Higher Chemistry: Unit 2 – Nature's Chemistry

Part E – Soaps, Detergents and Emulsions

Lesson 2 – Detergents and Emulsions

Learning Outcomes

By the end of this lesson you should know:

1. What is a detergent and how are they different to soaps
2. What is meant by the term 'hard' water
3. What is meant by the terms 'emulsion' and 'emulsifier'
4. How emulsifiers are made and how they work

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.

5. HOMEWORK: Details of this week's homework are at the end of this lesson

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 AND Soaps

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.

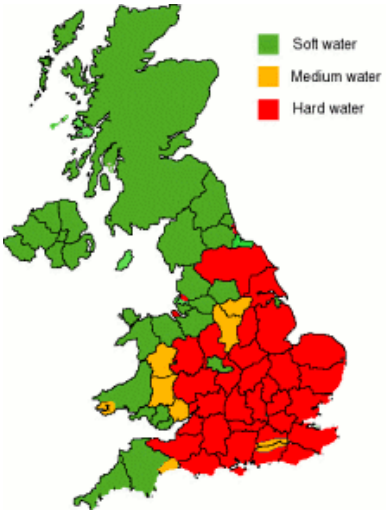
Detergents and Emulsions

WATCH: Click the link for a 7 minute recorded lesson:

PowerPoint with voice recording from Ms Hastie

Hard Water

Hard water is a term used to describe water containing high levels of dissolved metal ions. For example calcium and magnesium ions.



When soap is used in hard water it can form an insoluble precipitate called 'scum', instead of a lather.

The scum that forms reduces the effectiveness of the soap to clean.

Many parts of the UK have hard water. In Scotland, our water is mainly soft water. Soft water contains different ions, which don't tend to produce a precipitate when mixed with water.

WATCH - (3 mins)

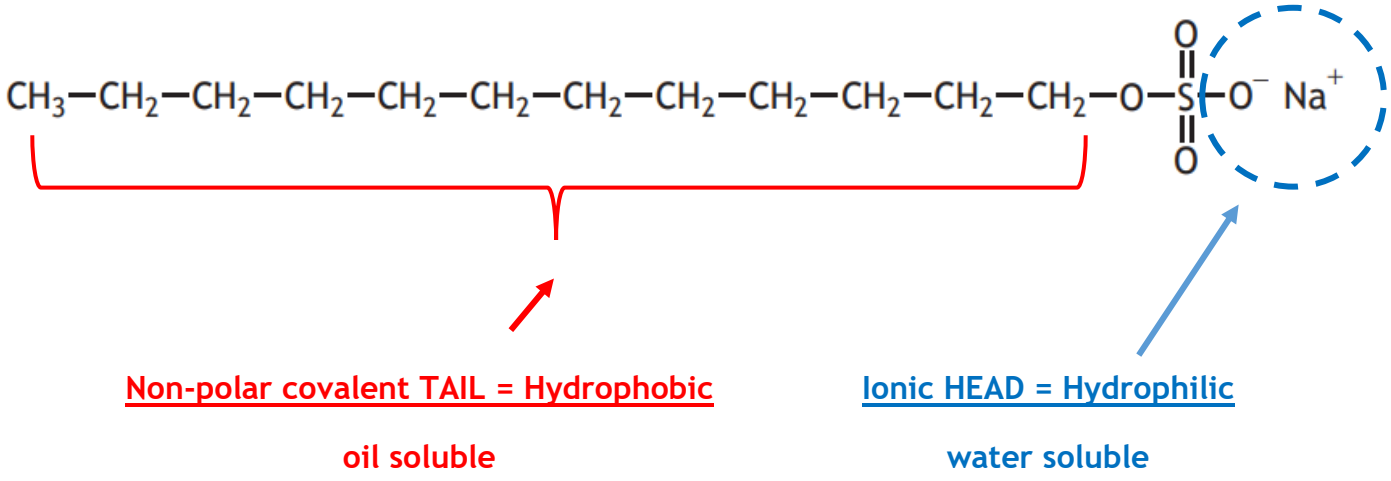
TWIG - **Hard and Sort Water** https://www.twigscotland.com/film/hard-and-soft-water-1424/

Soapless Detergents

To overcome the problem with scum in hard water areas, it is best to use **soapless detergents** which will not form a scum.

