Higher Chemistry: Unit 2 – Nature's Chemistry

Part E – Soaps, Detergents and Emulsions

Lesson 1 – Soaps

Learning Outcomes

By the end of this lesson you should know:

1. How are soaps made
2. The basic structure of soaps
3. How soaps are able to clean

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 questions provided
4. EXTENSION: There is a further reading section to help you gain more depth of understanding for this section. There are also suggested questions for you to try from the blue book of revision questions.

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:

Higher chemistry – fats and oils

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 - you should either copy, print or save the notes below.

You will receive a paper copy of these notes when we return to school.

Soaps

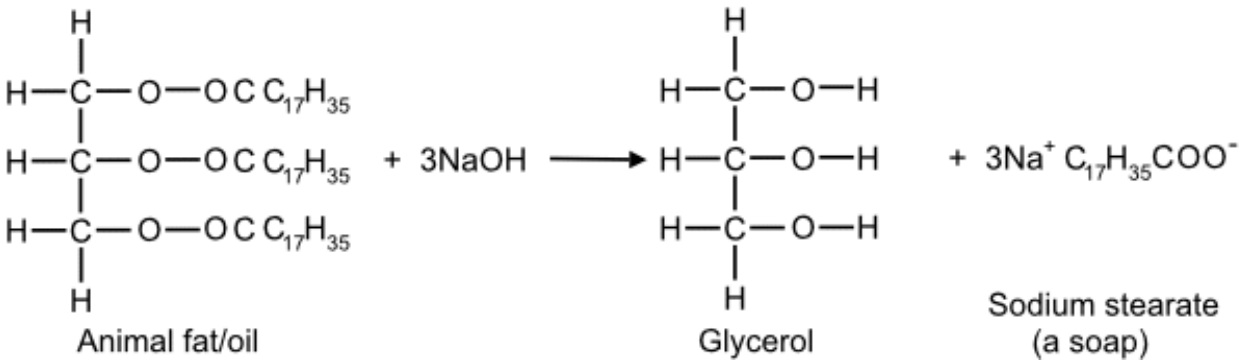
WATCH: Click on the link for a 5 minute recorded lesson:

PowerPoint with voice recording from Ms Hastie

Making Soaps

Soap is made by HEATING fats or oils with an alkali. This reaction is called **ALKALINE HYDROLYSIS** and is also known as **SAPONIFICATION**.

Example of alkaline hydrolysis:



The fat or oil is **HYDROLYSED** to glycerol and three fatty acids. The alkali reacts with the fatty acids in a **NEUTRALISATION** reaction to form a salt.

Example of a neutralisation reaction:

*stearic acid + sodium hydroxide → **sodium stearate** + water*

$$C_{17}H_{35}COOH + Na^+OH^- \rightarrow Na^+C_{17}H_{35}COO^- + H_2O$$

Soaps are **salts of fatty acids and alkalis**, such as sodium hydroxide or potassium hydroxide.

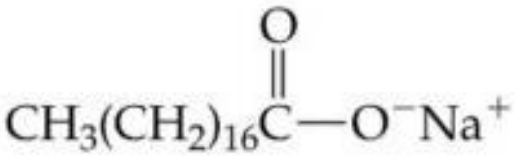
WATCH - (3 mins) You Tube - **How Ancient Palestinian Soap is made**

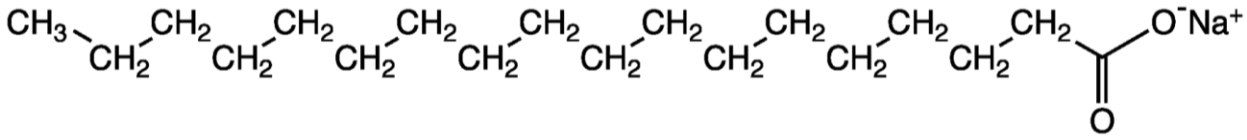
https://www.youtube.com/watch?v=X67helU71pk

