

Grade 12 Chemistry

Organic Chemistry

Class 4

Polymers

- Polymer – large molecule built from monomers
- Monomer – a simple, repeating unit
- Natural and synthetic polymers are used in textile fibres, rubber, and plastics

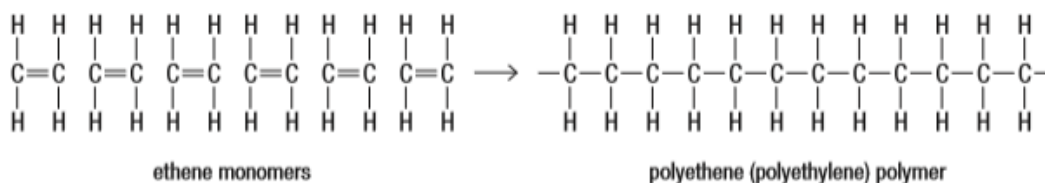
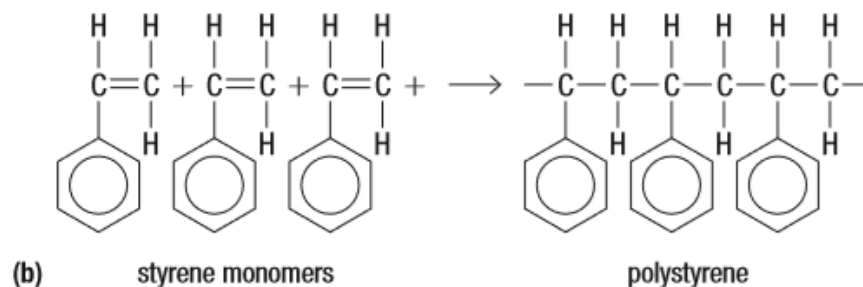
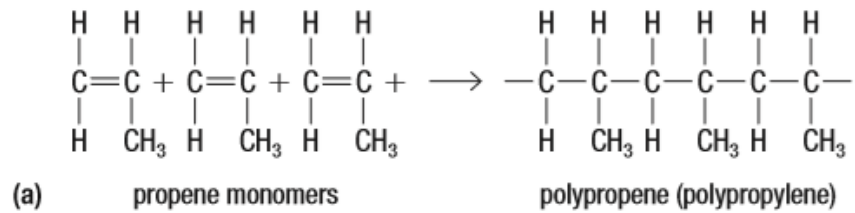
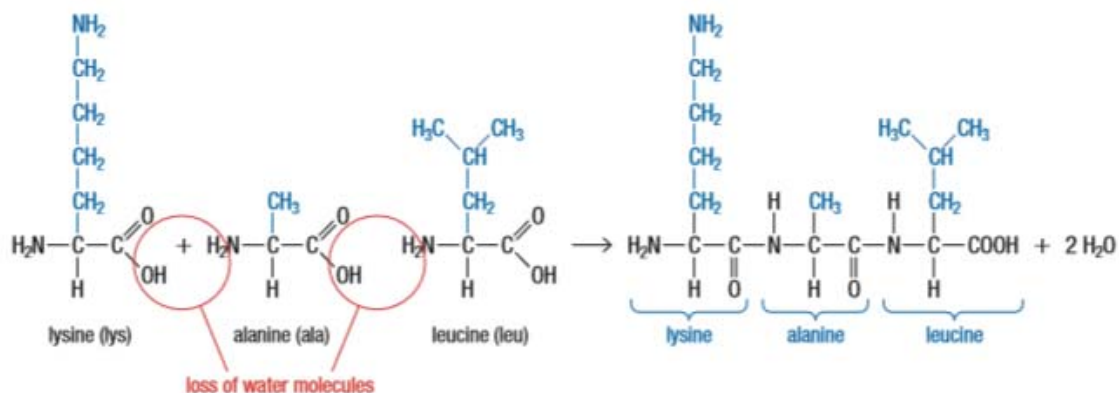


Figure 2 Polymerization of ethene molecules produces polyethene (polyethylene).