Detergents are similar to soaps in that they have a **hydrophilic head** that dissolves in water and a **hydrophobic tail** that dissolves in grease or oil.

A typical detergent is sodium lauryl sulfate, $CH_3(CH_2)_{11}SO^-_3\ Na^+$



Detergents remove grease and oil in the same way as soaps.

WATCH - (2 mins) YouTube - how soaps and detergents work - Surfactant is another word for molecules like soaps and detergents https://youtu.be/F7-ie4uWX04

From this useful website https://www.cleaninginstitute.org/understanding-products/science-soap/chemistry-cleaning

WATCH - (6 mins) YouTube - Ted Ed Which is better: Soap or hand sanitizer? **https://www.youtube.com/watch?v=x7KKkElpyKQ**

TASK - Try this at home

1. Add a teaspoon of oil to a glass or clear plastic cup.
2. Add some water
3. Observe that the two liquids don't mix (they are immiscible)
4. Using the spoon, mix the two liquids together to try make them dissolve in each other.
5. Put the cup aside for some time and you will see the two liquids separate out after a while.
6. Now add some washing up liquid and try again.

What do you notice this time?

Emulsions

Oil and water don't mix because oil is made of non-polar covalent molecules and water is water of polar covalent molecules. They are **immiscible**, which means they don't dissolve in one another.

It is only when you add detergent that you can get them to combine. The soapy mixture can be referred to as an **emulsion** because it is contains small droplets of one liquid dispersed in another liquid. The detergent is allowing the two liquids to mix without separating. It is acting as an **emulsifier**.

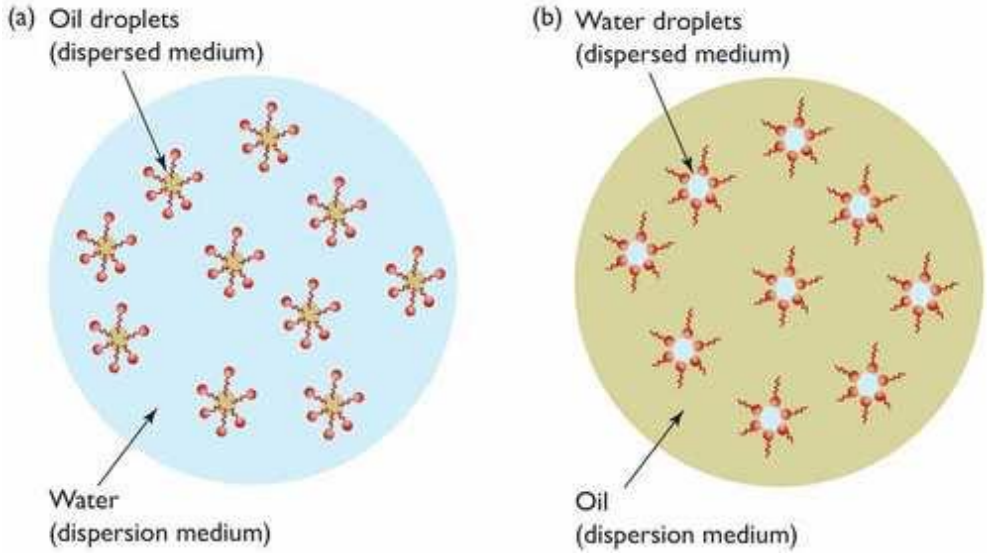


Image from https://nsb.wikidot.com/c-9-5-5-4

WATCH - (1 min) TWIG - **Emulsion**

https://www.twigscotland.com/film/glossary/emulsion-8344/

Emulsifiers

An **emulsifier** is used to prevent non-polar and polar liquids separating into layers.

