Condensation Polymerisation (A2)

- monomers join up with the expulsion of small molecules.
- not all the original atoms are present in the polymer.
- condensation polymers example.

polymer	example	relations between
polyesters	terylene	diprotic carboxylic acid and diols
polyamides	nylon	diprotic carboxylic acid and diamines
polypeptides	protein	amino acids
polysaccharides	starch	glucoses

Polyesters (eg. Terylene)

monomers : HOOC–C$_6$H$_4$–COOH benzene-1,4-dicarboxylic acid (terephthalic acid)

HOCH$_2$CH$_2$OH ethane-1,2-diol (ethylene glycol)

reaction : esterification

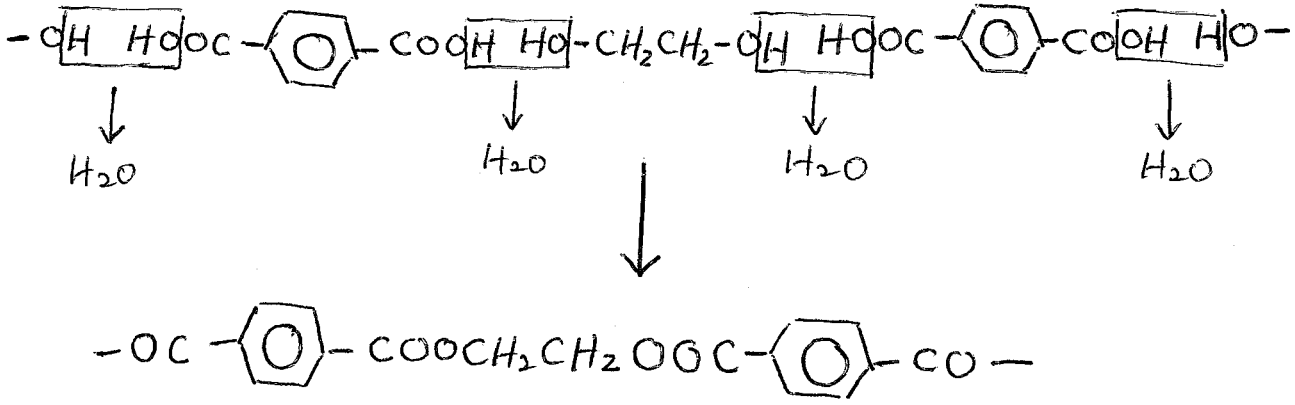
eliminate : water

product : poly(ethylene terephthalate) Terylene

linkage : ester linkage $-C(=O)-O-$

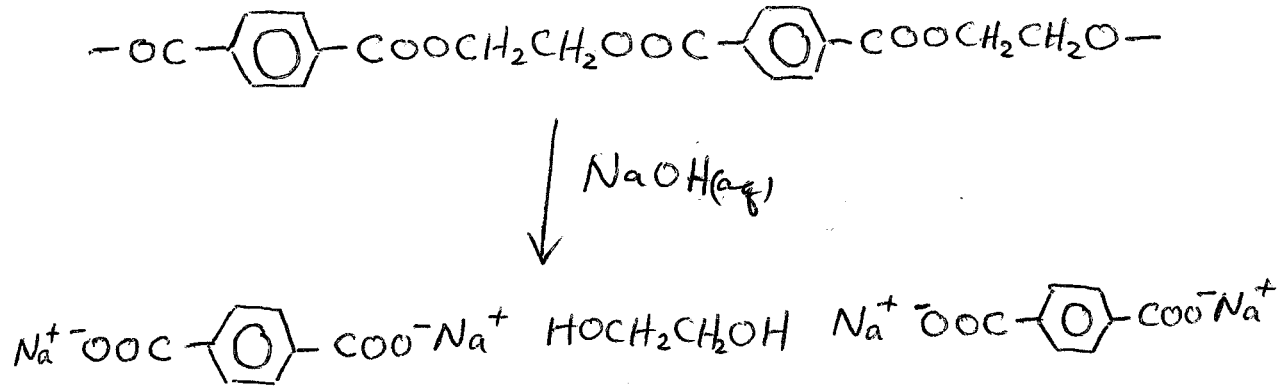
repeat unit : $-[-OCH_2CH_2OOC(C_6H_4)CO-]_n-$

polymerisation



Hydrolysis of Polyesters

- catalysed by dilute acids and alkalis.
- polyesters are readily hydrolysed by alkalis, but the process is slower with acid.
- The process of hydrolysis with water alone is not significant.
- Example : hydrolysis with $NaOH_{(aq)}$



Uses of Polyesters

- as fibre for clothing materials - Polyester (Terylene)
- making materials for bottles (PET)
- biodegradable by hydrolysis.