- Homopolymer – polymer formed by reactions involving a single type of monomer

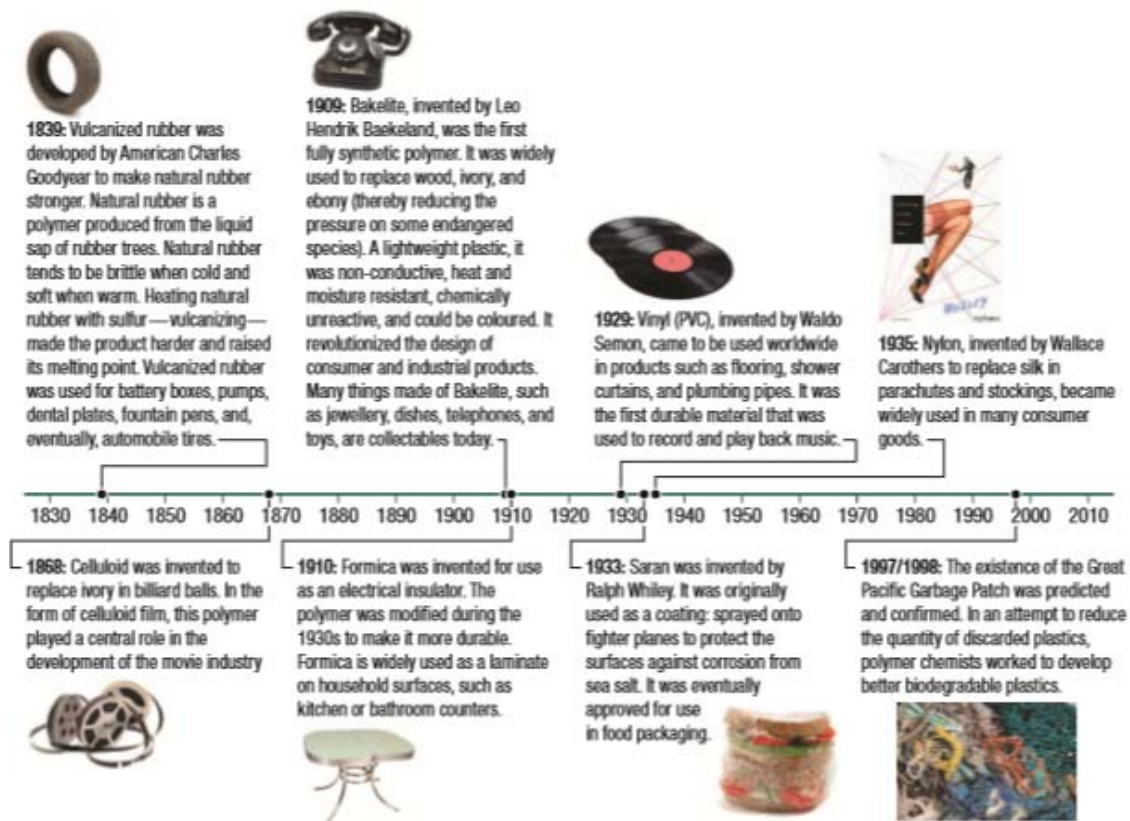


- Copolymer – different types of monomers combined to form the polymer chain
 - May join in an addition reaction or in a condensation reaction
 - Ex: Silk – a natural polymer is formed by joining amino acids in multiple condensation reactions



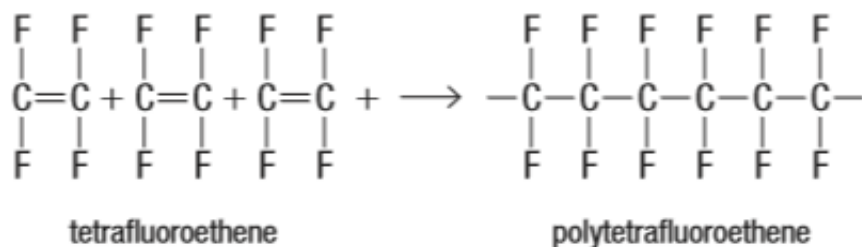
Natural vs. Synthetic

Natural	Synthetic
<ul style="list-style-type: none"> • Starch • Cellulose • Glycogen • DNA/RNA • Silk • Spider silk • Amber • Rubber • Animal horns 	<ul style="list-style-type: none"> • Polyester • Polyethene • Polypropene • Fluoropolymers – used in non-stick coating on cookware • Rubber tires • Kevlar fibres in body armour





