

NATURAL PRODUCTS (FATS AND OILS) AND POLYMERS.

FATS AND OILS;

A fat or an oil is an ester of a long chain carboxylic acid and propane – 1, 2, 3 – triol (glycerol) obtained from animals or plants respectively. A fat and an oil can be structurally distinguished as follows:

- ✓ Fats are solids at room temperature, oils are liquids at the same temperature.
- ✓ Fats are saturated esters while oils are unsaturated esters.

Sources of oils and fats.

- ✓ Vegetable oil; Ground nuts, castor seeds, cotton seeds, simsim seeds, sunflower, coconut seeds.
- ✓ Fats; Pork, mutton, beef, butter etc.

Extraction of an oil from a natural source.

The seeds or nuts are cleaned and husks are removed.

The seeds (or nuts) are roasted and then crushed to form a powder or paste.

The paste is mixed with a suitable organic solvent or boiled with water until the oil floats at the surface. The oil is then decanted off and purified.

SOAP AND NON – SOAPY DETERGENTS.

Soap is a sodium or potassium salt of long chain carboxylic acid derived by heating a fat or vegetable oil together with sodium hydroxide or potassium hydroxide solution. Soap is a detergent. A detergent is a substance that improves the cleaning properties of water during the removal of dirt from an article.

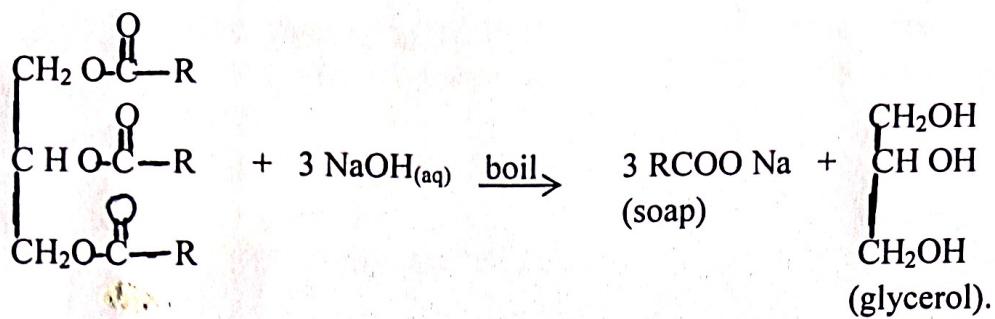
Common examples of soaps include;

- ✓ Sodium stearate (or sodium octadecanoate)
 $C_{17}H_{35}COO\ Na$ or $CH_3(CH_2)_{16} COO\ Na$
- ✓ Sodium palmitate (sodium hexadecanoate)
 $C_{15}H_{31}COONa$ or $CH_3(CH_2)_{14} COONa$
- ✓ Sodium octadecenoate; $C_{17}H_{33} COO\ Na$

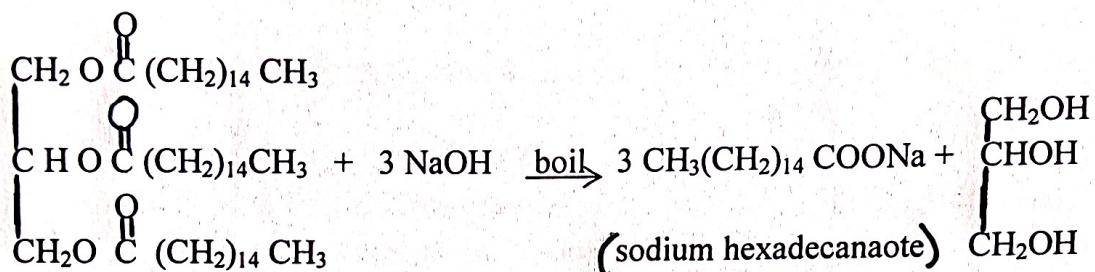
Preparation of soap from a fat or oil

The animal fat/vegetable oil is boiled with sodium hydroxide solution / an alkali while stirring until it completely dissolves. The solution is cooled and concentrated sodium chloride solution /brine added.

Soap precipitates and floats which is skimmed off. This process is known as saponification



Or



(An oil containing
hexadecanoic acid)

The cleansing action of soap.

