Polymers are materials with high molecular weight, as they are multiple monomers, which thereby increases the weight, depending on the number of monomers. Monomers are building blocks.

Multiple monomers make up a polymer. Each monomer has two bonding sites on either side with a free radical, therefore when it comes in contact with another monomer, it bonds with the same. Polymerization is when multiple monomers bond together to form a polymer.

There are four types of polymerization; Addition, Condensation, and Coordination Polymerization.

The functionality of a polymer is based on the total number of bonding sites/functional groups in a monomer.

There are two types of polymers, i.e, natural polymers, and synthetic polymers. Thermoplastics are polymers that turn soft when heated, and can be moulded to any shape, similar to metal and glass. These are made using Addition Polymerization, making a linear polymer. Due to their malleable nature, they can be recycled. Due to their high malleability, they are very soft and weak, and are soluble in certain solvents.

Thermosetting polymers are polymers that are permanently a certain shape, and unlike thermoplastic, heat does not make them malleable, but rather degrades the polymer itself. These are made with Condensation Polymerization, which then builds a 3D Network. As they are essentially the opposite of Thermoplastics, they are hard and strong, and are insoluble due to strong inter and intrachain cross links.

Homopolymers are linear polymers made of the same monomer.

Co-polymers can be found in either alternating, random, block (two or three linear polymers), and graft.(homopolymers of A and B in which there is one linear A homopolymer, and various B homopolymers attached to the side of the same).

Homochain polymers are like normal -C- polymers with 4 bonding sites in each monomer. Heterochain polymers are similar to homochain polymers, however they have a regular oxygen in between.

Organic polymers are those made of organic molecules, and vice versa with inorganic polymers. Polymers in reference to their side groups can also be divided into Isotactic, Syndiotactic, and Atactic polymers. Isotactic polymers are those with side groups on the same side. Syndiotactic polymers are those with alternating side groups, and Atactic polymers are those with side groups on random sides.

Different types of polymers have different uses.

Elastomers are polymers that return to their original form after pushing as weak van der waal forces force the polymer to return to their original form. These are found in various types of rubbers.
Fibers are thread like polymers that are linked with Hydrogen bonds. These are primarily used for clothes and found in fabric in both natural and synthetic forms.
Resins are polymers with low molecular weight which are mainly used as adhesives.
Plastics are polymers that can mould into different shapes using heat and pressure.

Addition Polymerization are olefinic compounds that undergo polymerization. There is no elimination of by-products, and double bonds are those that provide the required bonding sites in the form of initiator free radicals. Addition Polymerization occurs very fast, and have the same elemental composition as the monomer.

Condensation Polymerization occurs when monomers with multiple functional groups undergo polymerization. Unlike Addition Polymerization, the by-products are eliminated during polymerization. The chain is built slowly and step by step using catalysts like acids or alkalis. As there are different functional groups that combine to form these polymers, the elemental composition of the polymer differs from the composition of the monomer. Co-polymerization occurs when multiple monomers polymerize.

There are two general mechanisms of polymerization i.e, Chain and Step-Growth polymerization. Chain polymerization has 3 major steps i.e, Initiation, Propagation, and Termination.
An Initiator is a compound that is thermally unstable, and therefore decomposes into free radicals. There are two stages for this; the homolytic dissociation of the initiator which thereby produces free radicals.
The second step, propagation occurs when these radicals attack another monomer to then produce another free radical, which keeps going until the termination.
Termination occurs when the propagation step stops, and the free radicals couple and combine two growing chains.

Ionic Polymerization has 2 types; cationic in which the initiator is a cation from a Protonic or Lewis acids, and anionic, in which the initiator comes from alkali metal amides/alkyls.

Degree of Polymerization is the number of repeating units present in a certain polymer. If there are less than 10, then it’s a low polymer, and if it’s $100 < n < 1000$, then it’s a high polymer. Molecular weights of polymers are relevant to the physical properties of macromolecules.

The higher the molecular weight, the stronger the polymer, however extremely high molecular weights will eventually have processing difficulties. The average molecular weight is the sum of M_iN_I divided by the sum of N_i, in which N_i is the total number of molecules/moles, and M_i is the molecular weight. These are only applicable to linear molecules with two reactive end groups. Weight average molecular weight is the weight fraction of molecules in given size ranges.

The WAMW is always larger than the AMW, except for when molecules have the same weight, in which $M_w = M_N$. The smaller the molecular weight range, the closer the value of M_w and M_N, and thereby the ratio of the same. This ratio can then be used to represent the breadth of the Molecular Weight Range of a polymer to some extent. If all the polymer molecules have the same molecular weight, then they are known as monodisperse.
The molecular weight of a polymer can also be determined using viscosity measurement using viscosity average molecular weight. Synthetic polymers have a mixture of various molecules with different lengths and weights. These mixtures are also known as polydisperse. A typical distribution looks like the Gaussian Function/a Bell Curve.

The molecular weight of a polymer is important as in commercial uses, the polymers are chosen based on their melting point, viscosity, and other chemical properties that are dependent on the molecular weight of a polymer or the degree of polymerization.
Tensile and Impact strengths increase with molecular weight, however they reach a saturation point after a certain point, however melt viscosity steeply increases at low molecular weights, and less at higher molecular weights. Polymers with low melt viscosities are more useful commercially as it allows processing to be done easier, however they should also have good tensile strength.
Mechanical strength increases along with the degree of polymerization, however it has a saturation asymptote.
The threshold value is the value of the degree of polymerization below which no strength exists in any form. This value varies depending on the polymer. Any polymer with a degree of polymerization value of less than 30 do not show any strength, and usually obtain the required strength at a degree of polymerization of 600. The optimum range is 200 to 200, for molecular weights of 20000 to 200000.

Glass transition temperature is the temperature below which a polymer is hard and brittle, and above which is soft and flexible. The first is known as the glossy state in which there is no segmental and/or molecular motion, and the latter is known as the rubbery state, in which there is only segmental motion, however there is no molecular mobility.