## Name: Date:

## POLYMERS AND POLYMERIZATION

**Polymers** are large molecules composed of a repeating sequence of **monomers**. A monomer is usually a small molecule or compound. A common monomer is ethene (ethylene),  $C_2H_4$ . Polymers are typically produced using two types of reactions; **addition polymerization** and **condensation polymerization** reactions.

## **Addition Polymerization Reactions:**

Addition polymerization involves the bonding of monomers without the elimination of atoms. Bonding is accomplished by opening unsaturated bonds between carbon atoms in the molecules.

Example of an Addition Polymerization Reaction using Ethene:

As polymerization continues, more ethene units are incorporated into the structure to form the polymer polyethylene. The final product may contain thousands of monomers, defined by the number n.

polyethylene

One or more of the hydrogen atoms in ethene can be replaced by groups such as –F, –Cl, –CH<sub>3</sub>, and –COOCH<sub>3</sub>. By substituting the hydrogen atoms synthetic polymers with trade names such as Teflon, Saran, and Lucite, or Plexiglas result. By varying the additional components of the molecule it is possible to create compounds with customized properties.

Table 1: Examples of Common Monomers used in Addition Polymerization

Monomer	Monomer Name	Polymer	Uses
Structure			
H H	ethylene	polyethylene	films, coating for milk cartons, wire insulation, plastic bags, bottles, toys
H CI	vinyl chloride	polyvinyl chloride (PVC)	raincoats, pipes, credit cards, bags, floor tiles, shower curtains, garden hoses, wire insulation, gutters, down spouts
H	styrene	polystyrene	electrical insulation, packing material, combs
O CH <sub>3</sub> H CH <sub>3</sub>	methyl methacrylate	Plexiglas, Lucite	glass substitutes, paints
F F	tetrafluoroethylene	Teflon	gaskets, bearings, insulation, non-stick pan coatings, chemical resistant films

## **Condensation Polymerization Reactions:**

Condensation polymerization occurs when the formation of a polymer is accompanied by the elimination of atoms. For example monomeric units known as amino acids may combine to form chains known as polypeptides, or very long chains known as proteins. During this process water is eliminated as a by-product of the reaction.

Example of a Condensation Polymerization using an Amino Acid to Produce a Polypeptide:

Amino acids contain both an amine and a carboxylic acid functional group. When the amine end of the molecule is joined with the acid end of another molecule, a molecule of water is eliminated. The process of removing water is sometimes referred to as **dehydration synthesis**. The result is a longer molecule made from two amino acids linked by an amide bond. This particular type of bond is known as **a peptide bond**. If the reaction continues you form the long chained molecules known as **proteins**.

Example of a Condensation Polymerization to Produce Nylon-66:

As polymerization continues you would begin to form the polymer Nylon–66

The combination of two compounds, adipic acid and 1,6-diaminohexane, produce a polymer known as Nylon–66. When heated the monomer units bond by the formation of an amide between the two different functional groups. For each new bond formed, one water molecule is released.