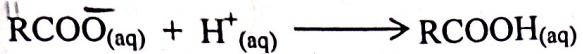
The soap molecule has an alkyl group which is non-polar and hydrophobic and the carboxylate group which is polar and hydrophilic. The alkyl group is attracted to the oil/dirt which reduces the surface tension between the water and the oil/dirt.

The carboxylate group dissolves in water. On agitation the dirt particles are removed and suspended in water (emulsified).

NOTE:

- (i) An aqueous solution of soap turns red litmus blue.
This is because soap being a salt of a weak organic acid; undergoes hydrolysis in water to produce hydroxyl ions that make the solution alkaline.
 $\text{RCOO}^{-}_{(\text{aq})} + \text{H}_2\text{O}_{(\ell)} \rightleftharpoons \text{RCOOH}_{(\text{aq})} + \text{OH}^{-}_{(\text{aq})}$
- (ii) Soap solution should not be used to wash aluminium or zinc vessels (utensils), because the excess hydroxyl ions formed after hydrolysis react with aluminium forming soluble compounds containing aluminate ions. This makes the utensils to continuously dissolve hence wear out.
 $2\text{Al}_{(\text{s})} + 2\text{OH}^{-}_{(\text{aq})} + 6\text{H}_2\text{O}_{(\ell)} \longrightarrow 2\text{Al(OH)}_{4(\text{aq})} + 3\text{H}_2^{(\text{g})}$
 $\text{Zn}_{(\text{s})} + 2\text{OH}^{-}_{(\text{aq})} + 2\text{H}_2\text{O}_{(\ell)} \longrightarrow \text{Zn(OH)}_{4(\text{aq})}^{2-} + \text{H}_2^{(\text{g})}$
- (iii) Soap cannot be used effectively in;
 (a) Hard water; contains dissolved calcium ions or magnesium ions which react with soap to precipitate scum.
 $\text{Ca}^{2+}_{(\text{aq})} + 2\text{RCOO Na} \longrightarrow (\text{RCOO})_2\text{Ca}_{(\text{s})} + 2\text{Na}^+$
 or $\text{Mg}^{2+}_{(\text{aq})}$

(b) Strongly acidic solution; This solution contains high amount of hydrogen ions which react with anionic part of soap, $\text{RCO}\bar{\text{O}}$ to form weak organic acid molecules.



This leads to wastage of soap.

Advantages of using soap; bio degradable, hence does not cause water pollution.

Disadvantages: - Form sum with hard water, hence wastes soap.

Form slightly alkaline solution which attacks the utensils made of aluminium or zinc.

NON – SOAP/ SOAPLESS DETERGENTS.

These are also known as synthetic detergents. A non-soapy detergent is a sodium or potassium salt of a long chain sulphonic acid. These detergents contain the sulphonate group or sulphate groups as the polar hydrophilic part, while the non-polar hydrophobic part remains the alkyl group.

Examples of non- soapy detergents include:

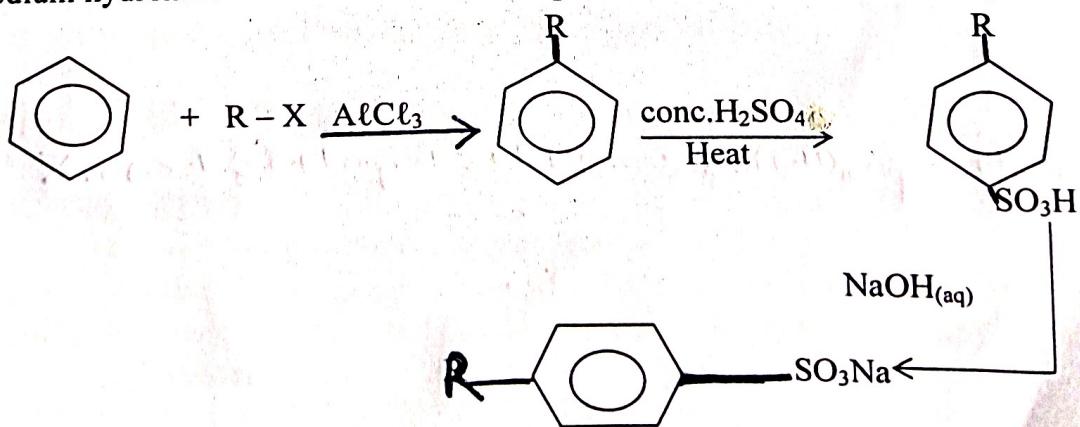
- $\text{CH}_3\text{CH}_2\text{O SO}_3\text{Na}$;
- Alkyl benzenesulphonates eg;



