Higher Chemistry: Unit 2 – Nature's Chemistry

Part B – Alcohols, Oxidation and Esters

Lesson 4 – Reactions of carboxylic acids and antioxidants

Learning Outcomes

By the end of this lesson you should know:

1. How to name and draw the products of common reactions of carboxylic acids
2. What is meant by the term antioxidants
3. How to identify antioxidants

Success Criteria

You will have been successful in this lesson if you:

1. Read and learn the notes given
2. Watch the links provided
3. Complete revision questions provided
4. Complete and submit the homework assigned by your class teacher.
5. EXTENSION: There is also a further reading section to help you gain more depth of understanding for this section.

If you have any questions about the content of this lesson, you should ask your class teacher either through your class MS team or via email. The teams will be monitored through the week and someone will get back to you as soon as they can.

Links to Prior Knowledge

You may wish to revise the following to help you understand this lesson:

- National 5 chemistry – alcohols and carboxylic acids

You may wish to have a copy of the data booklet handy for this lesson. Download or print a copy of the Higher Chemistry Data Booklet from MS Teams or the SQA website - https://www.sqa.org.uk/sqa/files_ccc/ChemistryDataBooklet_NewH_AH-Sep2016.pdf

Notes - Check your class notes - you may have already covered this in class. If so, you do not need to copy this lesson, as it is just a revision of what you covered in school. You may wish to add to your notes with the content below.

If you have not covered this in school, then you should either copy, print or save the notes below.

A full copy of these notes are available on the Higher Chemistry Teams site and you will receive a paper copy when we return to school.

Reactions of Carboxylic acids and Antioxidants

Click here for a 5 minute PowerPoint with voice recording from Ms Hastie for this lesson

Reactions of Carboxylic Acids

Like all acids, carboxylic acids react with bases in neutralisation reactions. When a carboxylic acid reacts, the hydrogen atom on the carboxyl group reacts with the base to form water and the remainder of the carboxylic acid becomes a negative ion. For example:

ethanoic acid + sodium hydroxide → sodium ethanoate + water

CH_3COOH + NaOH → $Na^+CH_3COO^-$ + H_2O

From National 5 you should know the following reactions of carboxylic acids. The name of the salt produced depends on the reactants:

1. **metal oxide + carboxylic acid → salt + water**

example: *calcium oxide + ethanoic acid → calcium ethanoate + water*

$CaO + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + H_2O$

2. **metal hydroxide + carboxylic acid → salt + water**

example: *sodium hydroxide + methanoic acid → sodium methanoate + water*

$NaOH + HCOOH \rightarrow NaHCOO + H_2O$

3. metal carbonate + a carboxylic acid → a salt + water + carbon dioxide

example:

potassium carbonate + propanoic acid → potassium propanoate + water + carbon dioxide

$K_2CO_3 + 2C_2H_5COOH \rightarrow 2KC_2H_5COO + H_2O + CO_2$

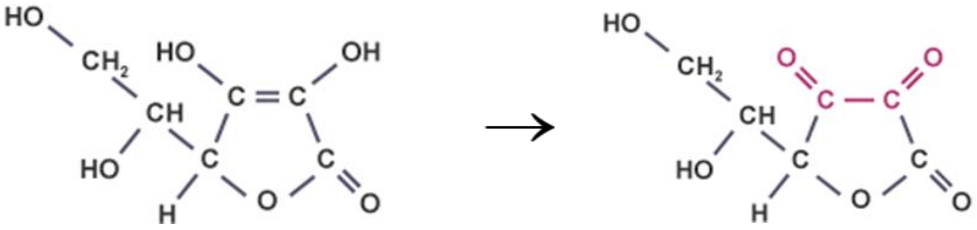
Antioxidants

Oxygen from the air causes oxidation of food. The oxidation of edible oils gives food a **rancid flavour**. **Antioxidants** are often added to food products to prevent oxidation.

Antioxidants are chemicals which prevent unwanted oxidation from occurring. Antioxidants readily undergo oxidation reactions, and will be oxidise instead of the substances in our food, thus protecting the other substance.

This is also useful in biological systems, where oxidation can cause damage of DNA and proteins, which can lead to cell damage, disease and cancer. Many of the antioxidants that protect against oxidation are found in fruit and vegetables, including Vitamins C & E. This is one of the reasons that fruits and vegetables are an important part of a healthy balanced diet.

Example: oxidation of vitamin C



Vitamin C

Ion-electron ½ equation for the oxidation of vitamin C:

$$C_6H_8O_6 \rightarrow C_6H_6O_6 + 2H^+ + 2e^-$$

The above equation can be described as an oxidation reaction because there is an increase in the oxygen to hydrogen ratio AND because the vitamin C is losing electrons.