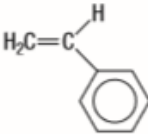

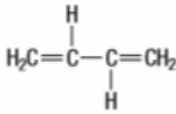
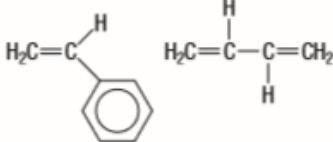
Synthetic Addition Polymers

- Addition polymer – result of the reaction between monomers with unsaturated carbon-carbon bonds



- Polytetrafluoroethene (PTFE) is commonly known as Teflon on non-stick pans

Monomer		Polymer	
Name	Formula	Name	Uses
ethene	$\text{H}_2\text{C}=\text{CH}_2$	polyethene (polyethylene)	plastic bottles and pipes, insulation on electric wires, toys
propene	$ \begin{array}{c} \text{H} \\ \\ \text{H}_2\text{C}=\text{C} \\ \\ \text{CH}_3 \end{array} $	polypropene (polypropylene)	rope, packaging film, carpet fibres, toys 
chloroethene (vinyl chloride)	$ \begin{array}{c} \text{H} \\ \\ \text{H}_2\text{C}=\text{C} \\ \\ \text{Cl} \end{array} $	polyvinyl chloride (PVC)	pipes, construction materials, floor tile, clothing, reusable bags 
cyanoethene (acrylonitrile)	$ \begin{array}{c} \text{H} \\ \\ \text{H}_2\text{C}=\text{C} \\ \\ \text{CN} \end{array} $	polyacrylonitrile (PAN)	carpet fibres, synthetic fabrics
tetrafluoroethene	$\text{F}_2\text{C}=\text{CF}_2$	polytetrafluoroethene (Teflon)	non-stick cookware, electrical insulation, ball bearings

vinylbenzene (styrene)		polystyrene	food and beverage containers, insulation, toys 
butane-1,3-diene (butadiene)		polybutadiene	tires, industrial coatings
vinylbenzene (styrene) and butane-1,3-diene (butadiene)		styrene-butadiene rubber (a copolymer)	synthetic rubber



Checkpoint



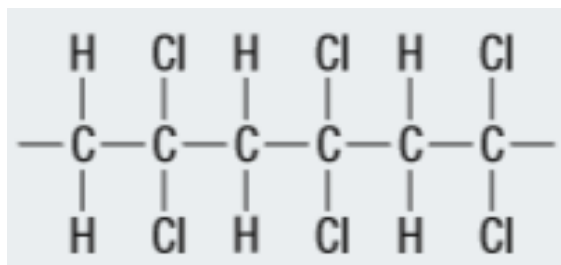
Draw a structural diagram showing three repeating units of the addition polymer formed from cis-but-2-ene



Checkpoint



Draw a structural diagram of the monomer used to make Saran wrap. Name the monomer.



Plastics

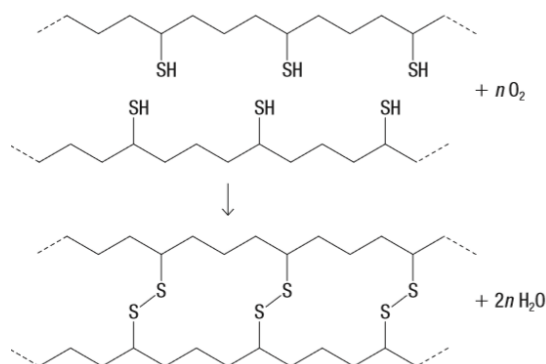
- A synthetic substance that can be moulded (often under heat and pressure) and retains its given shape
- Held together by single carbon-carbon bonds; very strong and less reactive than double bonds
- Weak intermolecular forces between carbon atoms allow the plastic to flex and stretch



- Plastics are categorized based on their density
- Low-density polyethene (LDPE) has more branches in its structure prevent it from packing as tightly as High-density polyethene (HDPE)
- LDPE is used in plastic bags, packaging materials
- HDPE is used in blow-moulded products such as milk jugs and water bottles