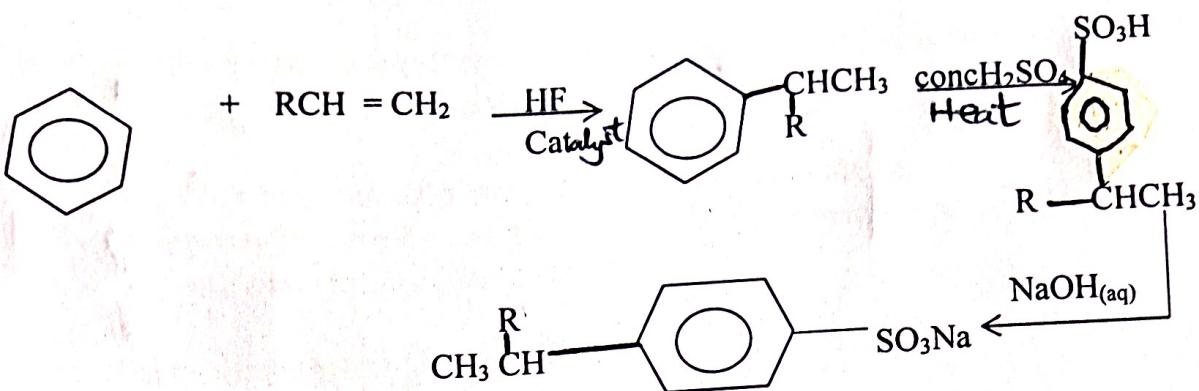
Synthesis of a non-soapy detergent.

a) From benzene:

Benzene is reacted with a long chain alkene / alkyl halide in presence of an acid / aluminium chloride to form alkylbenzene. The alkylbenzene is heated with concentrated sulphuric acid to form alkyl benzene sulphonic acid ~~we~~ is reacted with sodium hydroxide solution to form a detergent / sodium alkyl benzene sulphonate

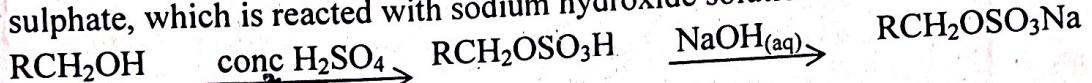


Or



b) From an alcohol;

An alcohol is reacted with cold concentrated sulphuric acid to form alkyl hydrogen sulphate, which is reacted with sodium hydroxide solution to form a detergent.



- ✓ $\text{CH}_3\text{CH}_2\text{OH} \longrightarrow$
- ✓ $\text{CH}_3(\text{CH}_2)_{10}\text{CH}_2\text{OH} \longrightarrow$
(duodecan - 1 - ~~OL~~)

Non-soapy detergents exist both in solid and liquid forms. They are made mainly from petroleum products or by-products of oil refining hence they are cheap. During the manufacture of detergents a little amount of the following substances are added.

i) Sodium sulphate (or disodium sulphate)

To increase the bulkiness of the powder making it economically profitable to the manufacturers.

ii) Sodium tripolyphosphate (or polyphosphates)

To remove soluble calcium salts by reacting with them.

iii) Sodium peroxoborate.

This is a bleaching agent and gives the detergent bleaching action.

Advantages of using non-soapy detergents;

- Do not form scum with hard water
- Cheap since they are made from by-products of oil refining.
- Are neutral in solution since they do not hydrolyse in water.

Disadvantages – Non-biodegradable hence cause water pollution.

