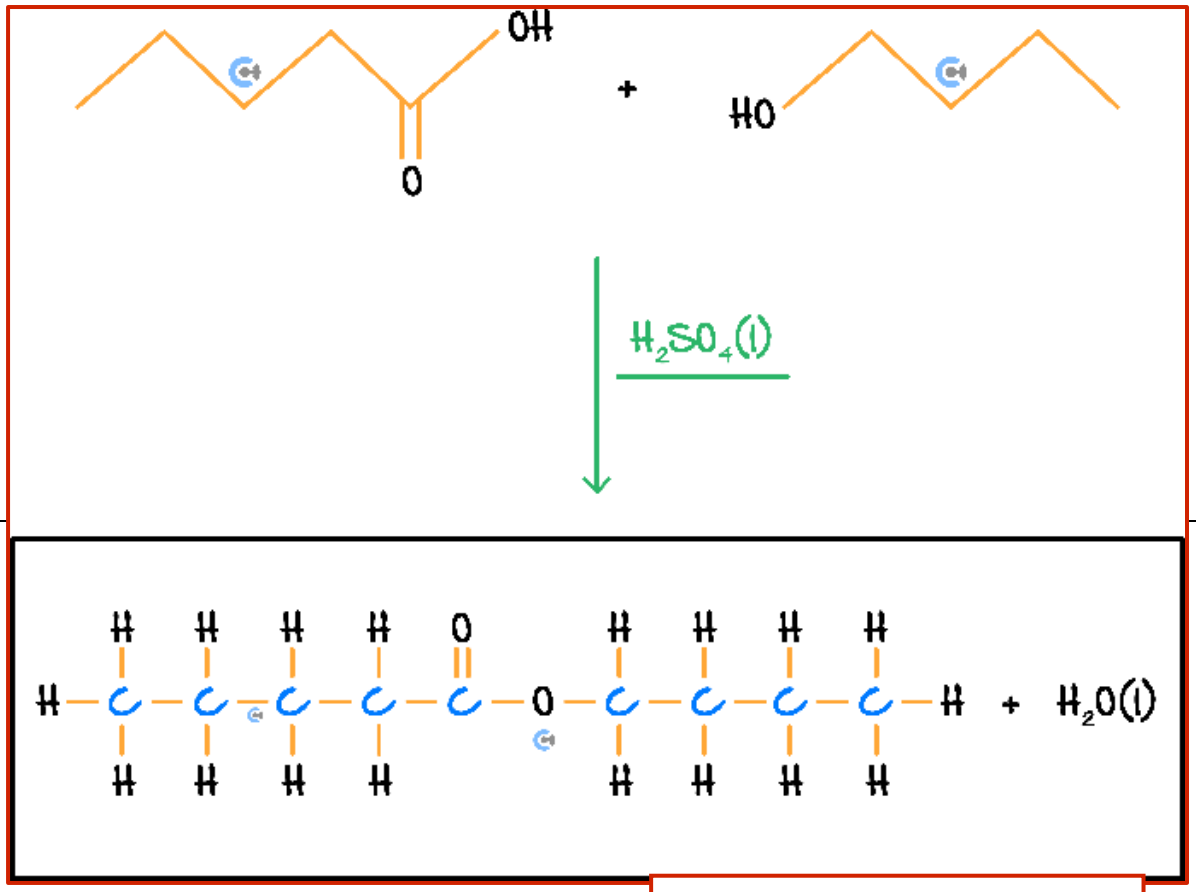
Draw the skeletal structure for methanoic acid.



Sub-Section [2.7.2]: Write Condensation Reactions for the Formation of Esters & Relevant Catalysts/Conditions

Question 16 (3 marks)

Complete the reaction below using the structural formula for all organic compounds. States are not required for organic compounds.



