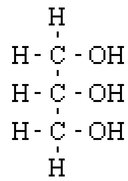
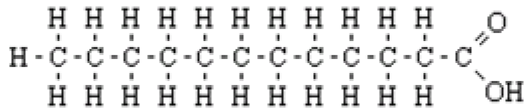
CHEM 9.5.5 SOAPS

Saponification is an important organic industrial process

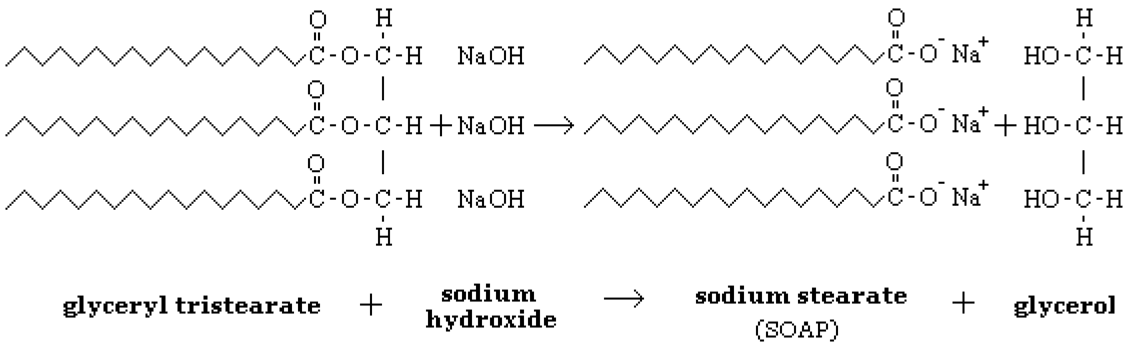
5.1 Describe **saponification** as the conversion in basic solution of fats and oils to glycerol and salts of fatty acids



- <u>**Fats and oils**</u>: fats are **solids**, oils are **liquids**, type of **organic compound** called **triglycerides**
  - <u>Triglycerides</u>: compound with three esters bonded to one **glycerol** – forms 3 **H_2O**
- <u>Glycerol</u>: 1,2,3-propanetriol – one OH group on each C
- <u>Fatty Acids</u>: **long carboxylic acids** with a **degree of saturation**
  - E.g. **Lauric Acid (12-C)** with carboxylic tail



- <u>**Saponification**</u>**: conversion of fats and oils in basic solution** into **glycerol and salts of fatty acids (soaps)**
  - **NaOH** or KOH used as bases
- E.g. **Sodium Stearate ($CH_3(CH_2)_{16}COONa$)** is formed by:



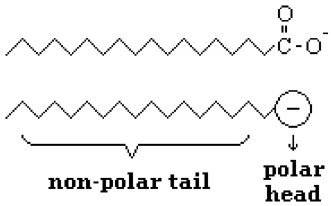
- NaOH splits the triglyceride at the COO-C bond, Na^+ ions attach to fatty acids, OH^- ions attach to form glycerol

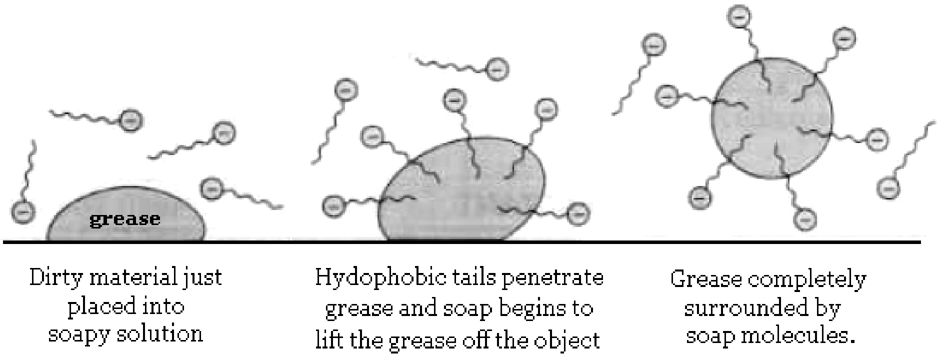
5.2 Describe the **conditions** under which saponification can be **performed in the school laboratory** and compare these with **industrial preparation of soap**

Conditions	**School Laboratory**	**Industrial Preparation**
Raw materials	**Pure oils** (e.g. olive oil), **NaOH** solution	Mixture of fats and oils, e.g. waste fats
Mixing, Stirring	Mixed and stirred with **glass rod**	**Kettle** method with **high pressure steam**
Time, °C, atm	**45 min to 1 hour**; **standard** 25°C; 1 atm	**Many days; 250°C; 5 atm**
Container	Beaker	Steel container, 100 t. capacity (Kettle)
Catalyst	None	Metal catalyst
Safety, Disposal	**Heat gently, NaOH; sink with water**	High **pressure**; **glycerol** recovered, unreacted **fatty acids** reused
Further processing	Washing to **remove NaOH**	**Washed** with steam, **distilled** to remove **impurities**, **colours and perfumes** added