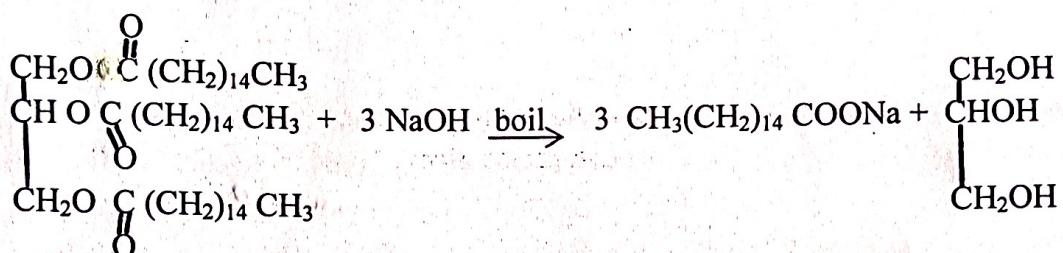
SAMPLE QUESTIONS:

1. (a) (i) Name two main sources of vegetable oil
 - (ii) Describe how a vegetable oil can be obtained from a natural source.
 - (iii) Name one use of the residue left after the oil has been extracted (animal feed or fertilizer)

(b) Soap was prepared from 19.0g of an oil mainly containing hexadecanoic acid, $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$, as the main component.

- Describe how pure soap was obtained from the oil above.
- Write equation for the reaction leading to formation of soap.
- Calculate the mass of soap formed.

Solution for b(iii)



Molecular formula of oil = $\text{C}_{51}\text{H}_{98}\text{O}_6$

Mr of the oil = $(51 \times 12) + 98 + (16 \times 6) = 806\text{g}$

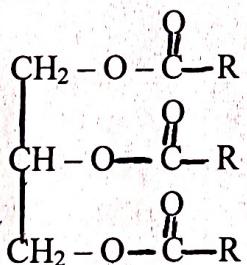
Mr of soap formed = $(16 \times 12) + 31 + 32 + 23 = 278\text{g}$

From equation: 806g of the oil give $3 \times 278\text{g}$ of soap.

$$19.0\text{g of the oil give } \left[3 \times 278 \times \frac{19}{806} \right] \text{g}$$

$$= 19.7\text{g of soap formed.}$$

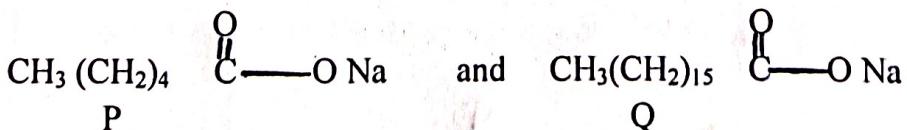
c) The structural formula of a fat X is shown below:



During the manufacture of soap from X, 1.108g of X were heated with 10cm^3 of 1.0M NaOH for sometime, and then cooled. The un-reacted alkali required 4.0cm^3 of 1.0M HCl for complete neutralization.

Determine the relative molecular mass of X.

d) The structured formulae of two salts P and Q are shown below



- i) Which one of the salts would you expect to be more effective as a cleaning agent. (Q)
- ii) Give a reason for your answer.
Because Q has a longer non – polar hydrophobic part than that of P. Hence Q dissolves more dirt than P can dissolve.
- e) 30.8g of soap were prepared from an oil which mainly consists of octadecanoic acid.
Calculate the mass of the oil that was used. $(CH_3(CH_2)_{16}COOH)$

POLYMERS:

A polymer is a long chain molecule formed by repeated joining together of many small molecules called monomers. Polymers may be natural or synthetic (or artificial). The process by which polymers are formed is known as polymerization.

Polymerization is the repeated joining together of many small molecules called monomers to form one large molecule called a polymer.

Types of polymerization

- Addition polymerization
- Condensation polymerization.

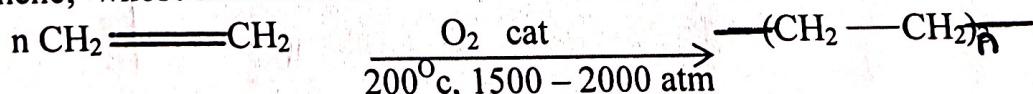
Addition polymerization:

This is the repeated joining together of many small unsaturated molecules called monomers to form one large molecule without loss of any small molecule. The relative formula mass of the polymer is the multiple of that of the monomer in it.

The structural requirement for addition polymerization is that the monomer should be unsaturated ie should contain atleast a carbon to carbon double or triple bond.