(1) Correct ester
(1) Water with correct state
(1) Correct catalyst with correct state

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Question 17 (4 marks)

a. Complete the esterification word equation below. States are not required. (2 marks)

Carboxylic acid + Alcohol $\xrightarrow{\text{catalyst}}$ Ester + Water/H_2O

(1) Carboxylic Acid and Water
(1) Ester

b. State the type of reaction in **part a.** (1 mark)

Condensation reaction (1)

c. State a suitable catalyst for this reaction. (1 mark)

$H_2SO_4(l)$ or Concentrated H_2SO_4 (1)

Question 18 (5 marks)

a. Complete the reaction below using the semi-structural formula for any organic compounds. States are not required for organic compounds. (2 marks)

$$CH_3CH_2CH_2CH_2COOH + CH_3CH_2CH_2OH \xrightarrow{H_2SO_4(l)} CH_3CH_2CH_2CH_2COOCH_2CH_2CH_3 + H_2O(l)$$

(1) Correct acid.
(2) Correct alcohol.

b. Explain why the reaction above is called a 'condensation' reaction. (1 mark)

The reaction removes water from the reactants to create a bigger compound (1).
The removal of water makes this a condensation reaction.

c. State the function of H_2SO_4 in terms of esterification reactions. (1 mark)

H_2SO_4 is a catalyst (1)

d. Name the ester formed in **part a.** (1 mark)

Propyl pentanoate (1)

Question 19 (5 marks) **Extension.**

The reaction combining an alcohol and an acid to form an ester is known as a 'condensation' reaction and is reversible under the correct conditions. The reverse reaction separates an ester into an alcohol and an acid by adding water to the ester. This reaction is known as a 'hydrolysis' reaction.

a. Complete the hydrolysis reaction below using your knowledge of esterification reactions. States are not required. (2 marks)

$$CH_3CH_2CH_2CH_2COOCH_2CH_2CH_2CH_2CH_3 + H_2O(l) \xrightarrow{H_2SO_4(aq)} CH_3CH_2CH_2CH_2COOH + CH_3CH_2CH_2CH_2CH_2OH$$

(1) Correct acid
(2) Correct alcohol

b. Explain why this reaction is called a 'hydrolysis' reaction. (1 mark)

This reaction splits esters into an alcohol and an acid using water. The word hydrolysis has components 'hydro', meaning water, and 'lysis', meaning to break apart (1).

c. State the purpose of H_2SO_4 in this reaction. (1 mark)

H_2SO_4 is a catalyst (1).

d. State the IUPAC name of the ester being hydrolysed. (1 mark)

Pentyl pentanoate (1)

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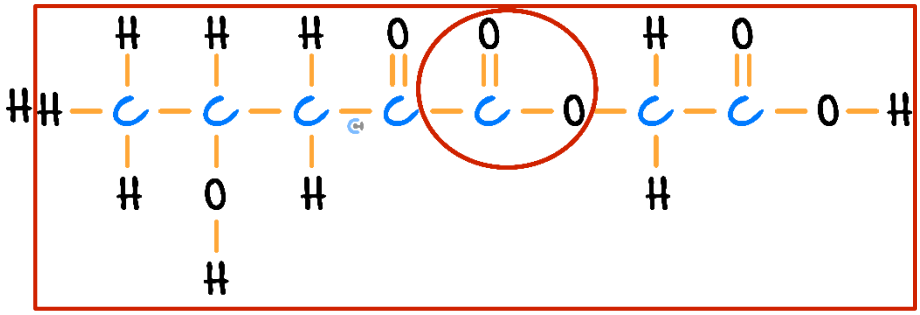
Sub-Section [2.7.3]: Apply IUPAC Conventions to Identify, Draw & Write IUPAC Names of Straight-Chained Esters

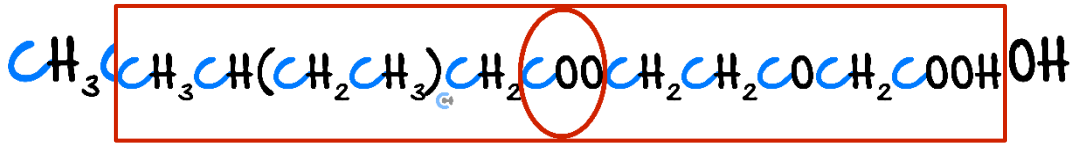
Question 20 (3 marks)

Circle the ester group in each of the following organic compounds.