Emulsifiers are commonly used in food products when polar and non-polar substances have to mix together to make the final product. Foods that contain emulsifiers include mayonnaise, ketchup, chocolate and custard.

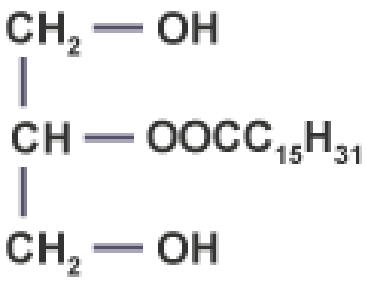
WATCH - (2 mins) You Tube - **Breaking Bad emulsion experiment**

https://www.youtube.com/watch?v=m_KXbRqGJ7M

Making Emulsifiers

Emulsifiers for use in food can be made **by reacting edible oils with glycerol.**

In the molecules formed, only **one or two fatty acid groups** are linked to each glycerol backbone. (Instead of the usual three).



monoglyceride

(2 x –OH groups remaining)

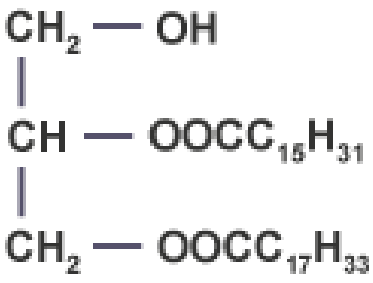


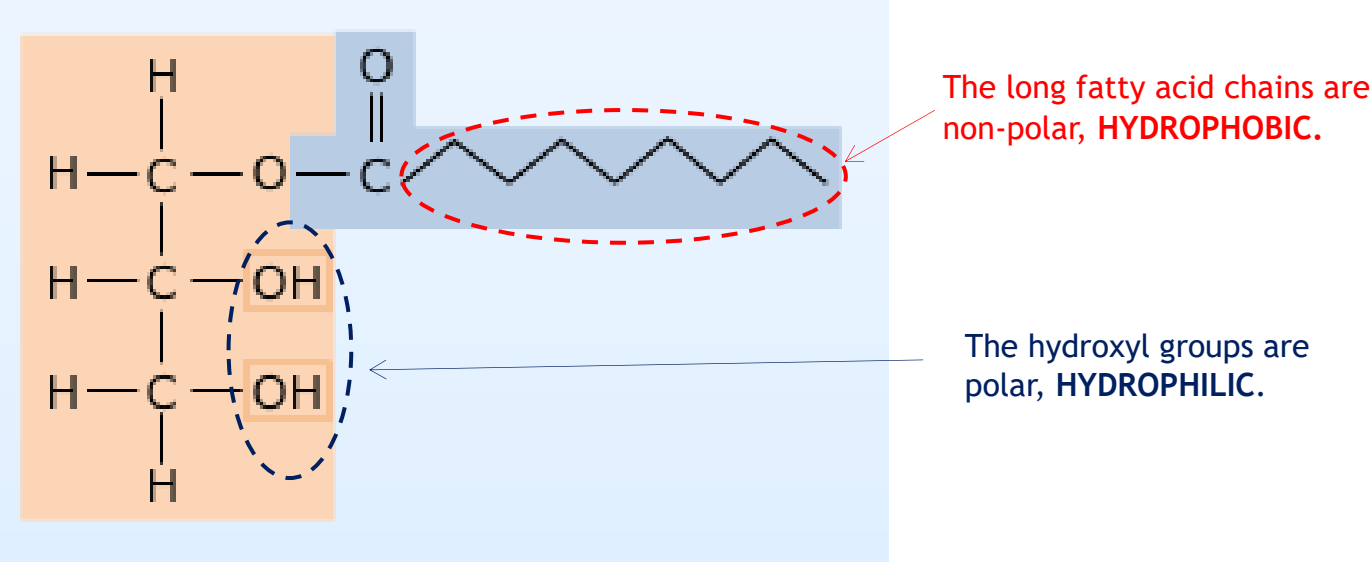
image from BBC bitesize

diglyercide

(1 x –OH group remaining)