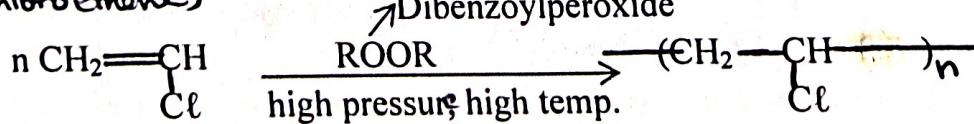
Examples of addition polymers;

1. Polyethene; whose monomer is ethene molecules



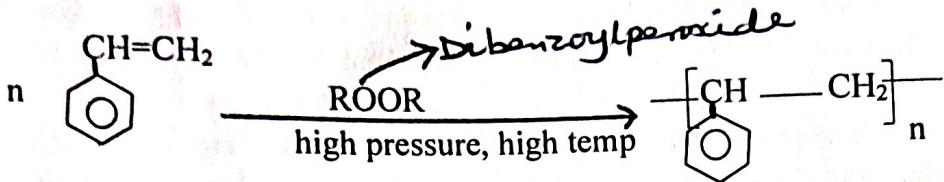
Used to make packaging materials, squeeze bottles, refrigerator trays etc.

2. Poly vinyl chloride (PVC), whose monomer is chloroethene
(Poly chloro ethene)



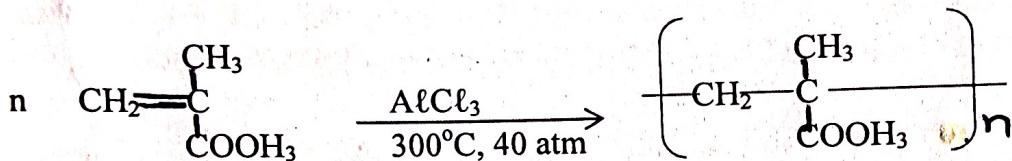
Used to make electrical insulators, floor coverings , pipes etc.

3. Polystyrene (polyphenylethene) whose monomer is phenylethene molecules



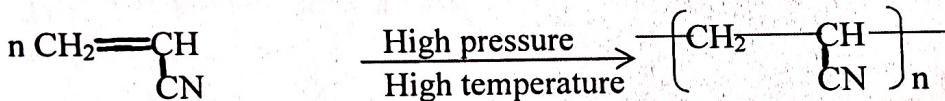
Used to make electrical insulators, plastic toys, egg tray, etc.

4. Perspex (or polymethyl 2 -methylpropenoate) whose monomer is methyl 2 - methyl propenoate.



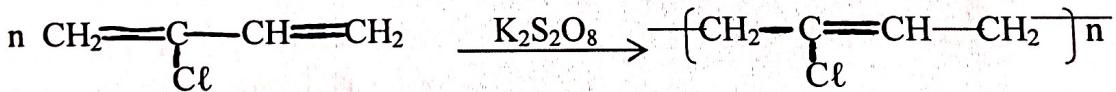
Used to make aeroplane window screens, lenses, corrugated roof lights etc.

5. Polypropenonitrile whose monomer is propenonitrile



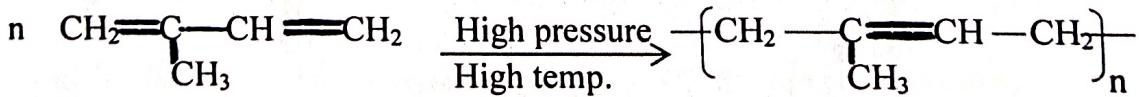
Used to make fabrics/cloth.

6. Neoprene rubber/synthetic rubber whose monomer is 2 – chlorobuta – 1, 3 – diene



Used to make gaskets . It is strong and resistant to corrosion by organic solvents.

7. Natural rubber : whose monomer is 2 – methyl buta – 1, 3 – diene



Used to make car tyres, shoe soles, etc.

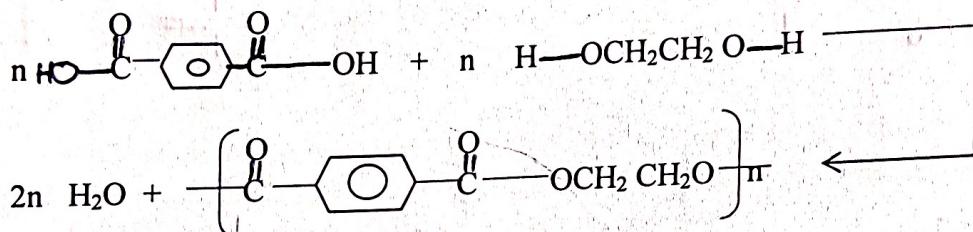
The properties of natural rubber can be improved by heating it with a small amount of sulphur, in a process known as vulcanization. Vulcanized rubber is stronger, durable and more elastic etc.