Polyamides

eliminate : water

mechanism : addition – elimination

linkage : peptide / amide link. $-\overset{\overset{O}{\|}}{C}-\underset{\underset{H}{|}}{N}-$

Example : 1. Nylon-6,6

2. Nylon-6

3. Kevlar

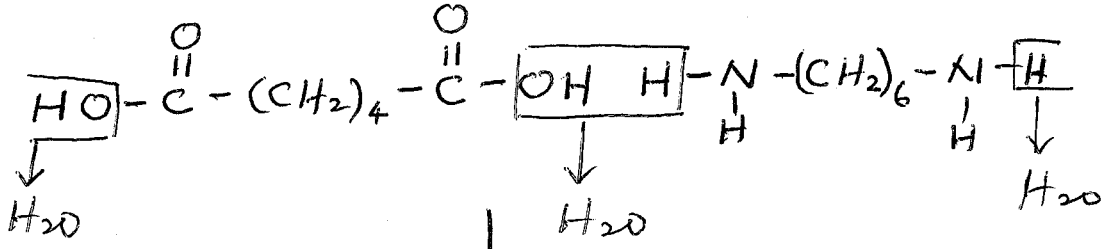
Nylon-6,6

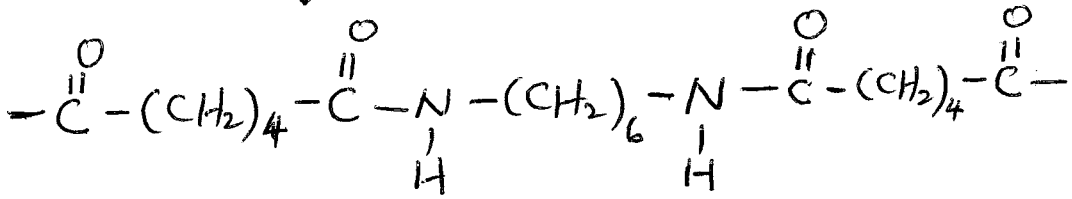
monomers : $HOOC(CH_2)_4COOH$ hexane-1,6-dioic acid

$H_2N(CH_2)_6NH_2$ hexane-1,6-diamine

repeat unit : $-[-NH(CH_2)_6NHOC(CH_2)_4CO-]_n-$

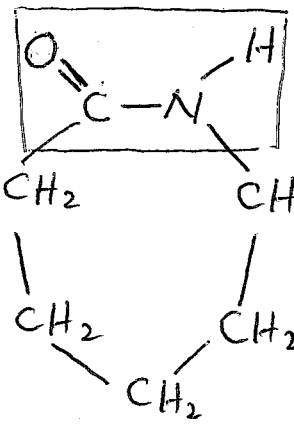
polymerisation





Nylon-6

monomer :

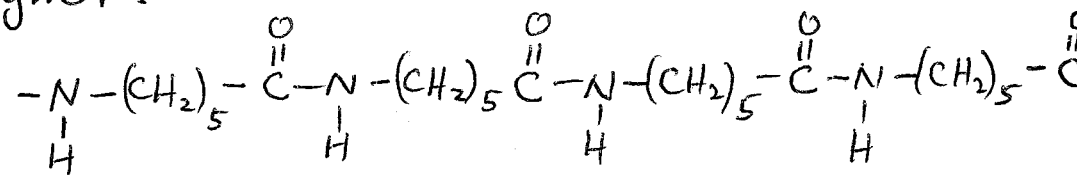


amide link

caprolactam
(cyclic amide)

the only example of a nylon polymer that is not formed by a condensation reaction. When heated in an atmosphere of nitrogen the ring breaks open at the amide group. The resulting chains join together to make nylon 6.

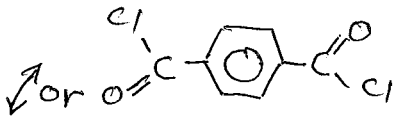
polymer :

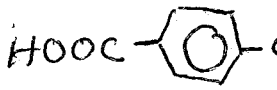


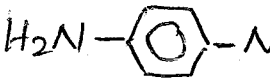
Uses of Nylon

Nylon's low density, its strength and its elasticity make it a very useful fibre in the clothing industry. These properties also make it ideal for climbing ropes, tyre cords (the inner structure of a vehicle tyre underneath the rubber) and cast into solid shapes for cogs and bearings in machines.