Drawing Soap Structures

Because of their long hydrocarbon tail, chemists often abbreviate fatty acids to make it easier to draw them. For example, the structures below all represent sodium stearate:

$$Na^{+}C_{17}H_{35}COO^{-}$$





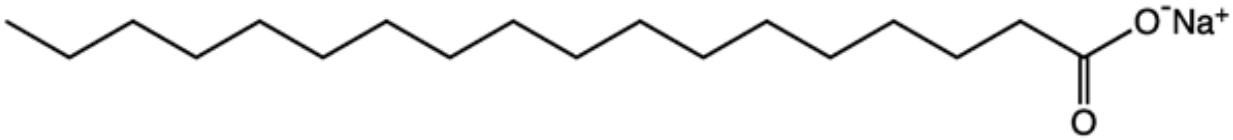
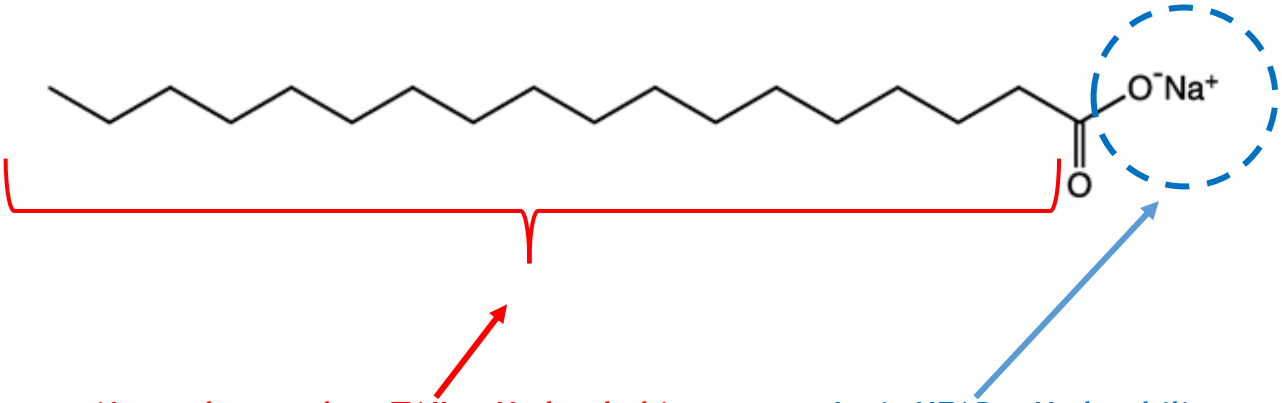


Image from: https://kids.kiddle.co/Sodium

Image from: https://rayeneh.com/sodium-stearate/

Structure of Soaps

A typical soap structure consists of a long fatty acid **'tail'** and an ionic **'head'.**



Non-polar covalent TAIL = Hydrophobic

oil soluble

The long hydrocarbon chain that has come from the fatty acid has a **non-polar covalent** structure and is described as **hydrophobic**, meaning is does not dissolve in water (hydrophobic means water 'hating' or 'scared' of water).

Hydrophobic structures will readily dissolve in other non-polar covalent substance such as oil and grease but will not dissolve in water.

Ionic HEAD = Hydrophilic

water soluble

The **ionic** head is described as **hydrophilic**, meaning it is able to dissolve in water (hydrophilic means water 'loving').

This end of the soap will only dissolve in water and will not dissolve in non-polar substances like oil or grease.

WATCH - (1 min)

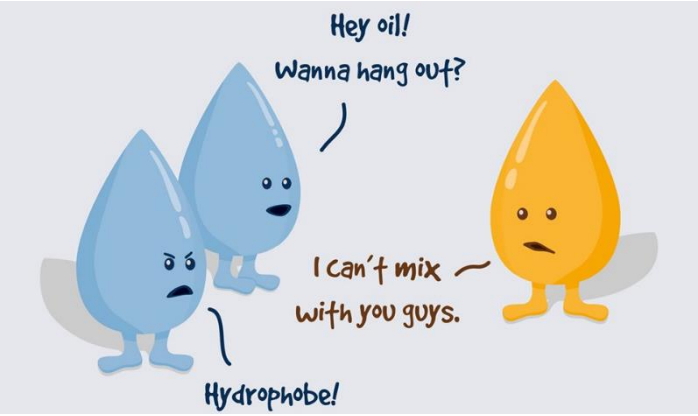
TWIG definition of **hydrophobic**

https://www.twigscotland.com/film/glossary/hydrophobic-419/

WATCH - (1 min)