How Emulsifiers Work

The hydroxyl groups present in the emulsifier are **hydrophilic** whilst **the fatty acid chains are hydrophobic.**



In this way, the emulsifier acts like a soap or detergent. The hydrophobic fatty acid chains dissolve in oil whilst the hydrophilic hydroxyl groups dissolve in water, forming a stable emulsion.

WATCH - (4 mins) YouTube - **What is an Emulsion**

https://www.youtube.com/watch?v=mBvKar6t1LY

TASK - Make your own mayonnaise

If you are interested in some kitchen chemistry follow the link below for a simple mayonnaise recipe. Enjoy!

https://www.bbcgoodfood.com/recipes/basic-mayonnaise

SUMMARY

Detergents and Emulsions

1. Hard water is a term used to describe water containing high levels of dissolved metal ions.
2. When soap is used in hard water, scum, an insoluble precipitate, is formed.
3. Soapless detergents are substances with non-polar hydrophobic tails and ionic hydrophilic heads.
4. These remove oil and grease in the same way as soap. Soapless detergents do not form scum with hard water.
5. An emulsifier can be used to prevent non-polar and polar liquids separating into layers.
6. An emulsion contains small droplets of one liquid dispersed in another liquid.
7. Emulsifiers for use in food can be made by reacting edible oils with glycerol. In the molecules formed, only one or two fatty acid groups are linked to each glycerol backbone.
8. The hydroxyl groups present in the emulsifier are hydrophilic whilst the fatty acid chains are hydrophobic.
9. The hydrophobic fatty acid chains dissolve in oil whilst the hydrophilic hydroxyl groups dissolve in water, forming a stable emulsion.

Learning Outcomes

You should now know:

1. What is a detergent and how are they different to soaps
2. What is meant by the term 'hard' water
3. What is meant by the terms 'emulsion' and 'emulsifier'
4. How emulsifiers are made and how they work

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 2

Scholar: Log in through GLOW

Higher Chemistry → Nature's chemistry → 7. Proteins

*Read through the exercises 6.4-6.7 and **TRY THE END UNIT TEST***

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

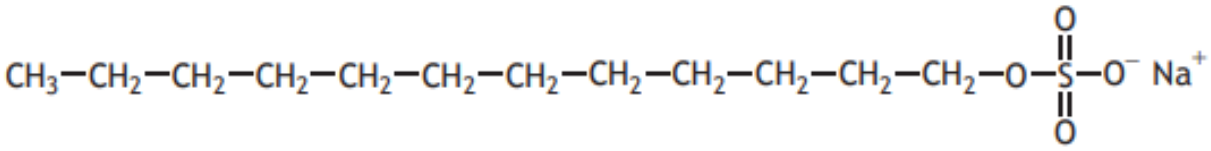
Username: snhs password: giffnock

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 2)

4. Chemists have developed soapless detergents:



They are used in areas of the UK that have "hard water"

a) What is hard water?

b) Why are these detergents used instead of soap?

5. Olive oil and wine vinegar(ethanoic acid) do not normally mix. If an **emulsifier** such as mustard is added, the oil and vinegar will form an **emulsion**.

a) **Explain fully** why olive oil and ethanoic acid don't mix?

b) Define the terms, emulsifier and emulsion.

c) What substances react to produce emulsifiers?

d) Emulsifiers and soaps have similar tail and head structures. State the type of bonding in the tails and heads of each substance.