5.3 Account for the **cleaning action of soap** by describing its **structure**

- Surfactant: substance that **decreases interfacial tension** of water or **disperses dirt/grease** throughout water
  - Interfacial tension: force between two **immiscible liquids** (do not mix)
- Cleaning action due to **the –'vely charged fatty acid** (not including Na^+ ion)
- **Polar head** is **hydrophilic** (water loving), able to **dissolve in water**
- **Non-polar** tail is **hydrophobic** (water hating), able to **dissolve in grease/dirt**
- Process:
  - Soap's **hydrophobic tail attaches to grease**, head remains in water
  - **Grease is lifted off object**, soap surrounds grease
  - Further agitation of mixture lifts off other grease/dirt on object
  - Grease and soap are **negatively charged** and **repel each other** to prevent joining together





5.4 Explain that **soap, water and oil together form an emulsion**, with the **soap** acting as an **emulsifier**

- Emulsion: **dispersion of small droplets** of one liquid throughout another liquid
- Emulsifier: **substance that causes** large droplets to form small droplets
  - Are a **class of** surfactants, therefore reduces **interfacial tension**
- E.g. Water and oil are initially **immiscible**, adding **soap (emulsifier)** allows even dispersion in water
  - More water than oil, so **oil is dispersed in water** (other e.g.: milk, cream mayonnaise)
- It can be **water dispersed in oil**, e.g. butter, margarine, sunscreen

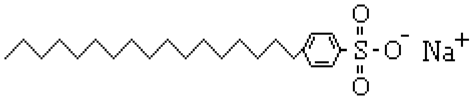
5.5 Distinguish between **soaps and synthetic detergents** in terms of the **structure** of the molecule, **chemical composition** and **effect in hard water**

- Three types of synthetic surfactants/detergents: **anionic, cationic and non-ionic**

SOAPS (NATURAL)

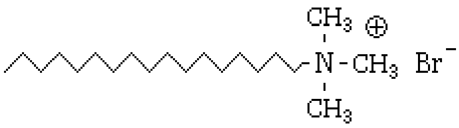
- Structure: salt of fatty acid (made of cation, **hydrophilic head** connected to **hydrophobic tail**)
- Chemical composition: Most soaps are **sodium stearate**, are **hydrocarbons**
  - Head contains **$-COO^-$** (carboxylate) anion, tail is **hydrocarbon chain**
- Hard water: **does not function well** – reacts with Mg^{2+} and Ca^{2+} ions to form **insoluble salts** (soap scum)
  - Therefore creates **grey soap scum stains** on sinks, baths, reduces **effectiveness of soap**

ANIONIC DETERGENTS (SYNTHETIC)



- Anionic – detergent ion has a **negative charge** (other than Na^+)
- Structure: long tail connected to **anionic head**
- Chemical composition:
    - Mainly salts of **alkyl benzene sulfonates** –**hydrocarbon tail**, **benzene ring** and **sulfonate** (SO_3^-)
- Hard water: **slight effect on effectiveness**, but not as much as soaps

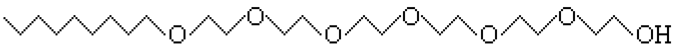
CATIONIC DETERGENTS (SYNTHETIC)



- Cationic – detergent ion has a **positive charge** (unlike above two)
- Structure: long tail connected to **negatively charged head**
- Chemical composition:
    - Mainly **halide** salts of **quaternary ammonium cations** – tail, ammonium ion with H's replaced
        - Often replaced with **methyl groups**, cation head **neutralised by halogens** (Cl^-, Br^-)
- Hard water: **do not react with cations** and are **very effective** in hard water

NON-IONIC DETERGENTS (SYNTHETIC)

- Non-ionic – does not have **an charged head or tail**, do **not ionise in water**:



- Chemical composition: **ethoxylates**, formed by many **ethoxy** chain$-\mathbf{CH_2}-\mathbf{CH_2}-\mathbf{O}-$)
    - Sections are **polar and hydrophilic** as oxygen atoms form H bonds
- Hard water: **do not react with ions** and are **very effective** in hard water

5.6 Distinguish between **anionic, cationic and non-ionic synthetic detergents** in terms of **chemical composition** and **uses**

- Chemical composition: see 5.5 (above)

	Anionic	**Cationic**	**Non-Ionic**
Uses	**Laundry detergents**, dishwashing, **general cleaning** (e.g. hands, toothpaste)	**Fabric softeners** and **hair conditioners** (-'ve fibres/hair), disinfectants/antiseptics (NH_4 slightly disinfecting)	**Low foam applications** (e.g. dishwasher powders), **emulsifying agent** in paints, adhesives, cosmetics