Condensation polymerization.

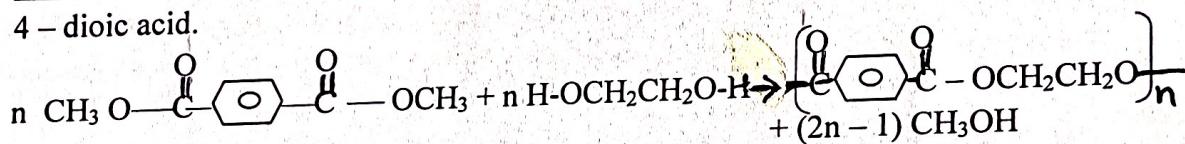
This is repeated joining together of two types of molecules having two functional groups on each molecule to form one large molecule with loss of a small molecule such as water, hydrogenchloride or ammonia etc.

For condensation polymerization to occur, the monomer should have two functional groups on each molecule. There are two types of condensation polymers ie polyesters and polyamides.

- ✓ Polyesters: Formed by condensation polymerization of ethane - 1, 2 - diol and benzene - 1, 4 - dioic acid or a dimethylester of benzene - 1, 4 - dioic acid eg
- a) Terylene; whose monomers are ethane - 1, 2 - diol and benzene - 1, 4 - dioic acid.

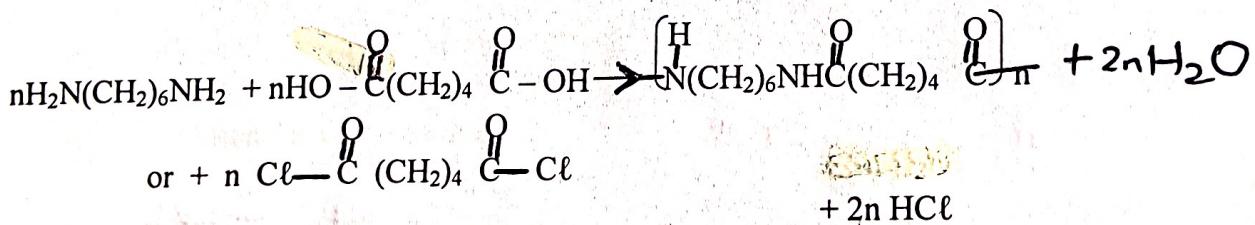


- b) Dacron whose monomers are ethane - 1, 2 - diol and dimethylester of benzene - 1, 4 - dioic acid.

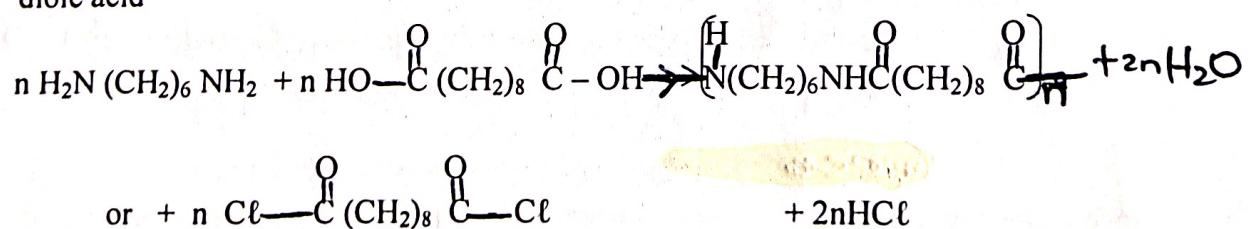


- ✓ Polyamides: Formed by reacting a diamine and a dicarboxylic acid e.g

- a) Nylon - 6, 6 whose monomers are hexane - 1, 6 - diamine and hexane - 1, 6 - dioic acid or hexane - 1, 6 - dioyldichloride



- b) Nylon - 6, 10 whose monomers are hexane - 1, 6 - diamine and Decane - 1, 10 - dioic acid



Nylon - 6, 6, nylon - 6, 10, terylene, Dacron are used in the manufacture of fabric / cloth.