WATCH - TWIG: the dark side of oxygen - https://www.twigscotland.com/film/the-dark-side-of-oxygen-986/

SUMMARY

1. Carboxylic acids take part in **neutralisation reactions** with**:**

   Metal oxides – to produce salt and water

   Metal hydroxides – to produce salt and water

   Metal carbonates – to produce slat, water and carbon dioxide

2. Antioxidants:
   - are molecules that **prevent unwanted oxidation** reactions occurring
   - are substances that are **easily oxidised**, and oxidise in place of the compounds they have been added to protect
   - can be identified as the **substance being oxidised in a redox equation**

Learning Outcomes

You should now know:

1. How to name and draw the products of common reactions of carboxylic acids
2. What is meant by the term antioxidants
3. How to identify antioxidants
4. The names of some common antioxidants

Further Reading

To learn more about carboxylic acids and antioxidants, try the following online resources:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zyq22hv/revision/3

Scholar: Log in through GLOW

Higher Chemistry → Nature's chemistry → Oxidation of food → read content 9.7-9.9

Evans2 chem web: https://www.evans2chemweb.co.uk/login/index.php#

Username: snhs password: giffnock

Select any teacher → revision material → CfE Higher → Unit 2: Nature's Chemistry → Oxidation of food

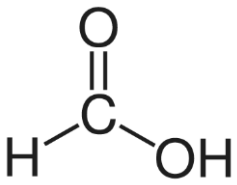
Check your understanding - Answers the questions below in you class jotter

2.7 Carboxylic Acids

1. For each of the carboxylic acids shown below,

(i) Name the acid
(ii) Write its shortened structural formula
(iii) Name the alcohol which would be oxidised to produce the acid.

a)



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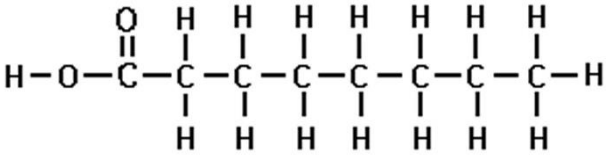

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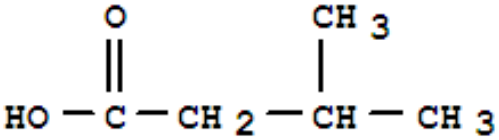

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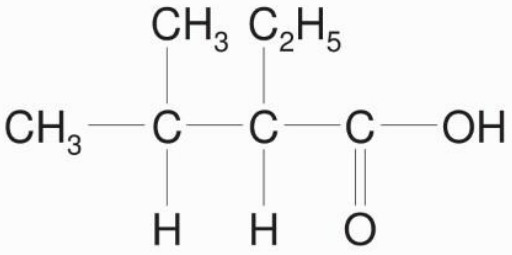


2. Name the products of the following reactions

a) Propanoic acid and sodium hydroxide
b) Hexanoic acid and calcium oxide
c) Ethanoic acid and copper(II) carbonate

3. Name the salts listed below.

a) $CH_3CH_2COO^-Li^+$ b) $CH_3COO^-K^+$

c) $(HCOO^-)_2Mg^{2+}$ d) $(CH_3CH_2CH_2CH_2COO^-)_3Al^{3+}$

4. Draw the full structural formula for the following salts:

a) Lithium ethanoate

b) Sodium butanoate

EXTENSION WORK

If you have already completed the above exercises in school, you should completed the following blue book questions:

Carboxylic acids Page 40 Q1-4

ANSWERS TO Ex 2.7 WILL BE POSTED ON WEDNESDAY FOR YOU TO CHECK YOUR OWN WORK

HOMEWORK

You should now complete "Homework 2 – Oxidation of alcohols" in your homework jotter, or the back of your class jotter if you don't have your homework jotter at home with you.

Take a picture of your homework answers and submitted them to your class teacher, through your class teacher by **1pm on Friday 22nd January.**

Your teacher will let you know how to submit this and will give you feedback on this homework.

If you have already completed this homework you should send a picture of the extension work above to your teacher.

A copy of the homework is on the next page.

Homework 2 – Oxidation of Alcohols

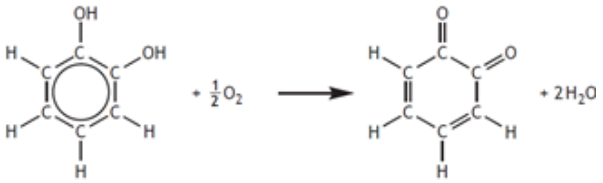
1. Compound X reacted with hot copper (II) oxide and the organic product did not give a colour change when heated with Fehling's solution. Compound X could be…

A Butan-1-ol
B Butan-2-ol
C Butanone
D Butanoic acid

2. Which of the following reactions can be classified as reduction?

A $CH_3CH_2OH \rightarrow CH_3COOH$
B $CH_3CH(OH)CH_3 \rightarrow CH_3COCH_3$
C $CH_3CH_2COCH_3 \rightarrow CH_3CH_2CH(OH)CH_3$
D $CH_3CH_2CHO \rightarrow CH_3CH_2COOH$

3. Enzymes are involved in the browning of cut fruit.
One reaction taking place is:



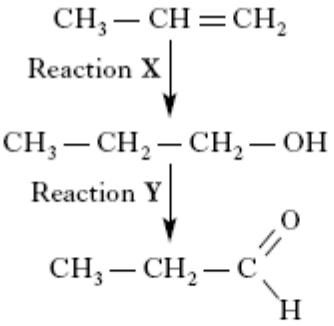
Which of the following correctly describes the above reaction?