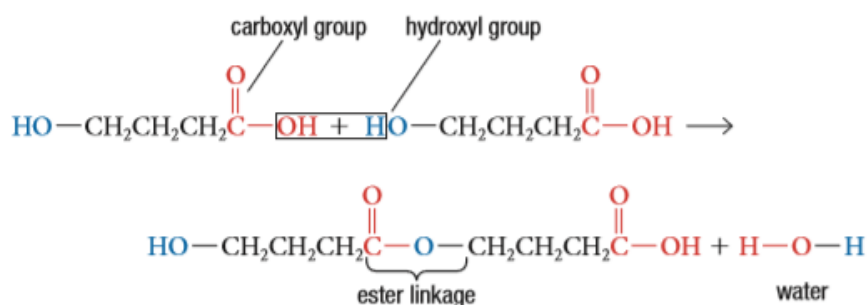
Polymer Cross-Linking

- Formation of chemical bonds between separate polymer strands
- The more cross-links, the more rigid and inflexible the polymer

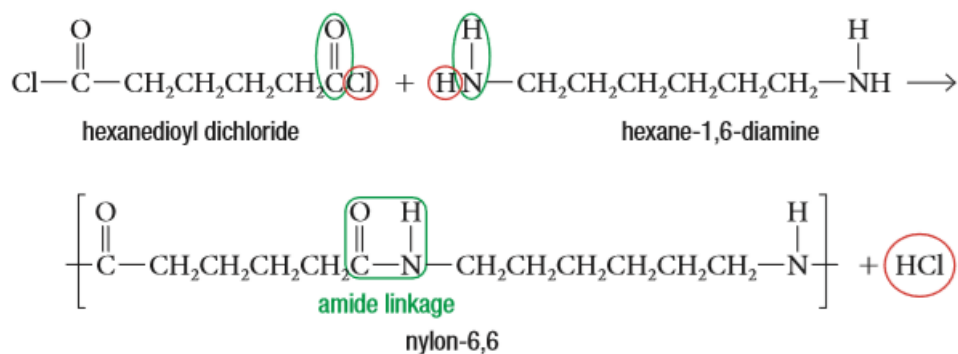


Synthetic Condensation Polymers

- Composed of repeating groups of monomers with two reactive functional groups involved in the polymerization reaction
- Polyesters are formed by a series of esterification reactions that produce a water



- Polyamides are formed by the condensation of an amine and a carboxylic acid
- Ex: Kevlar in body armour
- Nylon 6,6 is a copolymer with two types of monomers





Checkpoint



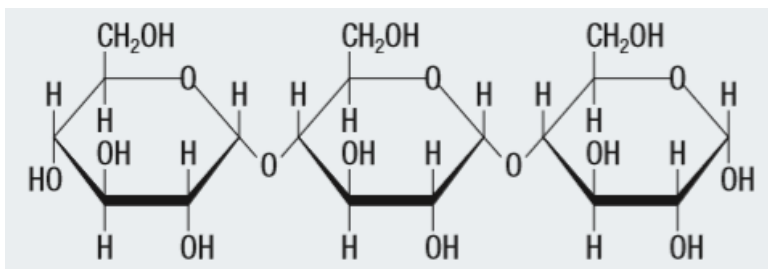
Draw a condensed structural diagram of the polymer made from repeating units of a 4-carbon diamine and a 6-carbon dicarboxylic acid



Checkpoint



Starch is a polymer formed in a condensation reaction in which molecules of water are eliminated from the new bonds. Draw the monomer that makes up starch.





Checkpoint

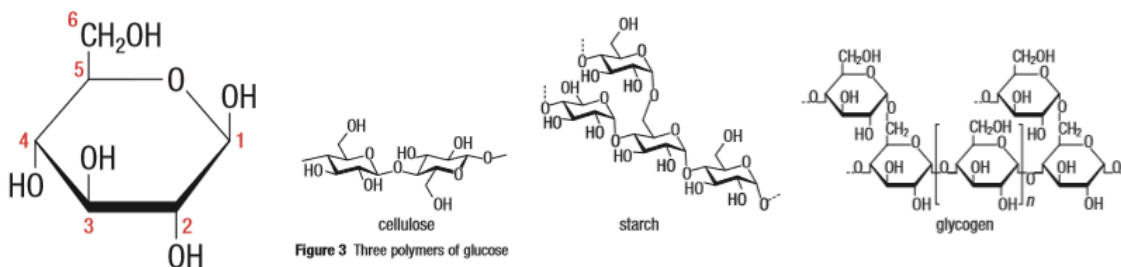


Draw a structural diagram of the polymer formed by the reaction of:

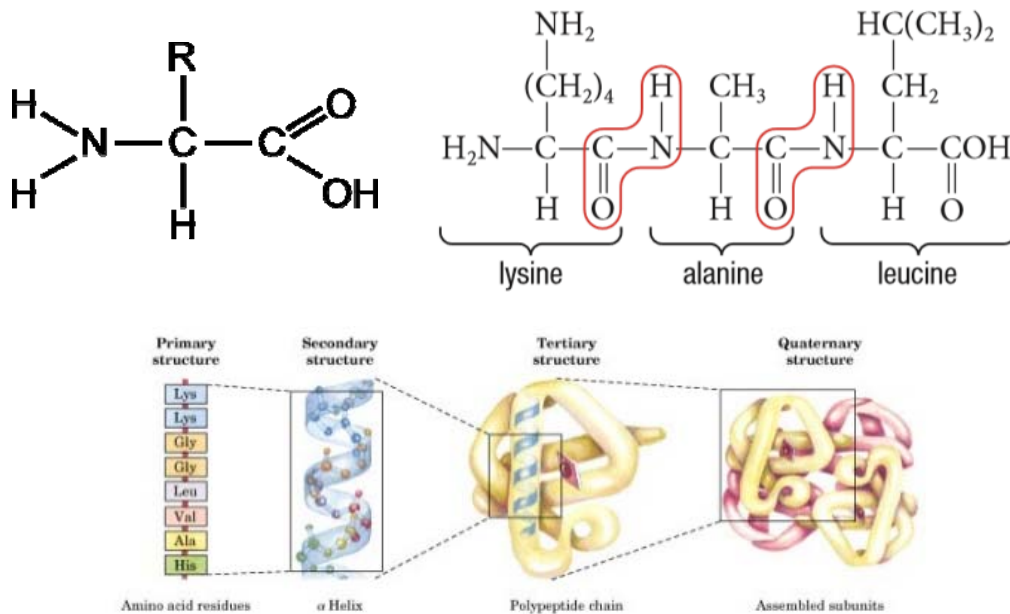
- a) Propane-1,3-diol and pentanedioic acid
- b) Butanedioic acid and a 5-carbon diamine
- c) Hexanedioic acid and a 3-carbon diamine

Natural Polymers

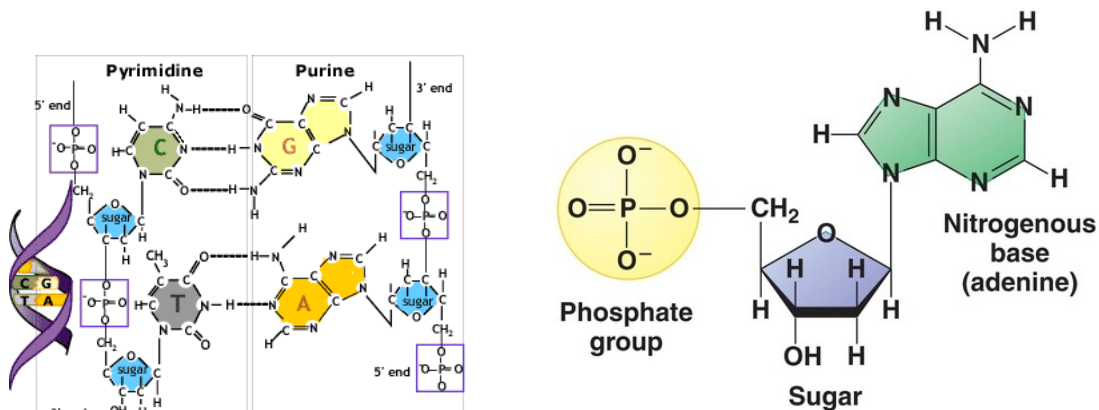
- Carbohydrates – polymer of monosaccharides (simple sugars) to form a polysaccharide
 - Ex: starch, cellulose, glycogen



- Protein – polymer made of amino acids joined together by peptide bonds through a condensation reaction



- Nucleic Acids – polymer made of nucleotides consisting of a 5-carbon sugar, a nitrogen-containing base and a phosphoric acid molecule
- Nucleotides link together through condensation reactions



Summary of Natural Polymers

Macromolecule	Monomer	Bond/Linkage	Polymer
Carbohydrate	Monosaccharides	Glycosidic Linkage	Polysaccharides
Protein	Amino Acid	Peptide Bonds	Polypeptide
Nucleic Acids	Nucleotide	Phosphodiester Linkages	Strand