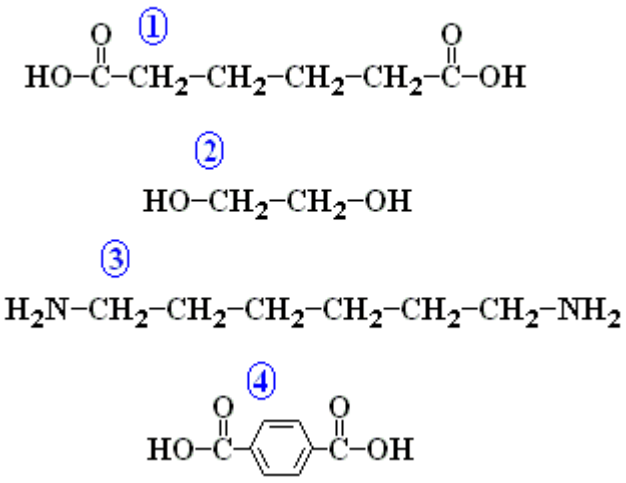
Step Growth Polymerization (Condensation Polymerization)

Monomers: Functional Groups

The monomers that are involved in condensation polymerization are not the same as those in addition polymerization. The monomers for condensation polymerization have two main characteristics.
⇨Instead of double bonds, these monomers have functional groups (like alcohol, amine, or carboxylic acid groups).
⇨Each monomer has at least two reactive sites, which usually means two functional groups. Some monomers have more than two reactive sites, allowing for branching between chains, as well as increasing the molecular mass of the polymer. Four examples of these difunctional monomers were introduced in Part 2 of this tutorial. Here they are again:

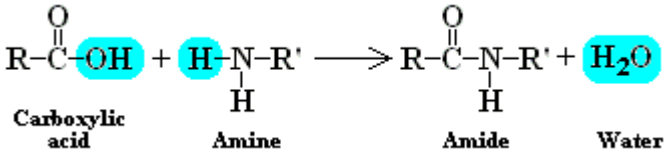
The Structures



The Amide Linkage:

When a carboxylic acid and an amine react, a water molecule is removed,

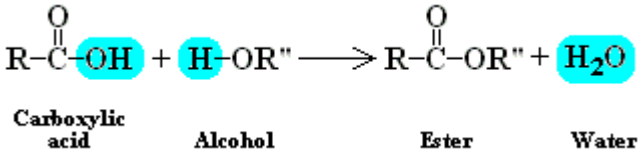
and an amide molecule is formed.



Because of this amide formation, this bond is known as an *amide linkage*

The Ester Linkage:

When a carboxylic acid and an alcohol react, a water molecule is removed, and an ester molecule is formed.



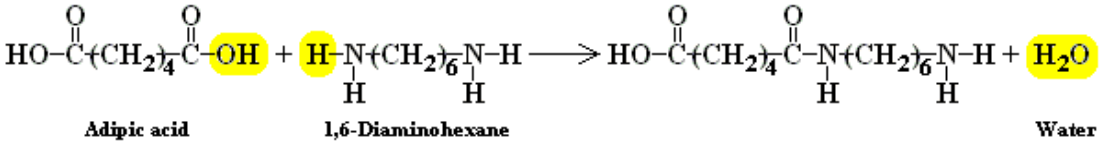
Because of this ester formation, this bond is known as an *ester linkage*.