TWIG definition of **hydrophilic**

https://www.twigscotland.com/film/glossary/hydrophilic-418/

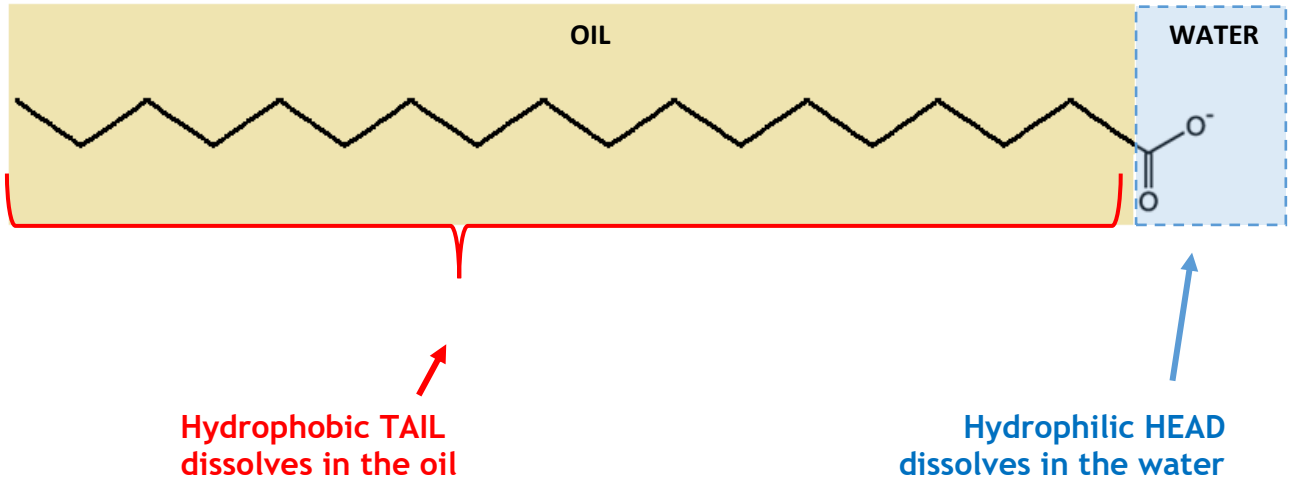


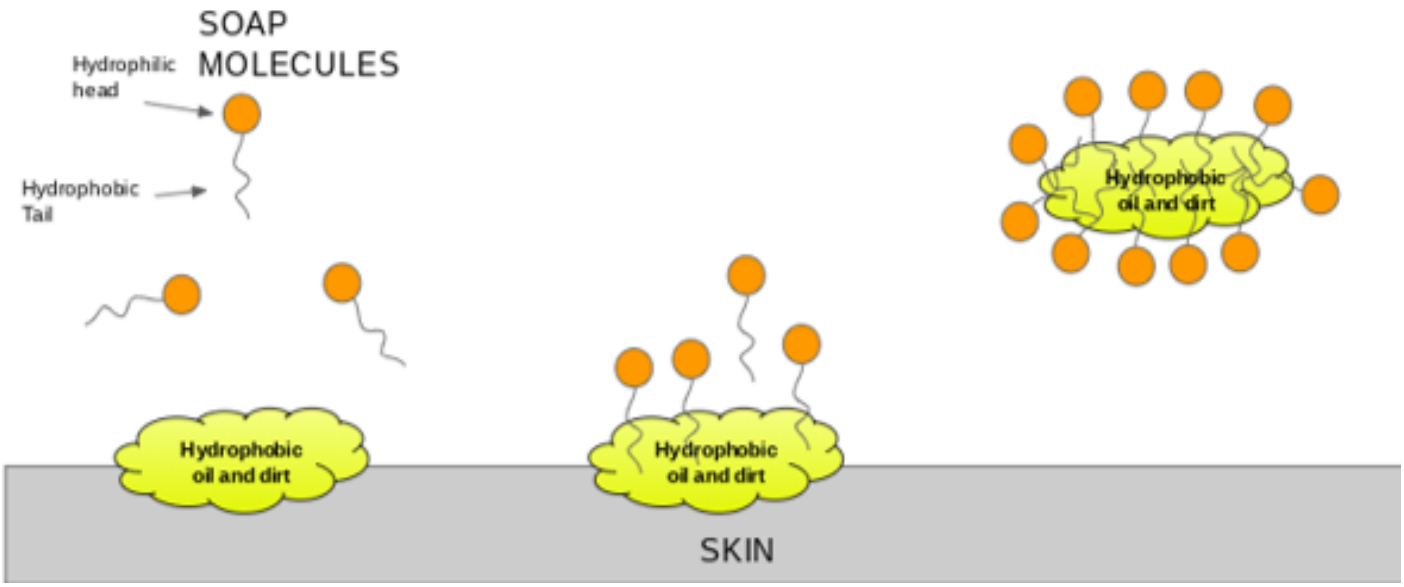
How Soaps Clean

When we wash our hands with soap and water, it is the hydrophobic and hydrophilic properties of the soap that removes non-polar substances such as grease and oil from our skin. Oil and grease are non-polar and water is polar, so without soap, they will not mix.