A Oxidation
B Reduction
C Hydrolysis
D Condensation

4. A compound with molecular formula $C_6H_{12}O_2$, could be

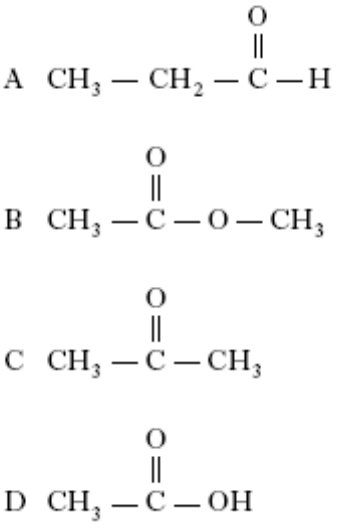
A hexanal
B hexan-2-ol
C hexan-2-one
D hexanoic acid

5. Which line in the table correctly describes reactions X and Y?



	Reaction X	Reaction Y
A	hydration	oxidation
B	hydration	reduction
C	hydrolysis	oxidation
D	hydrolysis	reduction

Questions **6, 7** and **8** refer to the structures below



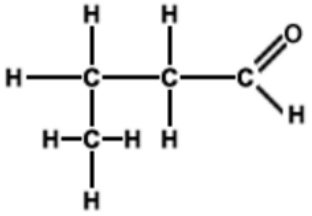
6. Which compound is an aldehyde?

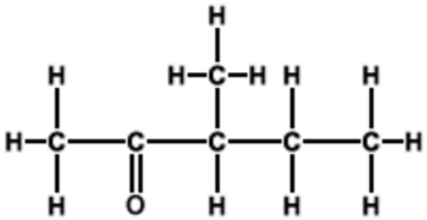
7. Which compound is an isomer of propanal?

8. Which compound would react with acidified potassium dichromate?

9. Give the full and shortened structural formulae for the following compounds.
(a) 2,4-dimethylpentan-3-one (1)
(b) 2,2,3-trimethylbutanal (1)
(c) 2-methylbutanoic acid (1)

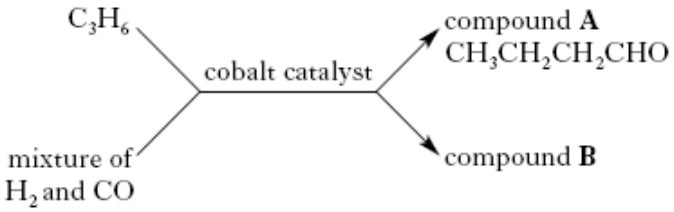
10. Name the following compounds.

(a) 

(b) 

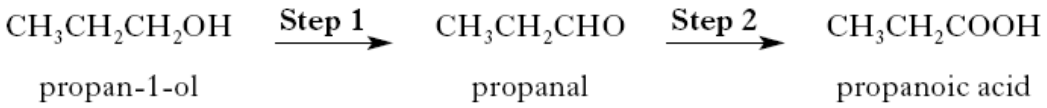
(2)

Using a cobalt catalyst, propene reacts with a mixture of hydrogen and carbon monoxide. The products are two isomeric aldehydes.



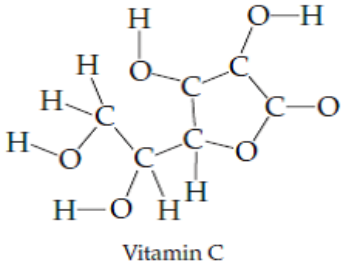
(a) Draw a structural formula for compound B. (1)
(b) (i) What would be observed if compound A was gently heated with Tollens' reagent? (1)
(ii) Suggest a safe method to heat the mixture? (1)
(c) Aldehydes can also be formed by the reaction of some alcohols with copper (II) oxide.
Name the type of alcohol that would react with copper (II) oxide to form an aldehyde? (1)

11. Below is an example of two oxidation reactions.



(a) Why can Step 1 be described as an oxidation reaction? (1)
(b) Acidified dichromate solution can be used to oxidise propanal in Step 2.
What colour change would be observed in this reaction? (1)

12. Oxidation reacts with oils in food, causing the food to spoil. Chemicals like vitamin C, prevent this reaction from taking place by undergoing oxidation themselves.


Vitamin C

Copy and complete the ion-electron equation for the oxidation of vitamin C:

$C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq)$

(1)

Total = 20