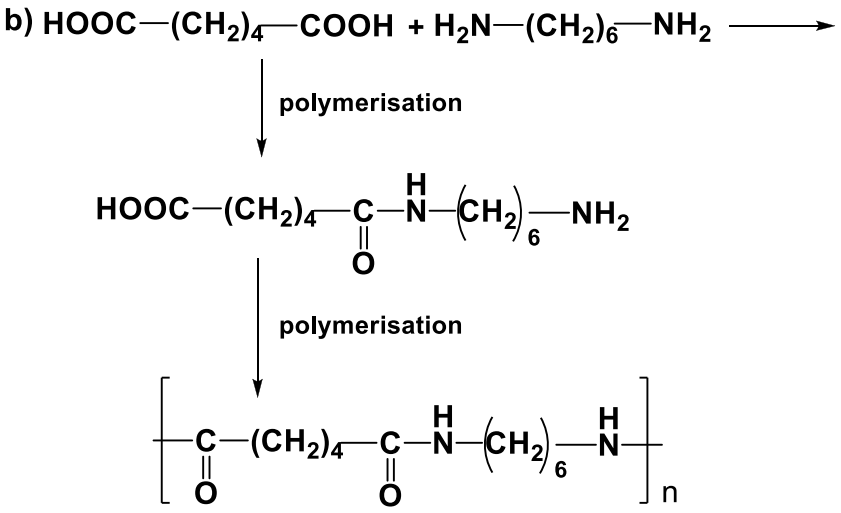
The Mechanism of Condensation Polymerization

You know that monomers that are joined by condensation polymerization have two functional groups. You also know (from Part 6) that a carboxylic acid and an amine can form an amide linkage, jand a carboxylic acid and an alcohol can form an ester linkage. Since each monomer has two reactive sites, they can form long-chain polymers by making many amide or ester links. Let's look at two examples of common polymers made from the monomers we have studied.

Example 1: Poly amide (nylon 6,6)

A carboxylic acid monomer and an amine monomer can join in an amide linkage.



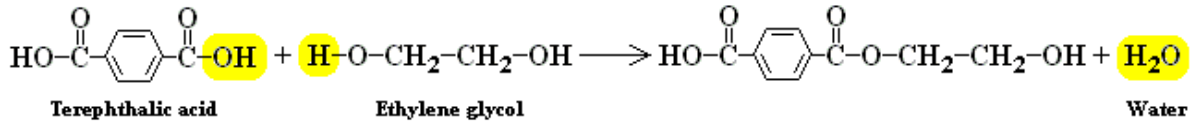


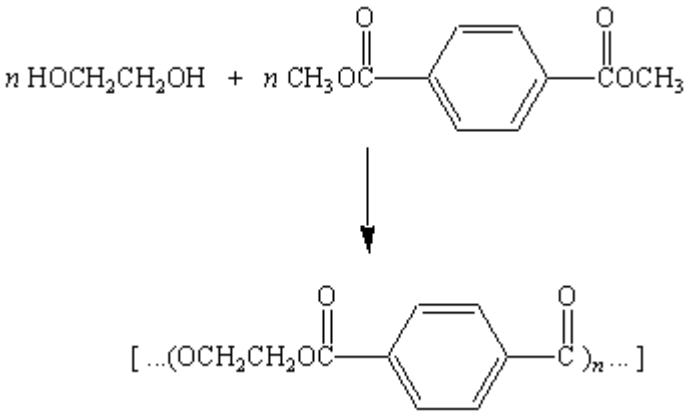
As before, a water molecule is removed, and an amide linkage is formed. Notice that an acid group remains on one end of the chain, which can react with another amine monomer. Similarly, an amine group remains on the other end of the chain, which can react with another acid monomer.

Example 2: (Poly ester, Dacron)

A carboxylic acid monomer and an alcohol monomer can join in an ester linkage.

The first polyester fibers were produced by reacting ethylene glycol and either terephthalic acid or one of its esters to give poly (ethylene terephthalate)





A water molecule is removed as the ester linkage is formed. Notice the acid and the alcohol groups that are still available for bonding. ause the monomers above are all joined by ester linkages, the polymer chain is a polyester. This one is called PET, which stands for poly(ethylene terephthalate). (PET is used to make soft-drink bottles, magnetic tape, and many other plastic products.)

Summary:

Monomers involved in condensation polymerization have functional groups. These functional groups combine to form amide and ester linkages. When this occurs, a water molecule in removed. Since water is removed, we call these reactions condensation reactions (water condenses out.). When a condensation reaction involves polymerization, we call it *condensation polymerization*.