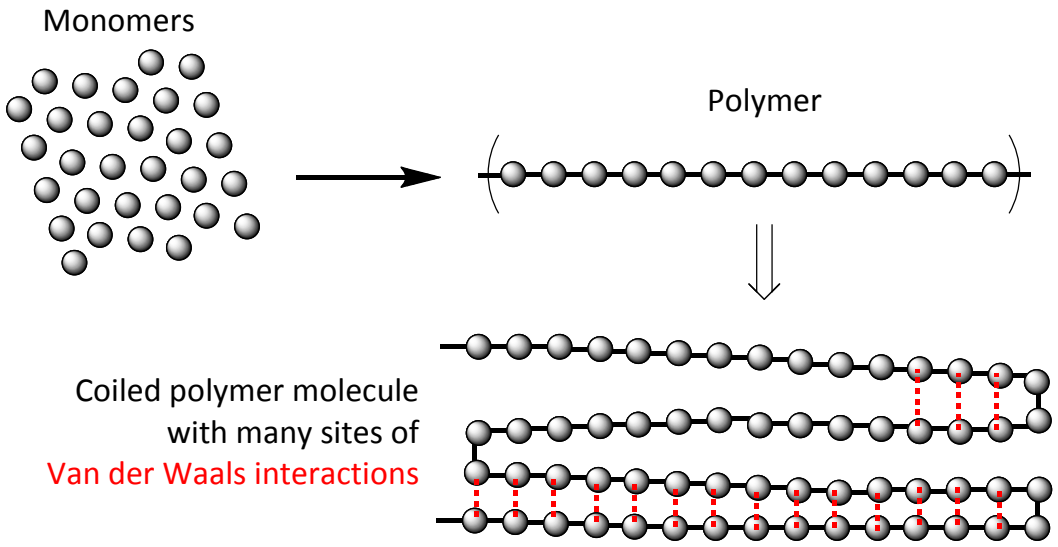
Polymers in AP Chemistry

The AP Chemistry curriculum for 2014 has added polymers as an example of how inter- and intramolecular bonding influence physical properties of a substance. This material shows up primarily under Big Idea 2: Properties of Matter.

Polymer Basics:

Polymers are the class of molecules encompassing most plastics and many synthetic fibers like polyester, nylons, polyethylene, Kevlar, polystyrene etc. Polymers tend to be solids at room temperature, and are often strong and flexible compared to other types of solids.

On the molecular level, polymers are large, chain-like molecules with high molecular weight. Polymers are formed through a reaction that joins many small molecules (called monomers) via covalent bonds. These monomers typically contain alkenes, carboxyilic acids, alcohols and/or amine functional groups. A polymer molecule is so long that it will coil up on itself, giving many sites of Van der Waals interactions in a single chain, or among different chains.



Although each individual Van der Waals interaction is small in magnitude, the sum of these attractions is very large and gives a polymer its overall strength and durability. Sometimes covalent bonding between different parts of a polymer chain can occur (called cross-linking), which increases the rigidity of the polymer. This is favourable for some applications of polymers like vulcanized rubber. It should also be noted that small changes in the structure of the monomer could cause significant changes in the physical properties of the polymer.

There are naturally occurring polymers as well, including proteins (made from amino acid monomers), polysaccharides (made from monosaccharide monomers), and DNA (made from nucleotide monomers). These biological macromolecules contain many hydrogen bond donors and acceptors, and therefore hydrogen bonding plays a key role in the structure and properties of biological polymers.

How are Polymers incorporated into the AP Chemistry curriculum?

In the new AP curriculum, polymers are discussed as an example of how bonding and intermolecular forces can affect the macroscopic properties of materials. Students should be able to identify the types of inter- and intramolecular bonding in a polymer, and explain how the bonding determines physical properties of the polymer.

Essential Knowledge 2.D.4: Molecular solids with low molecular weight usually have low melting points and are not expected to conduct electricity as solids, in solution, or when molten.

- **b.** Molecular solids are composed of distinct, individual units of covalently bonded molecules attracted to each **o**ther through relatively weak intermolecular forces.
  - **1.** Molecular solids are not expected to conduct electricity because their electrons are tightly held within the covalent bonds of each constituent molecule.
  - **2.** Molecular solids generally have a low melting point because of the relatively weak intermolecular forces **p**resent between the molecules.
  - **3.** Molecular solids are sometimes composed of very large molecules, or polymers, with important **c**ommercial and biological applications.

Essential Knowledge 5.D.3: Noncovalent and intermolecular interactions play important roles in many biological and polymer systems.

- **b.** The functionality and properties of molecules depend strongly on the shape of the molecule, which is largely dictated by noncovalent interactions. For example, the function of enzymes is dictated by their structure, and properties of synthetic polymers are modified by manipulating their chemical composition and structure.

Sample Questions: AP Chemistry Practice Exam and Notes, Fall 2013 *NONE GIVEN*

Resources:

Zumdahl, Stephen, S. Chemical Principles. 6th Edition. Belmont: Brooks/Cole. 2011. Pg. 1035-1060

This textbook contains a comprehensive section on polymer types, reactions, intermolecular forces and biological polymers. It is appropriate for student and/or teacher reading.