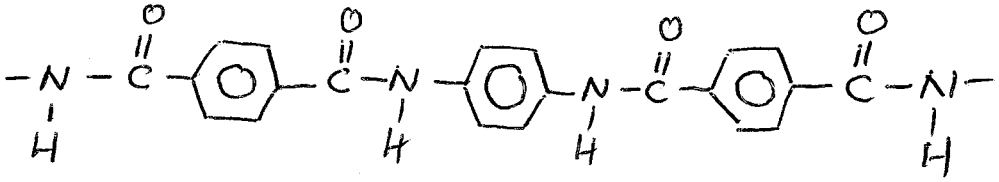
Kevlar



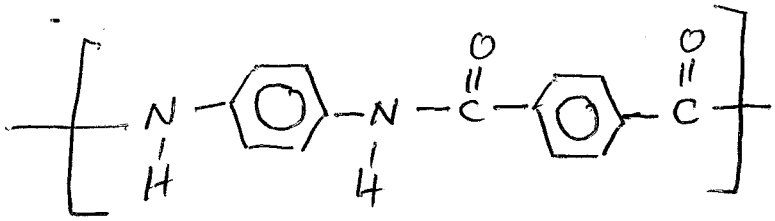
monomers :  benzene-1,4-dicarboxylic acid

 1,4-diaminobenzene.

polymer :



repeat unit :



Uses of Kevlar

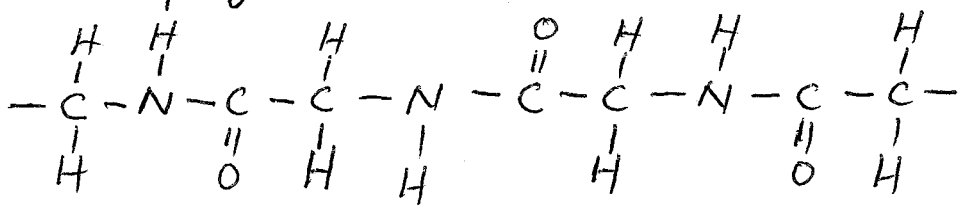
- Very strong material and about 5 times as strong as steel, weight for weight.
  - used in bulletproof vests
  - composites for boat construction
  - lightweight skis and racquets

Hydrolysis of Polyamides

- simple amides are easily hydrolyseed by dilute acids or alkalis
- Polyamides are readily hydrolyed by strong acids but are more resistant to alkali hydrolysis.
- Hydrolysis is faster at higher temperature
- Kevlar is more resistant to hydrolysis than nylon

Exercise 1

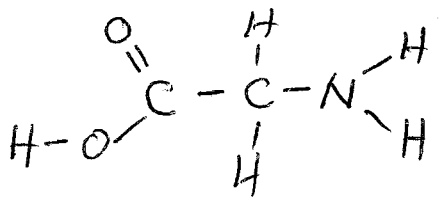
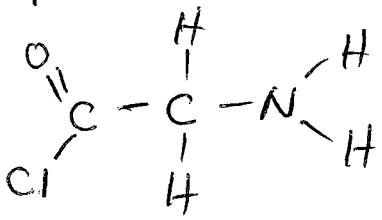
(i) What type of polymerisation reaction formed the polymer shown below?



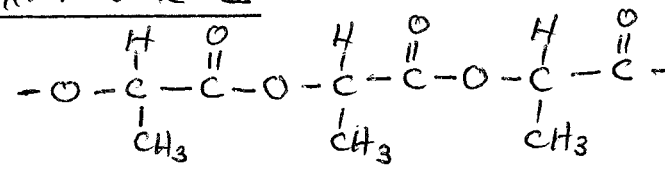
(ii) Draw the displayed formula of the single monomer used to make the polymer shown.

Answers

(i) condensation polymerisation

(ii)  or 

Exercise 2

 poly(lactic acid)

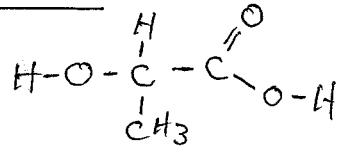
Draw structures for the organic product(s) formed when poly(lactic acid) is treated with the following reagents.

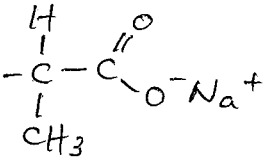
(i) $HCl_{(aq)}$

(ii) $NaOH_{(aq)}$

(iii) What name is given to this type of reaction.

Answers

(i) 

(ii) 

(iii) hydrolysis.