In the presence of polar and non-polar mixtures, the **hydrophobic tail dissolves in the non-polar oil or grease** and **the hydrophilic head remains in the surrounding water**.

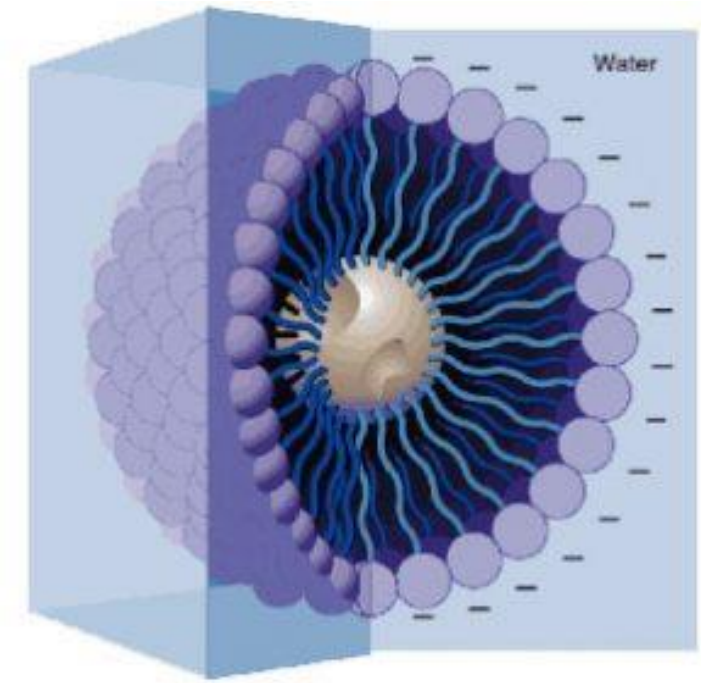
The positive sodium ion floats into the water, leaving a negatively charged head in the water.





Images from https://chembam.com/resources-for-students/the-chemistry-of/soap/

Agitation causes ball-like structures to form, called micelles.