PLASTICS:

These are solid materials which become mobile when heated and hence can be cast into moulds.

There are two types of plastics.

- ✓ Thermosoftening plastics (thermoplastics)
- ✓ Thermosetting plastics

Thermosoftening plastics.

These are linear polymers that become soft and melt on heating and therefore can be moulded
eg Perspex, poly ethene , PVC, etc.

Thermosetting plastics:

These are cross-linked chain polymers that contain three – dimensional network bonds which decompose on heating, hence can not be remoulded. Eg Bakelite and melamine. They are used as insulators and in making of plugs for electric appliances.

Note; Some condensation polymers occur naturally eg starch $C_6H_{10}O_5)_n$ whose monomer is glucose ($C_6H_{12}O_6$), protein whose monomer is amino acid, cellulose, glucogen, cotton, silk etc.

Questions

1. (a) (i) State what is meant by the term thermo-setting plastic.
(ii) Give one example of a synthetic thermosetting plastic
(b) Nylon - 6, 10 can be formed by reacting 1, 6 – diamino hexane with decane diol dichloride $Cl-C(=O)-C(CH_2)_8-C(=O)-Cl$

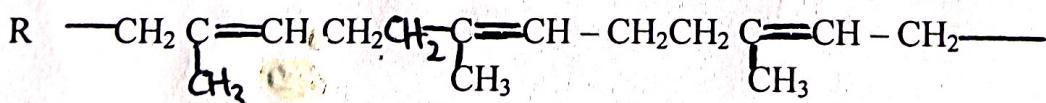
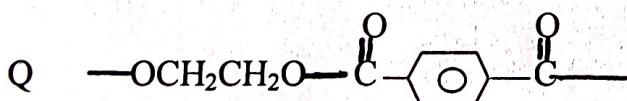
i) Write the structural formula of nylon - 6, 10
ii) State the type of polymerization involved in the formation of nylon 6, 10. Give a reason for your answer.
(c) The osmotic pressure of a solution containing 2 g dm^{-3} of nylon - 6, 10 at 25°C was 0.155 mm Hg . Calculate the;
i) Relative molecular mass of nylon - 6, 10 ($R = 8.31 \text{ or } 0.082$)
ii) Value of n in the nylon - 6, 10
(a) (i) Name two types of polymerization reactions
(ii) State the structural requirements for the formation of polymers by each of the two types you have mentioned above.

- (b) Write the names and structural formulae of.
- two naturally occurring condensation polymers
 - one naturally occurring addition polymer.
 - monomers of the polymer above in b(i), (ii).
- (c) The molecular structure of a polymer Z is $\left[\text{CH}_2 - \underset{\text{Cl}}{\text{C}} = \text{CH} - \text{CH}_2 \right]_n$
- Write the name and structural formula of the monomer in Z
 - With the reason, state the type of reaction for which Z is made.
- (d) When 71.76g of the monomer in (c)(i) was polymerized 2.67×10^{-2} moles of the polymer Z was formed. Determine the
- Formula mass of Z
 - Number of monomer units in Z

- (e) The general formula of polymer A is $\left(\text{CH}_2 - \underset{\text{CH}_3}{\text{C}} - \text{COOH}_3 \right)_n$.
- Write the structural formula and name of the monomer of A.
 - With the reason, state the type of reaction by which polymer A is made.
 - When 1.25×10^{-3} moles of A were heated strongly with silicon (IV) oxide as a catalyst, 4.85g of the monomer were formed. Calculate the formula mass of A (3880g) and hence the value of n (39)
 - State one use of polymer A.
 - State the method by which the formula mass of A can be determined

3. (a) Distinguish between addition and condensation polymerization reactions.

(b) The structural formulae of polymers P, Q and R are shown below



- In the table below, write the structural formula (e) of the monomer(s) in each case and name the type of polymerization that leads to formation of each polymer.

Polymer	Structural / formula of monomer(s)	Name of the monomer(s)	Type of reaction
P			
Q			
R			

- ii) State the process by which the properties of R can be improved.
- iii) State how the process you have named in (ii) above improves the properties of R
- iv) State one use of P and one use of R

(c) Complete each of the following equations and state one use of the product.