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 detergents and emulsions. For more practise questions for proteins, use your Revision Questions for Higher Chemistry "Blue book"

Miscellaneous Reactions page 57 Q1-4

HOMEWORK

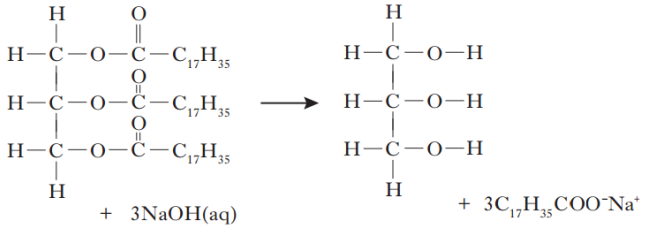
You should now complete "**Homework 5 – Soaps, Detergents and Emulsions**" in your homework jotter, or the back of your class jotter if you don't have your homework jotter at home with you.

Take a picture of your homework answers and submitted them to your class teacher by **1pm on Friday 19th February.** Your teacher will let you know how to submit this and will give you feedback on this homework.

A copy of the homework is on the next pages.

Homework 5 – Soaps, Detergents and Emulsions

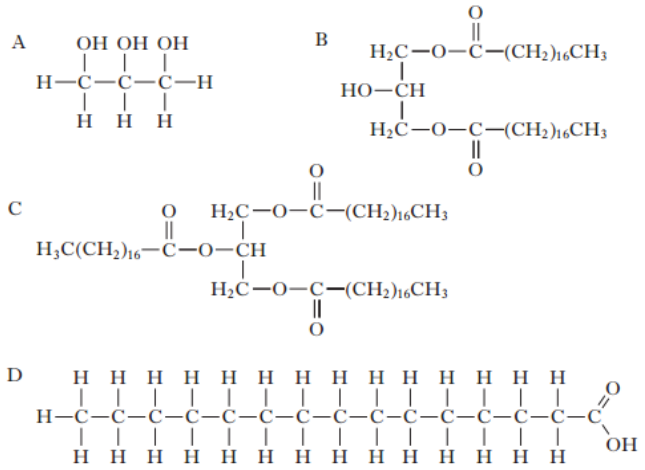
1. Soaps are produced by the following reaction.



This reaction is an example of

A condensation
B esterification
C hydrolysis
D oxidation

2. Which of the following could act as an emulsifier?



3. When ethanoic acid reacts with sodium hydroxide the products are

A sodium ethanoate and water
B sodium ethanoate and hydrogen
C sodium ethanoate and carbon dioxide
D sodium ethanoate, carbon dioxide and water.

4. Which of the following is the salt of a long-chain fatty acid?

A Fat
B Oil
C Soap
D Glycerol

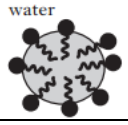
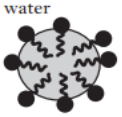
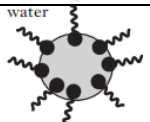
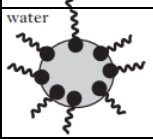
5. Substances added to foodstuffs to prevent separation of oil and water components are known as

A fatty acids
B emulsifiers
C free radicals
D antioxidants.

6. Emulsifiers for use in food are commonly made by reacting edible oils with

A esters
B glycerol
C fatty acids
D amino acids.

7. Which of the following diagrams and explanations best describes a step in the cleansing action of soap?

	Diagram	***Explanation***
A		Hydrophobic head dissolves in water. Hydrophilic tail dissolves in oil droplet.
B		Hydrophilic head dissolves in water. Hydrophobic tail dissolves in oil droplet.
C		Hydrophobic head dissolves in oil droplet. Hydrophilic tail dissolves in water.
D		Hydrophilic head dissolves in oil droplet. Hydrophobic tail dissolves in water.