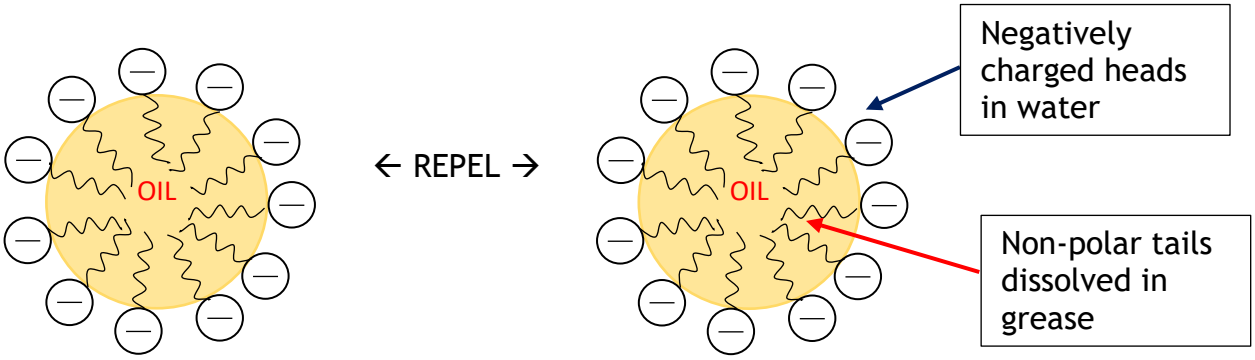
3D diagram of a micelle

Negatively charged heads in water

Non-polar tails dissolved in grease

Image from https://www.jrhessco.com/critical-micelle-concentration-measuring-surfactant-efficiency/

The negatively-charged ball-like structures repel each other and the oil or grease is kept suspended in the water.



When you rinse your hands, the **suspended micelles are washed away with the water**.

WATCH - (6 mins) YouTube - **How does Soap Work?**
https://youtu.be/wTuRmwSkuzQ

SUMMARY

Soaps

1. Soaps are produced by the alkaline hydrolysis of edible fats and edible oils.
2. Hydrolysis produces three fatty acid molecules and one glycerol molecule.
3. The fatty acid molecules are neutralised by the alkali, forming water-soluble, ionic salts called soaps.
4. Soaps can be used to remove non-polar substances such as oil and grease.
5. Soap ions have long non-polar tails, readily soluble in non-polar compounds (hydrophobic), and ionic heads that are water-soluble (hydrophilic).
6. The hydrophobic tails dissolve in the oil or grease.
7. The negatively-charged hydrophilic heads remain in the surrounding water.
8. Agitation causes ball-like structures to form.
9. The negatively-charged ball-like structures repel each other and the oil or grease is kept suspended in the water.

Learning Outcomes

You should now know:

1. How are soaps made
2. The basic structure of soaps
3. How soaps are able to clean

Further Reading

To learn more about proteins, try the following online resources:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zg6hhyc/revision/1

Read page 1

Scholar: Log in through GLOW

Higher Chemistry → Nature's chemistry → 7. Proteins

Read through the exercises 6.1-6.3

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 → Soaps, detergents and emulsions

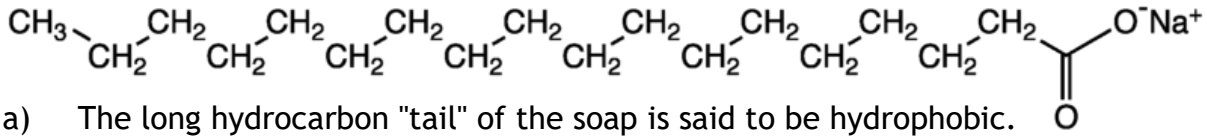
Check your understanding – Answers the questions below in you class jotter

2.17 Soaps and Emulsions (Part 1)

1. Soaps are salts that can be produced from the reaction of fats and edible oil with sodium hydroxide solution.

a) Name the reaction used to make soaps from fats and oils.
b) When fats and oils are turned into soap what other organic compound is produced?

2. The structure of a soap is shown below:



a) The long hydrocarbon "tail" of the soap is said to be hydrophobic.
   (i) Explain what is meant by *hydrophobic*.
   (ii) Explain in terms of bonding why the tail is hydrophobic.

b) The ionic "head" of the soap is said to be hydrophilic.

   (i) Explain what is meant by *hydrophilic*.
   (ii) Explain, in terms of bonding why the head is hydrophilic.

3. Soaps allow oil to mix with water, **explain fully** the cleaning action of soap.

ANSWERS TO EXERCISES WILL BE POSTED ON WEDNESDAY FOR YOU TO CHECK YOUR WORK

EXTENSION WORK

Use the online learning link above if you would like to extend your knowledge of soaps. For more practise questions for proteins, use your Revision Questions for Higher Chemistry "Blue book"

Miscellaneous Reactions page 57 Q1-4