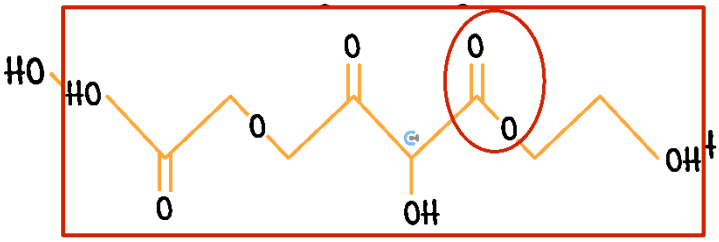
a. (1 mark)



b. (1 mark)



c. (1 mark)



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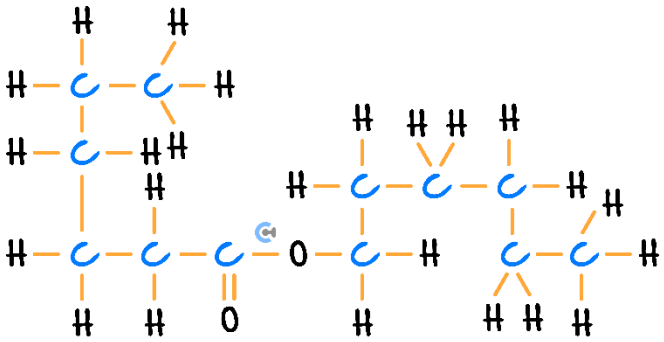
Question 21 (4 marks)

Identify the carboxylic acid and the alcohol that are reacted to form the following esters.

a. (1 mark)



Hexanoic acid – Hexanol

b. $CH_3CH_2CH_2CH_2CH_2COOCH_3$. (1 mark)

Hexanoic acid - Methanol

c. (1 mark)

Methanoic acid - Heptanol

d. Propyl pentanoate. (1 mark)

Pentanoic acid - Propanol

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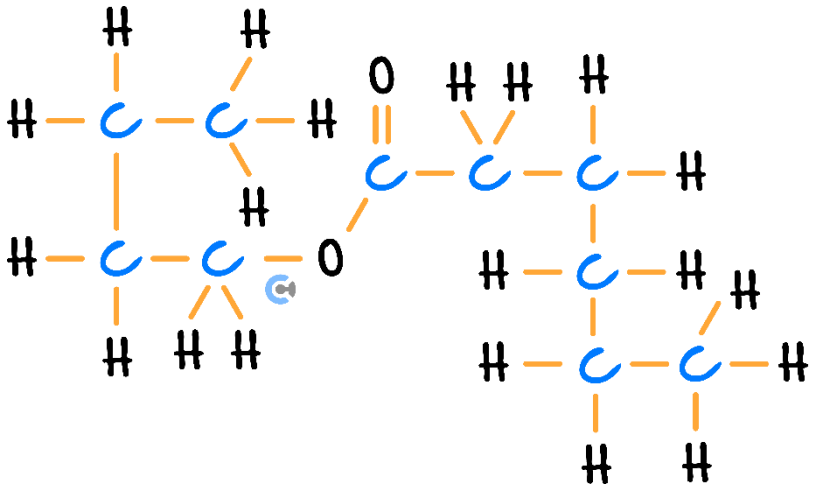
Question 22 (3 marks)

State the IUPAC names for the following organic compounds.

a. (1 mark)



Butyl hexanoate

b. $CH_3CH_2CH_2OCOCH_2CH_2CH_2CH_3$. (1 mark)

Propyl pentanoate

c. (1 mark)

Heptyl methanoate

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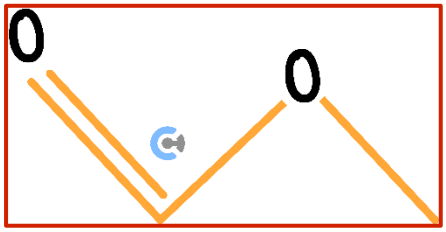
Question 23 (3 marks)

Methyl methanoate is also known as methyl formate. It is a colourless liquid and has an ethereal odour.

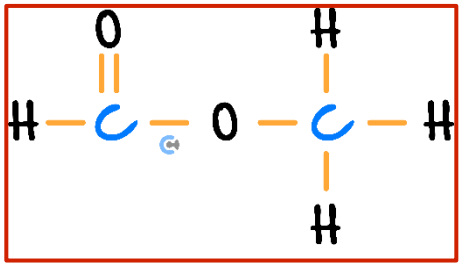
a. Draw the skeletal structure of methyl methanoate. (1 mark)



b. Draw the semi-structural formula for methyl methanoate. (1 mark)

$HCOOCH_3$

c. Draw the structural formula for methyl methanoate. (1 mark)



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