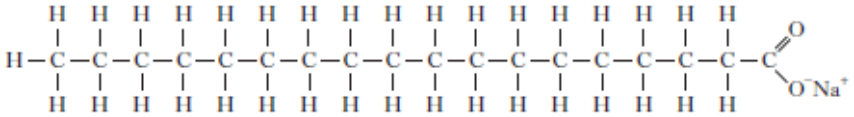
8. In which line of the table are fat, protein and soap correctly classified?

	Amides	**Salts**	**Esters**
A	*Fat*	*Soap*	*Protein*
B	*Fat*	*Protein*	*Soap*
C	*Soap*	*Fat*	*Protein*
D	*Protein*	*Soap*	*Fat*

9. A fatty acid is a long chain carboxylic acid.
Examples of fatty acids are shown in the table below.

Common name	Systematic name	Structure
stearic acid	octadecanoic acid	$CH_3(CH_2)_{16}COOH$
oleic acid	octadec-9-enoic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
linoleic acid	octadec-9,12-dienoic acid	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$
linolenic acid		$CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}(CH_2)_7COOH$

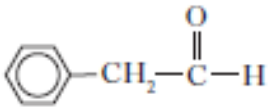
(a) What is the systematic name for linolenic acid? (1)
(b) Stearic acid reacts with sodium hydroxide solution to form sodium stearate.



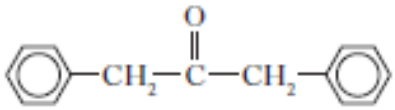
sodium stearate

(i) Name the type of reaction taking place when stearic acid reacts with sodium hydroxide. (1)
(ii) The long carbon chain ($CH_3(CH_2)_{16}$) of stearic acid is referred to as the hydrophobic part of the molecule. What is meant by the term **hydrophobic**? (1)

10. Chocolate contains various compounds. Many of the flavour and aroma molecules found in chocolate are aldehydes and ketones. Two examples are shown below.



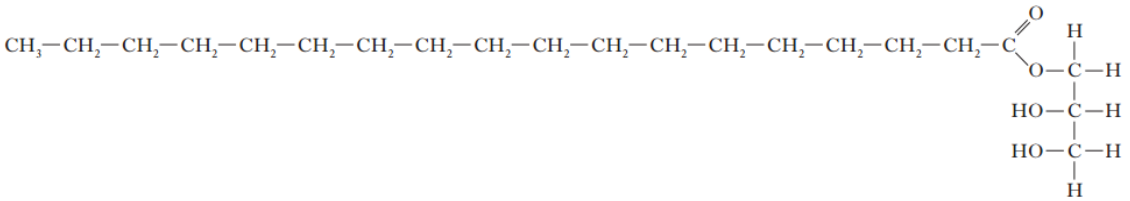
phenylethanal



1,3-diphenylpropan-2-one

Phenylethanal can be easily oxidised but 1,3-diphenylpropan-2-one cannot.

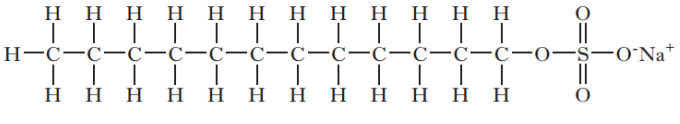
(a) **Describe fully**, a chemical test that could be used to distinguish between these two molecules including the result. (2)
(b) Name the type of organic compound formed when phenylethanal is oxidised. (1)
(c) Glycerol monostearate is an emulsifier used in chocolate.



(i) What is the purpose of an emulsifier? (1)
(ii) Glycerol monostearate is formed by the condensation reaction of stearic acid and glycerol.
What is meant by a **condensation** reaction? (1)
(iii) Draw a structural formula for glycerol. (1)

11. Sodium lauryl sulfate, $CH_3(CH_2)_{11}OSO_3Na$, is a compound found in hand wash. It has a similar cleaning action to soap.

Explain fully the cleaning action of sodium lauryl sulfate. (You may wish to use diagrams to illustrate your answer.) (3)



sodium lauryl sulfate

Total = 20